Department of Geology 2012 Field Trip

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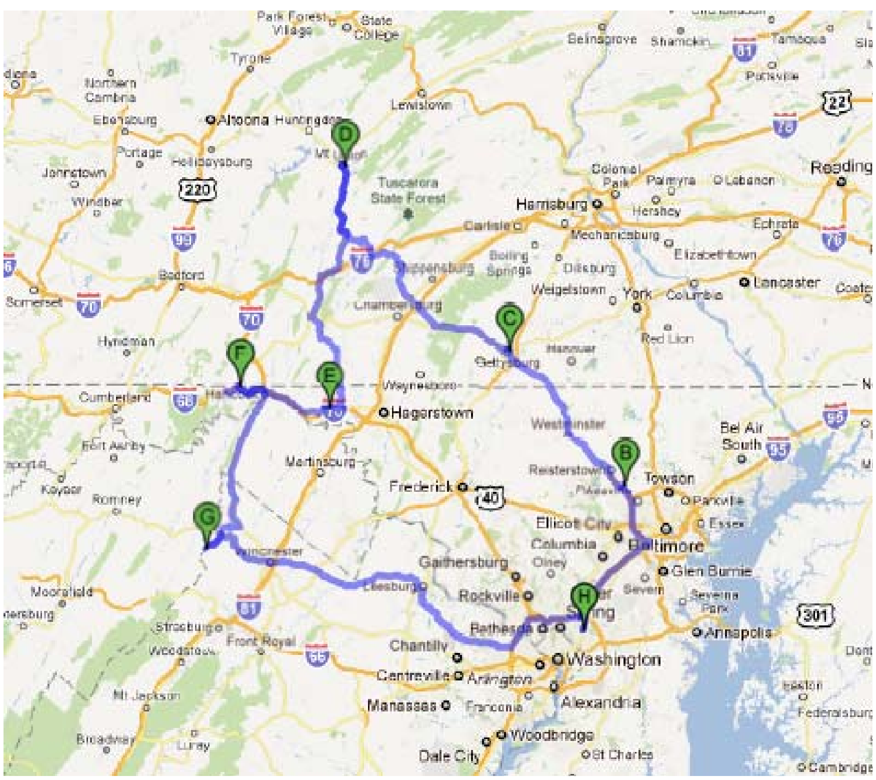
Saturday, August 25, 2012

1) **Leave College Park at 8 a.m. from behind the Geology Building**
2) **Drive to Owen Mills, MD north of Baltimore to observe the Baltimore Mafic Complex at Soldier's Delight (~40 miles)**
3) **Drive to Gettysburg, PA to observe the Newark Supergroup from Little Round Top (62 miles)**
4) **Drive to Kistler, PA to observe the Marcellus Shale (68 miles)**
5) **Drive to Clear Spring, MD for the cookout and overnight at Camp Singewald (64 miles)**

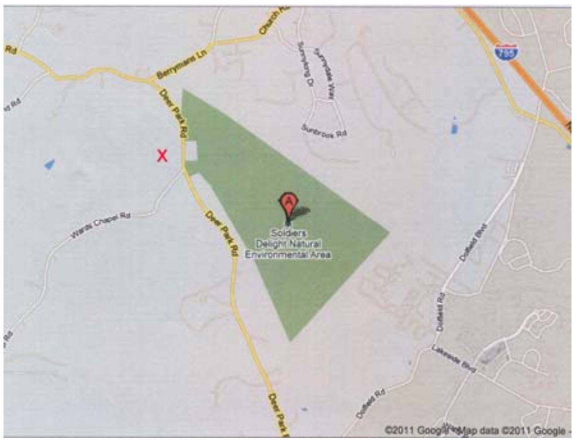
Sunday, August 26, 2012

6) **Drive to Sideling Hill, MD to observe the Tonoloway Formation and Keyser Limestone (28 miles)**
7) **Drive to High View, WV to observe the Needmore Formation and to collect fossils (42 miles)**
8) **Return to College Park and the University of Maryland Geology Building (103 miles)**



Stop 1. Soldiers Delight
Assoc. Prof. Sarah Penniston-Dorland

Soldiers Delight Natural Environment Area
5100 Deer Park Road
Owings Mills MD 21117
GPS 39.40944 76.83537



The rocks of this region form an assemblage of upper greenschist to lower amphibolite facies metasedimentary rocks with intercalated mafic and ultramafic rocks. These rocks are part of the Liberty Complex. At this stop we will have a brief look at some of the metamorphosed peridotites (now serpentinites) near Soldiers Delight. The ultramafic (and nearby mafic) rocks likely represent a small proportion of oceanic lithosphere (Iapetus) caught up in the Taconic accretionary event. The peridotites, now serpentinites, likely originated as mantle rocks. Thus, this is likely a part of a dismembered ophiolite. Ultramafic rocks, like these, occur both northward into Pennsylvania and southward into North Carolina. The Soldier's Delight area was once mined for chromite, which in turn was processed for chromium, an important constituent of steel. This portion of Maryland was for a short time in the 19th century was a major supplier of Cr to the world. If you look carefully at the serpentinites, you can see sizable pieces of chromite (black blocky mineral). If open, we'll visit the Soldier's Delight Visitor's Center. At the entrance is a large piece of chromitite (a rock dominantly comprised of chromite).

The serpentinites of the area impact biology. The main outcrops of serpentinite are manifested as *pine barrens*. The high MgO and Ni contents of serpentitites, and ultimately soils derived from it, is not favorable for most plants. Thus, pine barrens are are commonly characterized by sparse vegetation. The only trees that can grow in this soil is a short type of pine. This means field mapping of serpentine can be accomplished by observing the vegetation.

The assemblage at nearby Mineral Hill, visited during the 2010 field trip, is believed to be part of an accretionary wedge fronting a continent-facing volcanic arc during the Cambrian.

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Additional information by Dale Shelton of the MD Geological Survey reproduced below can be found at: **http://www.mgs.md.gov/esic/features/soldiers.html**

Soldiers Delight Serpentine Barrens, Baltimore County

Soldiers Delight Serpentine Barrens is located in the Soldiers Delight Natural Environmental Area (NEA) in western Baltimore County. The barrens are underlain by serpentinite, a rock that contains very little quartz and aluminum-bearing minerals and consists mainly of serpentine. When serpentinite weathers most of the rock dissolves leaving behind a thin, sand- and clay-poor soil which is easily eroded. Therefore the land surface over serpentinites is stony, unfertile and sparsely vegetated - hence the term "serpentine barren." Typically a serpentine barren contains scrub oak and pine, cedar, grasses and some unique and rare wildflowers.

Serpentine is valued as a decorative building stone, road material, and, in two Maryland localities, a historic source of chromium ore. During the 19th century Soldiers Delight and the Bare Hills district of Baltimore City were the largest producers of chrome in the world. In these two locations, chromite is a significant accessory mineral in the serpentine and was mined up until 1860. Several old mines and quarries are still visible in these serpentine barrens. An excerpt from the MGS Baltimore County Report of 1929 discusses the historical chrome deposits, and is adapted here:

The commercial source of the element chromium is exclusively in the mineral chromite, which when pure, is an iron chromate of the formula $FeO.Cr_2O_3$. It is a heavy, opaque, iron- to brown-black mineral, with a pitchy luster, uneven fracture and hardness nearly that of steel. Geologically it is almost entirely restricted in occurrence to the dark ultrabasic rocks and their serpentinous derivatives. In Maryland chromite is found only in serpentine – a rock which is readily recognized by the barren country it produces. These “barrens,” as they are locally called, are stretches of uncultivated country which support only a sparse growth of grass, scrub oak, and pine. It is believed that this condition is due to the chemical composition of serpentine (a hydrous magnesium silicate), which prevents a vigorous growth of vegetation, thus allowing the soil to be rapidly eroded, leaving the dull, fractured, greenish-yellow serpentine rock exposed at the surface.

The principal use of chromium is in the manufacture of ferrochrome, which, in turn, is used in making high-grade steel. The second most important use is as a refractory substance – chiefly as a lining in the basic open-hearth steel process, which produces three-quarters of the steel of the United States. Considerable amounts are used in the chemical industries – in tanning, dyeing cloth, and for pigments.

The history of chrome mining in Baltimore County is of particular interest, in that it was due to the activities of Isaac Tyson, Jr., of Baltimore, that Maryland came to be the chrome producing center of the world for a considerable time*. It was on Tyson’s farm at Bare Hills, just north of Baltimore, that chromite was first discovered and mined. This date is variously placed between 1808 and 1827, but from the fact that most of the workings at Bare Hills had been abandoned some time previous to 1833 a time nearer to 1808 is probably correct. The occurrences at Soldiers Delight, the barren stretch of country 12 miles northwest of Baltimore, were discovered in 1827, and the discovery of other regions in Maryland followed soon after. These were all the result of the superior acumen of Tyson, who recognized that the chromite always occurs in the serpentine and was able to follow this rock by the barren areas to which it gives rise.

All the ore mined in Maryland and the adjacent region in southeastern Pennsylvania was shipped to Baltimore, and nearly all of the chrome produced in the world between 1828 and 1850 came here. Isaac Tyson, Jr. established a chrome plant in Baltimore in 1845, and thereby gained a monopoly in the chemical use of chrome as well as in its mining. Maryland continued to be the principle producer of chrome until the middle of the 19th century, when the deposits in Asia Minor assumed importance, and the exports from Baltimore ceased in 1860. The Baltimore Chrome Works maintained its monopoly until 1885, and continued to do a thriving business until 1908, when the Tyson family sold out to the Mutual Chemical Company of America.

The mining of chromite again became active in Maryland during the 1870's, but since 1880 there has been but a small and irregular production of sand chrome, and, except a small amount between 1917 and 1925, none of rock chrome.

The mineral chromite is widely disseminated in small quantities in the serpentine of Bare Hills and Soldiers Delight, but is is only at a few places that it occurred in payable quantities. These bodies of richer material are very irregular in size and shape, and it is very difficult to determine their value or extent. At several places at Bare Hills adits run into the hill below the outcrops above failed to find ore at the lower levels. The dimensions of the ore bodies vary from a few inches to several hundred feet in extent. Since serpentine weathers more readily than chromite the disintegration of the rock leaves the chromite intact, and surfaces waters collect it at favorable localities. This “sand chrome,” as it is called, is recovered by washing, and has been the main source of the more recent workings at Soldiers Delight.

Because of the comparative small size of the Maryland chromite deposits, the mining and milling of the ore has been on a small scale and by simple methods. Many of the workings at Bare Hills and Soldiers Delight were in small open pits, and these may still be seen from the roads which traverse the areas. At both localities, however, shafts with drifts were dug and at some places large volumes of rock removed. The Weir mine, Soldiers Delight, on the Ward's Chapel Road, 1.5 miles north of Holbrook, was the largest in the county, and the workings, which consist of two vertical shafts 60 feet apart, are said to have reached a depth of 200 feet. The Choate mine, on Deer Park Road, Soldiers Delight, was another large operation, and considerable work was done during 1917 and 1918 in clearing debris about the mine, but no ore was produced.

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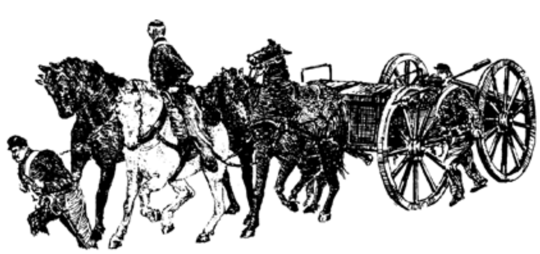
Stop 2: Gettysburg, PA Little Round Top
Prof. Alan J. Kaufman

Gettysburg National Military Park
1195 Baltimore Pike, Suite 100
Gettysburg, Pennsylvania 17325



GEOLOGY ***and the Gettysburg Campaign***

COMMONWEALTH OF PENNSYLVANIA, DEPARTMENT OF CONSERVATION AND NATURAL RESOURCES, BUREAU OF TOPOGRAPHIC AND GEOLOGIC SURVEY, COMMONWEALTH OF PENNSYLVANIA

by Andrew Brown

U.S. Geological Survey
Illustrations on cover and title page by Albert E. Van Olden

PREFACE

This booklet on *Geology and the Gettysburg Campaign* was first published by our bureau in 1962 during the 100th anniversary of the Civil War. A crucial event in that great conflict, the Battle of Gettysburg has special pertinence to Pennsylvania and its citizenry. Since its first printing, the booklet has received widespread interest from tourists visiting the battlefield, students of the Civil War, professional geologists, and others who are fascinated by the interrelationship between the local Gettysburg area geology, the terrain, and the course of the battle.

We are most grateful to the author, Andrew Brown, a staff member of the U.S. Geological Survey at the time of writing and an avid student of the Civil War, and to Dr. Robert C. Stephenson, former director of the American Geological Institute, for their permission to reprint this article, which appeared originally in the July-August 1961 issue of *Geotimes*, a professional news magazine of the geological sciences published by the American Geological Institute. Minor revisions have been made to the original article. It is our hope that the distribution of this booklet will bring a greater understanding of the importance of geology and physical surroundings, not only with respect to the Battle of Gettysburg, but also with respect to the current problems of the conservation and preservation of all of our great historical monuments and natural resources.

GEOLOGY AND THE GETTYSBURG CAMPAIGN

Each year thousands of sightseers clamber over Little Round Top and Devils Den on the Gettysburg battlefield, and gaze with awe over the mile of treeless plain across which Pickett's men charged toward "the little clump of trees" on July 3, 1863. All are impressed by the rocky heights—the Round Tops, Cemetery Ridge, Cemetery Hill, and Culps Hill—against which Lee's men hurled themselves in vain throughout three days of bitter fighting. Few, however, know that these heights are the outcrop of a diabase sill, appropriately enough called the Gettysburg sill, that about 200 million years ago intruded the Triassic sandstones and shales that floor the broad Gettysburg plain. Even fewer have any concept of the extent to which the movements of the two armies toward Gettysburg, and the battle itself, were influenced by the geology of the region in which the campaign was conducted.

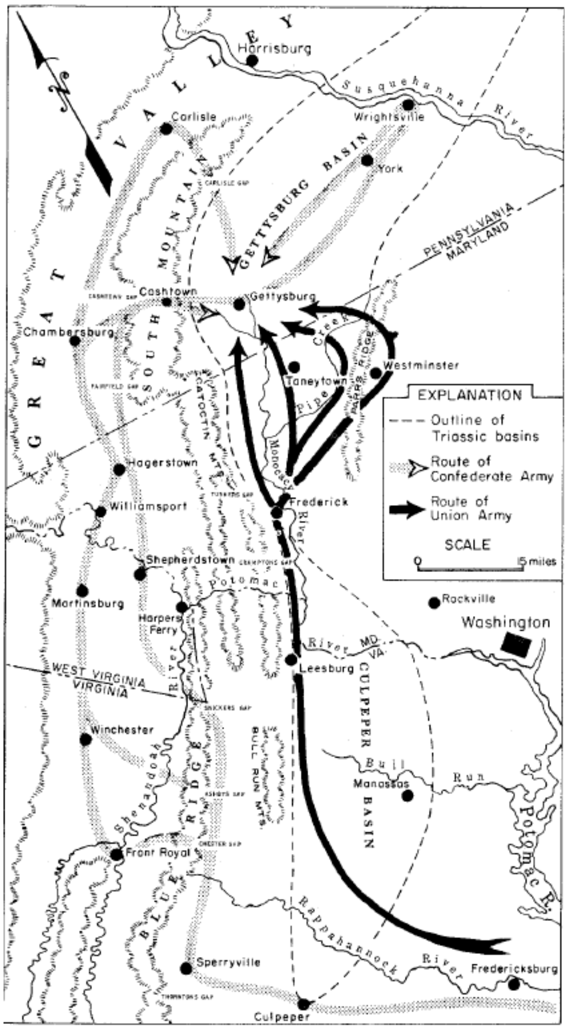
The Gettysburg battlefield covers an area of about 15 square miles. The battle, however, was but the climax of a campaign that covered an area of about 11,000 square miles. This area is approximately 140 miles long—from Fredericksburg on the Rappahannock River in Virginia to Harrisburg on the Susquehanna River in Pennsylvania—and 80 miles wide—from a line drawn on the southeast through Fredericksburg, Washington, and Baltimore, to the northwestern edge of the Great Valley of Virginia, Maryland, and Pennsylvania (see Figure 1). A further idea of the immensity of the military effort that reached its culmination in Pickett's charge is gained from the mere fact that the campaign started on June 3 at Fredericksburg, reached its climax on July 3 at Gettysburg, and did not end until the Confederate army recrossed the Potomac into Virginia on July 14.

At the time of the Civil War, the science of geology was young, and military geology, as the term is understood today, was years in the future. Yet the principles of military geology, applied or all too often not applied, influenced decisively the outcome of more than one campaign. The Gettysburg campaign is an excellent example of intelligent use by commanders of both armies of terrain and topography and, therefore, of geology.

THE ADVANCE TO GETTYSBURG

June 3 to June 30, 1863

The region in which the Gettysburg campaign was conducted (Figure 1) falls into four roughly parallel bands. From southeast to northwest, these are the Piedmont proper; the Triassic basins, including the Culpeper basin in Virginia and Maryland and the Gettysburg basin in Maryland and Pennsylvania; the Blue Ridge of Virginia and its continuation, South Mountain, in Maryland and Pennsylvania; and the Great Valley, including approximately the northern half of the Shenandoah Valley in Virginia, the Hagerstown Valley in Maryland, and the Cumberland Valley in Pennsylvania. Each of these four regions played a distinctive role in the Gettysburg campaign.



After the campaigns of 1862, the Confederates went into winter quarters on the south bank of the Rappahannock River, the Union armies on the northern bank. The Rappahannock and its tributary, the Rapidan, which joins it about 10 miles west of Fredericksburg, flow eastward across the entire 50-mile width of the Piedmont in steep, easily defended valleys, and were in effect the outermost defense line of Richmond.

In this area, the Piedmont rises from approximately sea level at Fredericksburg, Washington, and Baltimore, to about 400 or 500 feet near the Blue Ridge. The exposed rocks, mostly of Precambrian age, are granite, gabbro, and hornblende gneiss in the southeastern part and the Wissahickon Schist in the northwestern part of the Piedmont. The rocky roads of this region of ridges and ravines were hard on men, animals, and equipment, so were to be avoided by the armies of the sixties. To use a term coined later by military geologists, the “trafficability” of the roads was poor. Although the Gettysburg campaign started in the Piedmont, both armies left it as soon as possible. At Fredericksburg in December 1862 and at Chancellorsville in May 1863, Union armies attempted, with disastrous results, to breach the Confederates’ river lines.

After his great victory at Chancellorsville, General Robert E. Lee, commanding the Confederate Army of Northern Virginia, decided to invade Federal territory. He built up his army to a strength of 70,000 to 80,000 men (exact figures are impossible to obtain) and about 250 pieces of artillery. He divided his infantry into three corps of about 20,000 men each. The First Corps was commanded by General James A.

Longstreet; the Second Corps by General R. S. Ewell; and the Third Corps by General A. P. Hill. The cavalry, about 10,000 strong, was commanded by General J. E. B. Stuart.

Facing the Confederates across the Rappahannock was the Union Army of the Potomac, about 100,000 strong, commanded by General Joseph A. Hooker. Hooker had about 350 pieces of artillery; his infantry was divided into seven corps, each approximately half the size of a Confederate corps; his cavalry, commanded by General Alfred Pleasanton, was about 13,000 strong. Lee's reasons for invading the North were political, military, and economic. Politically, the prospect of European intervention on the side of the Confederacy would be greatly enhanced by a decisive victory on northern soil. The military objective was the capture of Harrisburg, the capital of Pennsylvania. With Harrisburg in his hands, Lee could threaten Philadelphia, Baltimore, or Washington as circumstances might make advisable, and he could also cut the Pennsylvania Railroad, a vital supply line for the Union armies. Such a campaign was a sound if bold concept, particularly as Lee counted on outmarching the Army of the Potomac and meeting with no opposition except that of militia. The economic reason for the campaign had to do with such mundane things as food, forage, horses, shoes—in fact almost everything an army needs except ammunition, with which the Confederates were well supplied. The Confederate commissary system, never good, had so broken down that the army had no alternative but to "live off the country"— not in the friendly Shenandoah Valley, but in the hostile Hagerstown and Cumberland Valleys.

The Gettysburg campaign began on June 3, 1863. On that day, Ewell's Corps of the Army of Northern Virginia left Fredericksburg, marching by way of Culpeper toward the Blue Ridge and the Great Valley. A glance at the map might give the impression that the Confederate commander was taking a roundabout route to Harrisburg, but it was in fact the only practicable road. Lee, outnumbered as he knew he was, could not hope to drive the Union army northward and across the Potomac by a frontal attack, but the situation was almost ideal for a flanking movement. Using the Blue Ridge as a barrier, and marching in the wide, fairly level Great Valley, the Confederates were not only safe from attack but to a surprising degree safe from observation. The Blue Ridge and the Valley, therefore, were the keys to Lee's strategy.

In Virginia, the Blue Ridge is high and rather narrow, formed of tightly folded and metamorphosed quartzite and volcanics, gneiss, and other resistant rocks mostly of early Paleozoic age. The crest of the ridge drops from about 4,000 feet south of Thorntons Gap to 1,500 feet at the Potomac, where it is known locally as Loudoun Heights. An extension, Elk Ridge, continues about 10 miles into Maryland; the southern end of Elk Ridge is known as Maryland Heights. At the Potomac River, the main ridge is offset about 3 miles to the east, and an extension, Short Mountain, continues for about 10 miles into Virginia. Near the Maryland-Pennsylvania State line, a spur of South Mountain, the Catoctin Range, swings eastward and southward into Virginia, passing a few miles west of Frederick, Md. The Bull Run Mountains in Virginia are an interrupted extension of the Catoctin Range.

South Mountain in Pennsylvania and northern Maryland is wider and more complex in structure than the Virginia Blue Ridge, though it is formed by the same rock types. Altitudes of the crest in that region range from about 1,500 feet at the Potomac to 2,000 feet near Carlisle. Of military importance equal to the Blue Ridge and South Mountains were the gaps, which, so to speak, are the doors in the mountain wall. The only water gap in the area of the Gettysburg campaign is at Harpers Ferry where the Potomac River cuts through the mountains. The Harpers Ferry gap, however, is commanded by Loudoun Heights, Maryland Heights, and the high ground west of Harpers Ferry, and therefore was of little military significance. The only places where the armies of the sixties could cross the mountains were the wind gaps, eight of which influenced the campaign. From south to north, these are Chester Gap (and Manassas Gap, about a mile to the north), Ashbys Gap, and Snickers Gap in Virginia; Cramptons Gap and Turners Gap (and Fox Gap, about a mile to the south) in Maryland; Fairfield (or Monterey) Gap near the Maryland-Pennsylvania State line; and Cashtown Gap and Carlisle Gap in Pennsylvania. Altitudes of these gaps range from 600 feet at Manassas Gap to 1,400 feet at Cashtown Gap. The Virginia and Maryland gaps are of erosional origin; Fairfield, Cashtown, and Carlisle Gaps in South Mountain were formed by a combination of faulting and erosion.

After it became apparent, on June 15, that the Union army was moving northward and not toward Richmond, Longstreet’s and Hill’s Corps of the Army of Virginia followed Ewell’s Corps across the Blue Ridge into the Great Valley using the three Virginia gaps, and thence northward. Lee’s concentration area, in and around Chambersburg, Pa., was reached between June 24 and June 28.
In the Gettysburg campaign area, the Great Valley is from 10 to 20 miles wide and averages about 15 miles. It is underlain by limestone and shale, mostly of Ordovician age, and owes its existence to the incompetent nature of these formations as compared to the harder ridge-forming rocks on either side. In Virginia and West Virginia, the valley drains northward through the Shenandoah River into the Potomac. The divide north of the Potomac is a few miles north of Chambersburg, standing at an altitude of about 650 feet. From that area, the Hagerstown Valley is drained by Conococheague Creek, which flows into the Potomac at Williamsport, Md. The Cumberland Valley drains northeastward into the Susquehanna at Harrisburg through Conodoguinet Creek.

The Great Valley was and is a fertile region, from which the Confederates, once across the Potomac, impressed a vast quantity of supplies of all kinds. Because of the gentle grades and deep soil, the trafficability of the valley roads was good, and the Confederates reached Chambersburg in excellent condition. Lee’s selection of Chambersburg as a concentration point was based on the geology of Cashtown Gap. The other gaps in the northern part of South Mountain are narrow and tortuous; but Cashtown Gap, through which U.S. Highway 30 now runs, owes its existence and character to a great cross-fault, the Cashtown fault, which offsets the topographic crest of the main ridge of South Mountain about 3 miles. Erosion has carved in the fault zone an almost straight pass about 8 miles long, the highest point in which is a ridge less than a mile wide between the head-waters of Conococheague Creek on the west and Marsh Creek on the east. Of the eight passes that figure in the Gettysburg campaign, Cashtown Gap was the only one through which it was possible to move expeditiously a large force with artillery and wagon trains. By concentrating west of this gap, Lee was able not only to protect his communications to the south, but to move either east or northeast over easy roads.
Lee held the initiative throughout his movement toward Gettysburg, and therefore movements of the Union army were dictated by those of the Confederates. The march across the Blue Ridge and into the Valley was so well screened by Stuart’s cavalry that for a time Hooker had little idea of where the Confederate army was or where it was going. He did, however, move slowly northward in the Culpeper basin and, on June 25, crossed the Potomac. He then moved up the valley of the Monocacy River to Frederick, sending three of his infantry corps to cover Cramptons and Turners Gaps in South Mountain against a possible attack on Washington from that direction.

The exposed rocks in the Culpeper and Gettysburg basins are sandstone and shale that were deposited in Triassic time in the downtilted western part of the Piedmont, which abuts the Blue Ridge and South Mountain. In Early Jurassic time, these sediments were intruded by sills and dikes of diabase. As the roads generally avoided the diabase outcrops, trafficability across the Triassic sediments was good, much like that in the Great Valley. Like the Confederates, the Union troops took advantage of geologic conditions to expedite their movements. A critical day in the Gettysburg campaign, and possibly its turning point, was June 28. On that day, two of Lee’s three corps were concentrated in the Chambersburg area. Two divisions of the third corps, Ewell’s, were at Carlisle, threatening Harrisburg from the west. The other division was at York, where it was in a good position to move toward either Harrisburg or Baltimore. From Lee’s standpoint, the campaign was progressing favorably except for one fatal lack: the usually dependable Stuart, instead of keeping his cavalry between the Confederate and Union armies, had started a raid toward Washington, east of the Federals, and as far as Lee was concerned, was lost. Because of Stuart’s unaccountable absence, it was not until the night of June 28 that Lee learned from a spy that the Union army had crossed the Potomac and was concentrated around Frederick. He therefore recalled Ewell’s troops from Carlisle and York and moved Hill’s Corps through Cashtown Gap to Cashtown, to be in position to meet the Union threat.

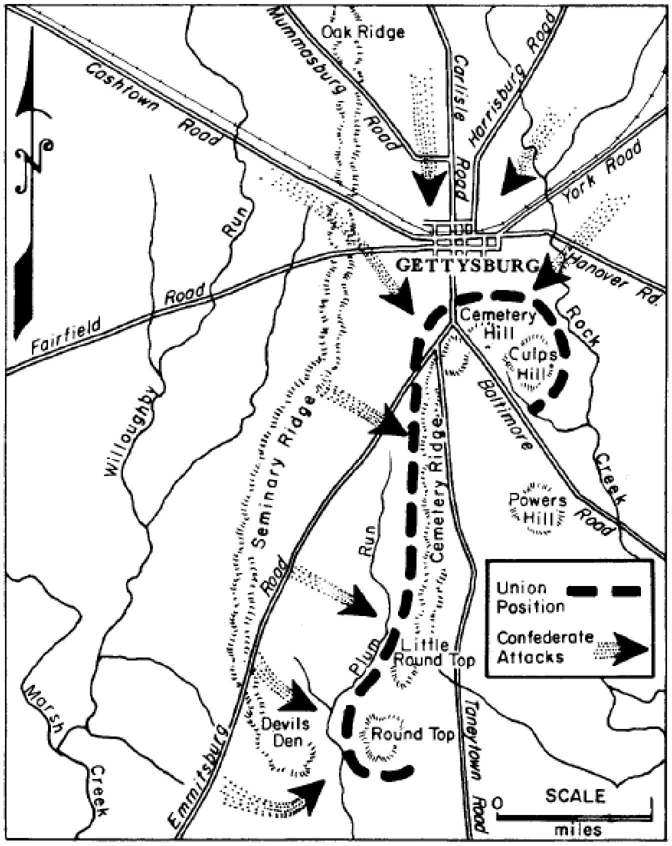
General George G. Meade, commanding the V Corps, was awakened at 2 a.m. on that same June 28 and told that he had been named to succeed Hooker as Commander of the Army of the Potomac. Meade, assuming command under most disadvantageous circumstances, acted promptly. He recalled the three corps from Cramptons and Turners Gaps, and sent cavalry through Turners Gap to ascertain the Confederate position around Chambersburg. Knowing that Confederate troops were at Carlisle and York, Meade moved his headquarters to Taneytown and sent his engineers to select a strong defensive position, which later was to become known as the Pipe Creek line. He then sent three infantry corps, preceded by a strong cavalry screen, toward the town of Gettysburg, while the other four corps moved northeast and took position behind Pipe Creek. Both movements were made on the basis of the geology of the areas concerned.

The Gettysburg basin, from its southern end near Frederick, widens northeastward toward the Susquehanna River; in southern Pennsylvania, it is a wide, fairly level plain, except for the diabase outcrops. The town of Gettysburg, on this plain, was the hub from which radiated ten roads. Such was the road pattern that the Confederates, whether they came from Cashtown, Carlisle, or York, had no choice but to pass through Gettysburg. It was for that reason that Meade sent almost half his army toward that little town. Meade, however, did not want to fight at Gettysburg, desiring a stronger position. The line which he selected, generally known as the Pipe Creek or Westminster line, might be better described as the Parrs Ridge line. Parrs Ridge, in the western edge of the Piedmont, extends northeast and southwest through Westminster. It forms the divide between the Monocacy River drainage on the west and the direct drainage to the Chesapeake Bay on the east. The ridge near the Pennsylvania-Maryland State line stands at more than 1,000 feet above sea level, and at Westminster about 800 feet; this compares with the usual Piedmont elevations of 400 to 500 feet. Pipe Creek, flowing through the Triassic basins north of the ridge and into the Monocacy River, is not particularly formidable, but Parrs Ridge, to the east, upheld by highly resistant schists and quartzites, has not only height, but widths of 4 to 10 miles that could have been fortified into an almost impregnable defensive position. Although Meade never used his Pipe Creek line, his choice shows his good eye for geology and topography. Circumstances beyond his control brought the two armies together at Gettysburg.

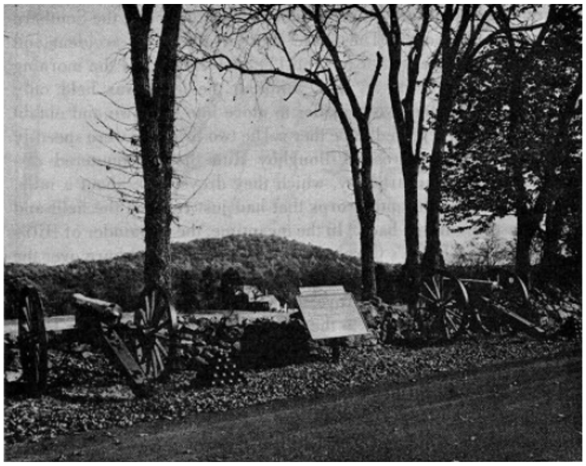
THE BATTLE OF GETTYSBURG

July 1 to July 3, 1863

The Battle of Gettysburg was essentially an effort by the Confederates to drive the Union army from the outcrop of the Gettysburg sill (York Haven Diabase) south of the town of Gettysburg. This outcrop is shaped like a fishhook extending northward about 3 miles from Round Top through Little Round Top and Cemetery Ridge to Cemetery Hill, then east and south to the barb of the fishhook, Culps Hill. Round Top stands at 785 feet above sea level, Little Round Top at 650 feet. Between Little Round Top and Cemetery Hill, the ridge drops to about 570 feet. For comparison, the elevation of the town of Gettysburg is about 500 feet. Seminary Ridge, the Confederate position on the second and third days of the battle, stands throughout most of its extent at about 560 feet, but rises northward to 650 feet at Oak Ridge. Seminary Ridge is the trace of a diabase dike (Rossville Diabase) that apparently is an offshoot of the westward-dipping Gettysburg sill.



One of the peculiarities of the Battle of Gettysburg is that the Northern armies moved to the battlefield from the south, the Southern armies from the north. The battle started, almost by accident and certainly against the wishes of both Lee and Meade, on the morning of July 1. General A. P. Hill, thinking the town was held only by militia, authorized two brigades to move into the town and obtain a supply of shoes reported to be there. The two brigades were speedily disillusioned; once across Willoughby Run, they encountered dismounted cavalry and artillery, which they drove back about a mile. Then they met two infantry corps that had just reached the field and were themselves driven back. In the meantime, the remainder of Hill's Corps and all of Ewell's Corps were pouring into Gettysburg over the Cashtown, Carlisle, Harrisburg, and York roads (see Figure 2). During the afternoon, these troops drove the outnumbered Federals through the town of Gettysburg and to the base of Cemetery and Culps Hills. Then occurred the first of a series of almost inexplicable Confederate blunders that marked the course of the battle. The Southerners were flushed with victory, the Union troops badly beaten, and enough of the long July daylight remained to storm the hills, which could not be protected by entrenchments because the diabase was practically at the surface. Yet Ewell, who up to that time had performed ably and even brilliantly as a corps commander, made no move to attack, and the opportunity was lost. During the night, the positions were reinforced so strongly that later efforts to take them failed. Once the battle had started, the next phase was a race for the field by both armies. Of the Confederates, Longstreet's Corps, except Pickett's Division, reached Gettysburg early on July 2; Pickett arrived about 24 hours later. On the Union side, Meade moved all his infantry, except the VI Corps under General John Sedgwick, to the field by the morning of the second; Sedgwick arrived late in the afternoon. Thus, on the second day of the battle, the Federals outnumbered the Confederates, reversing the situation of the first day. Meade himself reached the field about 2 a.m. on the second, having sent General W. S. Hancock of the II Corps to reconnoiter the situation. Hancock reported that the Union position was strong, though it could be turned rather easily, and recommended that, as the battle had already begun, it be fought out there.



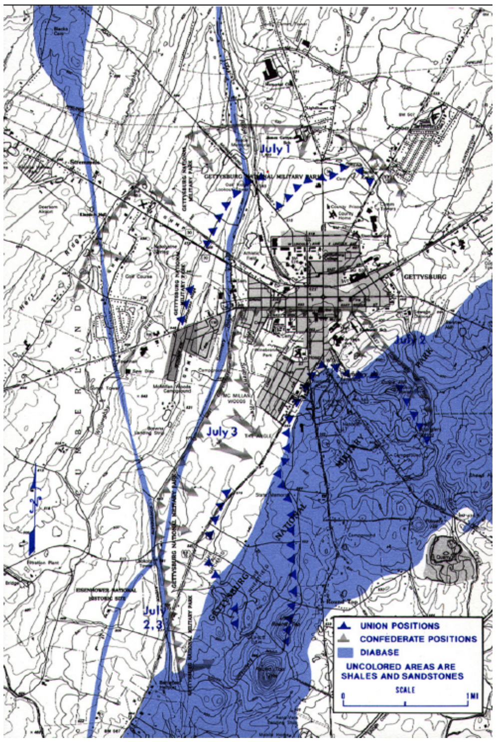
On July 2, Lee took position along Seminary Ridge and launched a series of attacks against the southern end of the Union line—the Round Tops. Devils Den, a mass of diabase boulders facing Little Round Top across Plum Run, became the scene of bitter fighting. After the Confederates had taken Devils Den, they used sharpshooters, sheltered by the huge boulders, to pick off troops on Little Round Top throughout much of the day. Partly because Longstreet's Corps was late in starting, the attack on the Round Tops was only partly successful, and the southern end of the Union line was not turned as it might have been. On July 3, Lee, having attacked the Union right and left flanks, attempted to break the center by a charge led by Pickett's fresh division. The charge failed, partly at least because it was not supported on either flank, and the Battle of Gettysburg ended with the Federal army holding its position.

Almost until its end, the battle could have gone either way. Lacking the services of the redoubtable "Stonewall" Jackson, dead these two months, and in the absence of Stuart, Lee did not have his army under full control until July 2 and admittedly fought his worst battle. Meade, sound and methodical, won because he handled the Army of the Potomac better than it had been handled by any previous commander. It is ironic that for this achievement he has received more blame than praise. Meade has been criticized for preferring to fall back to his Pipe Creek line before meeting Lee. His reasoning was sound, however, for as Hancock had reported, the heights could be turned. If Ewell, on July 1, and Longstreet, on July 2, had done what they should have done, Meade's forces would have been outflanked, and there is good reason to believe that, had not the Confederate command system broken down, Meade would have been driven from the Gettysburg position. If that had happened, he would have had no choice but to fall back on his Pipe Creek line.

The Union position at Gettysburg had another weakness that became more and more evident as the battle progressed; owing to the geology, it could not be entrenched. The resistant diabase sill is so close to the surface that it was impossible for the soldiers to "dig in," and what little protection they could obtain was provided by existing stone walls, outcrops of rock such as Devils Den, and isolated boulders. Because of its inability to solidly entrench its position, the Union army suffered disproportionate casualties (about 23,000 men killed, wounded, and missing), considering that it was the defending force throughout the battle.

The Confederates suffered about 28,000 casualties, but spent three days unsuccessfully attacking the Union line—first on the flanks and finally in the center. When Union forces attacked well-entrenched Confederates at Fredericksburg (December 1862) and Spottsylvania (May 1864), they lost about twice as many men as the Confederates—and at Cold Harbor (June 1864), more than four times as many. This is in accordance with the axiom of infantry warfare that an attacking army must expect significantly higher losses than a defending force, which ordinarily will be entrenched. Unlike the rocky Gettysburg line, Meade's preferred position on Parrs Ridge behind Pipe Creek could have been effectively entrenched.

THE RETREAT
July 4 to July 14, 1863



Throughout July 4, the two badly mauled armies faced each other across the field of Pickett's charge, burying their dead and succoring their wounded. Meade did not attack, though the Confederate position, like the Federal, could not be entrenched to any appreciable degree. The Confederate wounded and supply trains were sent westward through Cashtown Gap, while the main army prepared to retreat through South Mountain at Fairfield Gap. On the fifth, the Federals followed, but decided that Fairfield Gap could not be forced. Accordingly, Meade sent his infantry south to Frederick and into the Great Valley through Turners Gap. Lee won the race to Williamsport, where he planned to cross the Potomac. There he fortified a strong line east of the town, anchored on the Potomac and on Conococheague Creek. Meanwhile the river had risen, and it was not until the night of July 13–14 that the Confederates were able to cross on rebuilt bridges. Meade, who had planned to attack the Confederate works on the fourteenth, marched in to find empty fortifications. He crossed the river and followed Lee south, and within a matter of weeks both the Army of Northern Virginia and the Army of the Potomac were just where they had been on June 3—facing each other across the Rapidan River.

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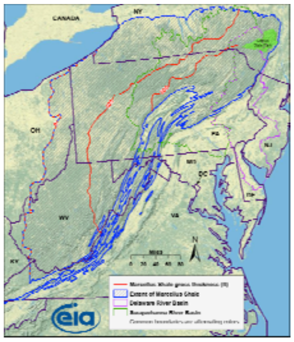
Stop 3: Marcellus Shale
Profs. Alan J. Kaufman and Phil Candela

Harrisburg to Altoona Conrail line at Newton-Hamilton, PA: UTM coordinates
18T257646 m E – 4474003 m N

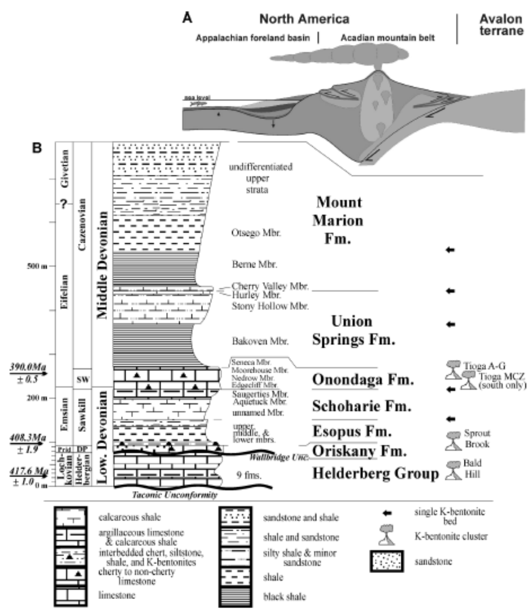
As an energy source, natural gas is far more efficient and cleaner than either petroleum or coal, so finding new reserves of natural gas would support our economy (over 20% of U.S. energy needs are currently met through the burning of natural gas) and our environment. New horizontal drilling techniques for the extraction of gas from deeply buried shale formations thus have the potential to lessen our dependence on foreign sources of energy, and tremendous shale deposits are in our own back yard.

The Marcellus Shale Formation is one of these rock units that stretch from New York to West Virginia in the Appalachian Mountains of the eastern United States. It is composed primarily of black shale, a sedimentary rock that forms when clay and silt sized particles and microscopic plants and animals are deposited together in quiet oceanic environments. The Marcellus Formation accumulated over 380 million years ago, when present-day eastern North America was located just south of the equator, in a deep marine environment adjacent to the ancestral Acadian Mountains, which later became part the modern Appalachians.

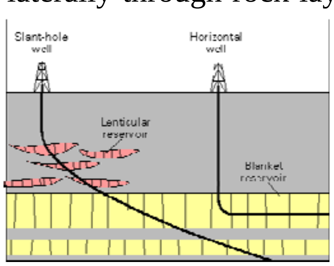


The rise of sea level and upwelling of nutrients from deep ocean settings is believed to have resulted in high rates organic productivity, reduced sediment supply, and widespread anoxia (lack of oxygen) in the depositional zone. This led to the preservation of thick organic-rich shale in the Marcellus Formation, which is of great current interest to energy companies as it provides an excellent source rock for the extraction of natural gas.

Once buried to adequate depths the increased pressure and temperature organic-rich sediments encounter convert organic matter to fossil fuels. The Marcellus is primarily a source of natural gas as temperatures increased beyond the window for liquid oil production. Energy companies have been extracting gas from the Marcellus at commercial quantities since 2000, but the outdated techniques being used to mine the gas has limited production. Since then new mining and extraction techniques such as horizontal drilling and hydraulic fracturing have greatly increased production.



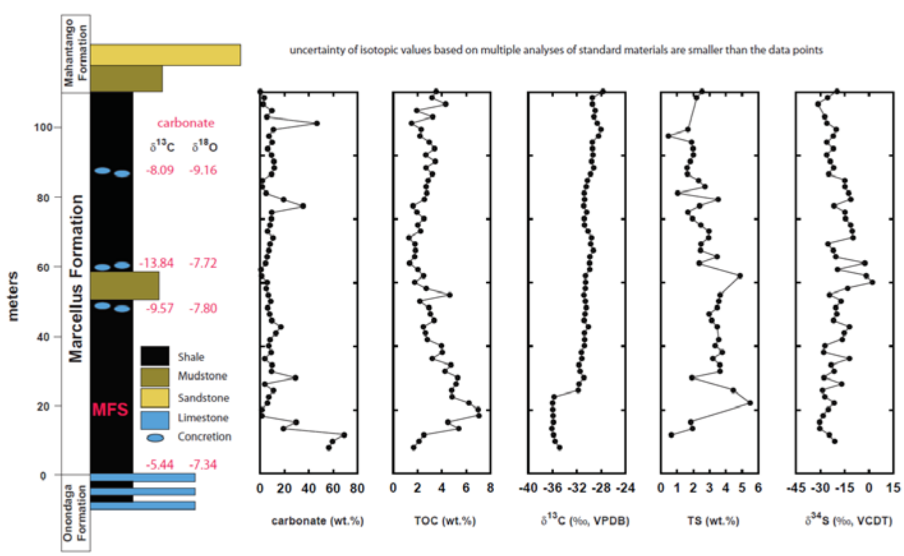
Horizontal drilling is a method where the drill operator turns the bit sideways to travel laterally through rock layers generating more avenues for gas to escape. Even after this method has been used there are sometimes not enough fractures for large quantities of gas to escape. The solution to this is called hydraulic fracturing, a process by which a mixture of water and other chemicals is pumped into the shale at extremely high pressures to induce fracturing, providing even more pathways for the gas to escape. Current estimates on the amount of recoverable gas from the Marcellus



Formation shale vary dramatically, but range up to 363 trillion ft^3. At the current usage rate (23 million cubic feet per year) this largely untapped resource of clean energy alone could support all U.S. demand (at current levels) for as many as 16 years.

Assessing the bed-to-bed geochemical composition of the >100 meter thick Marcellus Formation is critical in determining its capacity to produce natural gas. Energy companies depend on such studies when deciding where and at what depths to drill into the formation. Previous work on the Marcellus Shale, however, has focused on mapping its distribution throughout the Appalachians, determining the processes by which organic matter is preserved, and estimating the size of the reservoir. Work completed by past undergraduate students Tyler Baril and Benn Breeden focused on identifying the most productive levels within the unit, and the relationship of these intervals with notable changes in the isotopic composition of carbon, sulfur, and nitrogen.

Samples for a time-series geochemical study of the Marcellus Shale were collected at two meter intervals from a railroad cut outcrop near Kistler, PA because of its high organic content and insofar as it is the only known complete section of the Marcellus exposed in Pennsylvania. Samples span the interval between the Marcellus contact with the overlying Mahantango Formation, a gray siltstone to fine grained sandstone down to the contact with the Onondaga Formation, a marine limestone. The section is gently dipping to the WNW and just to the SE of the axis of a third order syncline. The outcrop has a number of structural features including deformed strain markers, small-scale buckle folds, and pencil cleavage.



Natural gas from low permeability (or "tight") shale units, known as "shale gas", is one of the most rapidly expanding trends in domestic oil and gas exploration and production. Natural gas is a mixture of low-molecular weight alkanes comprising dominantly methane (CH_4) but also lesser butane, ethane, propane, and other gases. Much of the technically recoverable natural gas in North America is present as "unconventional gas" that is found in tight shale and in coal beds. The Devonian Marcellus Shale is the most expansive "shale gas play" in the U.S.

Crudely, 1/4 of total U.S. energy needs are satisfied by natural gas; if we add petroleum and coal to the mix, they account for 85%. Generation of electricity accounts for about 2/5 of our total energy usage, of which 1/5 is gas; a full 3/4 of residential and commercial heating is by natural gas. Clearly, natural gas is an important part of our today's energy palette, and will be so for many more years.

So what constitutes a good "gas shale"? Typical gas shales are self-sourced and self-sealed, that is, they serve as both source rock and trap for the natural gas; they contain both free gas (dominantly in bubbles in kerogen) and adsorbed gas; and they are thermally mature and naturally fractured. Porosities of kerogen should be in the general range of 20-50%. Further, good gas shale will have a high silt and/or carbonate content, making the rock more brittle, and therefore more amenable to fracturing. Higher carbonate content also correlates with higher organic matter content. Generally, one is exploring for a shale with less than 30% clay, greater than 2% wt. total organic carbon, and a maximum temperature of burial (or alteration) of ~250^{o}C.

Depth to the top of the Marcellus shale ranges from 0 feet where it crops out in central Pennsylvania to over 9,000 feet in parts of southwestern and northeastern Pennsylvania (although metric units are preferred for scientific communication, I use non-metric units here because of their dominance in practical resource science in the US). The thickness of the Marcellus ranges from less than 20 to several hundred feet; however, the net thickness of organic-rich Marcellus shale in PA varies from less than 10 feet into over 250 feet.

A note on Earth resources: The classic idea of exhaustible resources states that a fixed quantity of e.g., copper or natural gas exists within the Earth's crust, and therefore the supply is "exhaustible", with prices rising as further production of the resource becomes more expensive. However, this idea is bad geology, and bad economics. Papp et al., 2008, in USGS Open File report 2008-1356, report that, over the last century,"…long-term metal prices (measured in current dollars) have changed at about the same pace as inflation." That is, copper for example, is about as expensive now as it was a century ago. Further, Adelman, (1995) points out, with regard to fossil fuels, "There is an endless tug-of-war between diminishing returns and increasing knowledge." Nothing exemplifies this better than the shale gas phenomenon. Just a decade ago, "experts" were reporting that the United States could not drill its way out of a natural gas shortage, and we built terminals for the import of LNG (liquefied natural gas). However, resources do not exist in and of themselves in nature; they don't exist as little packets of "ore" or "fossil fuel".

Our innovation can turn worthless stone into a valuable resource. The combination of hydraulic fracturing (“fracing”) and horizontal drilling, including the use of sand and other “proppants” to hold the fractures opened once formed, has allowed natural gas from “tight” rocks to become a viable and plentiful resource. Reserve estimates for the Marcellus from January 2007 were ~ 5 TCF (trillion cubic feet) of gas, but ballooned to 50 TCF eleven months later; in 2011, the DOE’s number is in the hundreds of TCF, and the 2011 USGS number is just under a 100 TCF. Total shale gas reserves account for abuot 25% of our domestic reserves, which represent enough natural gas to last 100 years at present rates of consumption. Obviously, these are all very soft numbers, and such reserve estimates, historically, usually turn out to be minima, as technological innovations advance with production. Human innovation once again falsifies the “peak” resource hypothesis.

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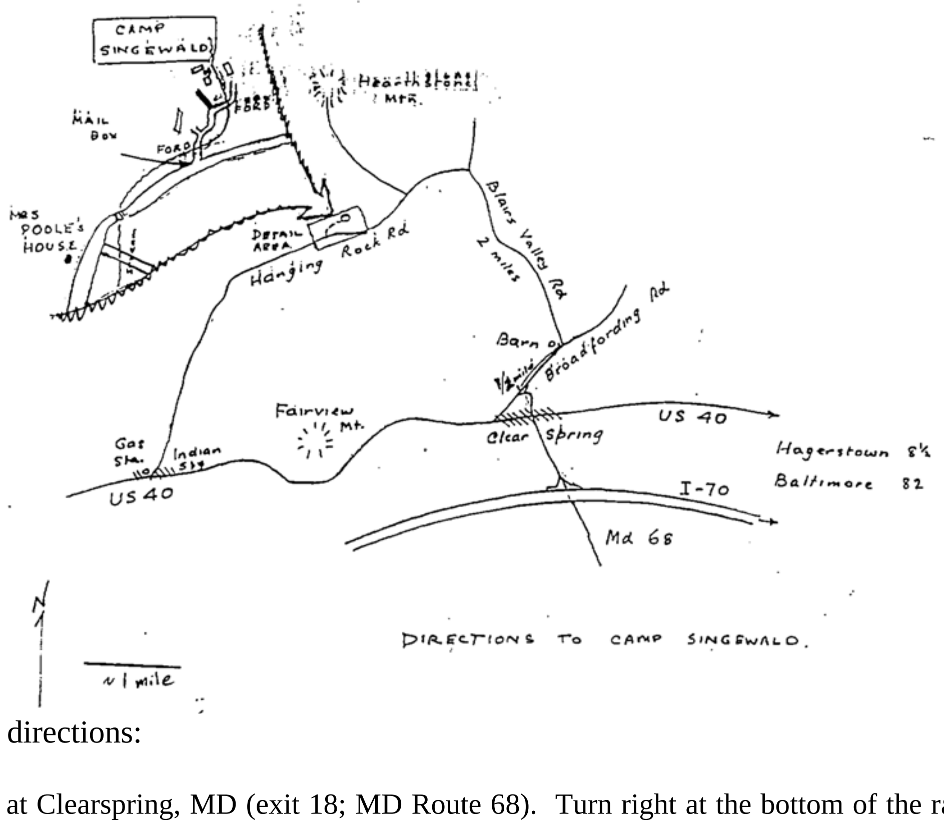
Stop 4: Johns Hopkins University Camp Singewald, Clear Spring, MD
Contact: Kim Trent (410-516-7135) for reservations



Detailed directions:

Exit I-70 at Clearspring, MD (exit 18; MD Route 68). Turn right at the bottom of the ramp and proceed north to stop light at the intersection with Route 40, in the center of Clear Spring. Cross Route 40 and continue northward to intersection with Broadfording Road. Turn right and go ~0.5 miles northeastward along Broadfording Road. Turn left onto Blair’s Valley Road at intersection marked by White Barn. Continue ~2 miles to intersection with Hanging Rock Road on left. Turn left onto Hanging Rock Road and go about 2.2 miles to entrance to camp (Pass intersection with Hearthstone Mountain Road (paved) on right at about 1.5 miles, continue on to Hanging Rock Road). Turn right onto dirt road. End of road has several mailboxes. If you cross a small bridge over a stream and come to Mummert Road…you have gone a little too far. SLOWLY ford stream and continue on dirt lane – past white house on left – to fork a few hundred feet ahead. Bear right into second stream fording. Ford stream and proceed into camp.

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Stop 5: Tonoloway Formation and Keyser Limestone near Sideling Hill road cut
Asst. Prof. Aaron J. Martin

A rails-to-trails path cuts through the Silurian Tonoloway Formation and upper Silurian-Lower Devonian Keyser Formation in a small area here at the base of Little Round Top. The exposures at the main railroad cut provide exceptional three-dimensional views into the hearts of photogenic mesoscopic structures. I am going to refrain from listing these structures here so that you can experience the joy of discovering them for yourselves. Field geologists typically draw and photograph important field relationships – you might do the same. They also measure the orientations of structures, and we will discuss what measurements should be made.

Two items to consider when exploring these outcrops are the following.

1. Observe the ways that different types of structures interact with one another. There are at least three different types of structures that work together, but differently, to accommodate the deformation.

2. Observe the vastly different spatial scales at which the same type of structure occurs.

Both features frequently are present in deformed regions around the world.

Getting there: From Hancock, head west on MD 144, West Main Street, out of town. Approximately 500 meters west of the Hancock High School, turn left (south) on Locker Road. Follow Locker Road until it ends against Berm Road, within sight of the Potomac River. Walk west on the rails-to-trails path approximately 1.5 kilometers to the railroad cut, which is near 39.67748 °N, 78.22535 °W.

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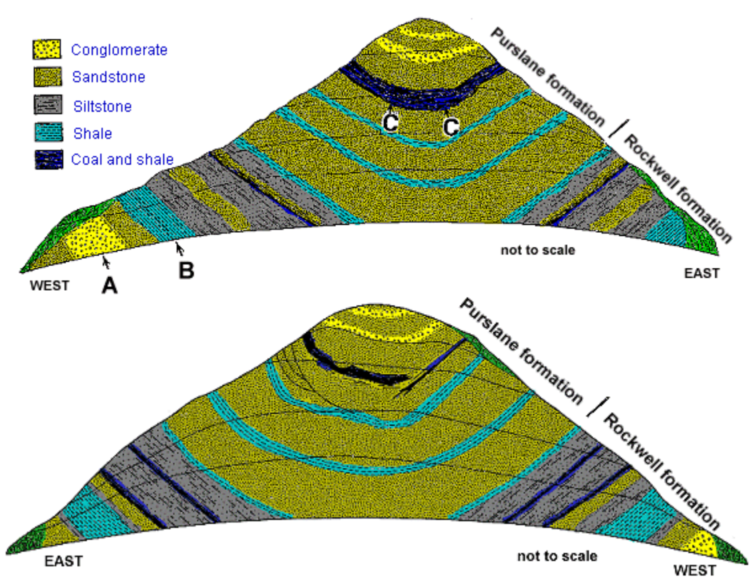
Geology of the Sideling Hill Road Cut

by David K. Brezinski
MD Geological Survey
1989 (revised 1994)

One of the best rock exposures in Maryland and indeed in the entire northeastern United States is located approximately 6 miles west of Hancock in Washington County, where Interstate 68 cuts through Sideling Hill. Almost 810 feet of strata in a tightly folded syncline are exposed in this road cut. Although other exposures may surpass Sideling Hill in either thickness of exposed strata or in quality of geologic structure, few can equal its combination of both. This exposure is an excellent outdoor classroom where students of geology can observe and examine various sedimentary rock types, structural features, and geomorphic relationships.

Sideling Hill lies in the Valley and Ridge Physiographic Province of eastern North America, a region characterized by tightly folded strata. Erosion of these folds has produced a series of subparallel ridges and valleys, in which the ridges are capped by erosion-resistant sandstones, and the intervening valleys are underlain by soluble limestones and easily eroded shales. At first, Sideling Hill may appear to be a somewhat unusual feature, inasmuch as the downfold, or syncline, exposed in the road cut would seem to be more likely to form a valley, rather than a ridge. However, the youngest rocks, or those highest in the stratigraphic section, are the resistant sandstones and conglomerates of the Purslane Formation, which occur in the center of the fold and cap the ridge.

The valleys on either side are underlain by more easily eroded rocks of the Rockwell and Hampshire Formations. This topographic inversion, in which the structural low becomes a topographic high, is also seen at Town Hill, the next major ridge to the west and a structural twin to Sideling Hill. Between these two ridges the intervening lower area is composed predominantly of Devonian age shales and siltstones.



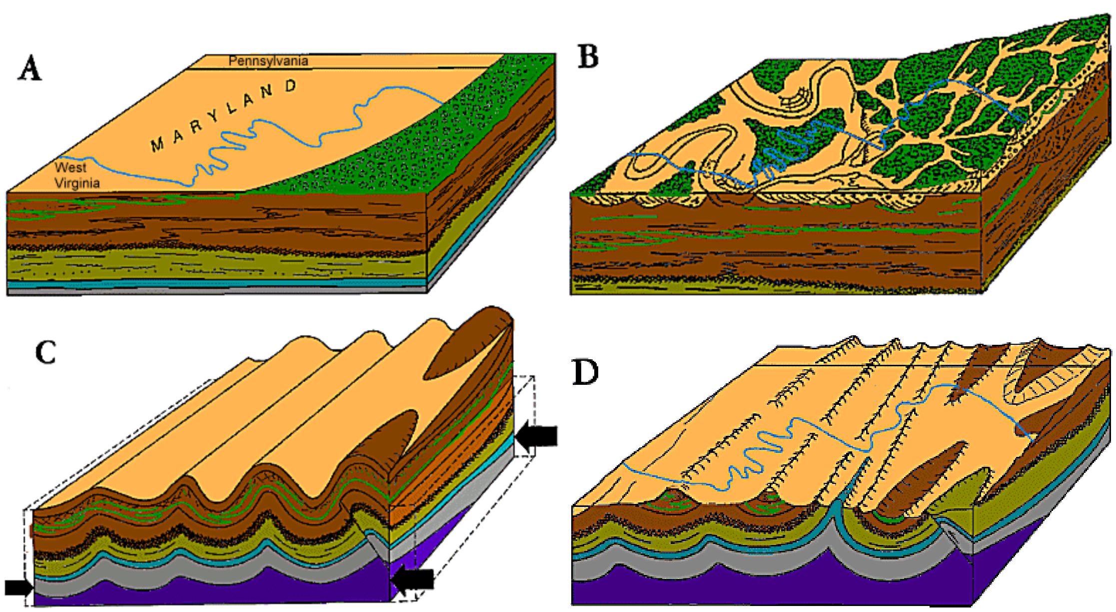
The Rockwell and Purslane Formations were deposited during the early Mississippian, about 330 to 345 million years ago. At the road cut, approximately 450 feet of the Rockwell Formation are exposed and consist of interbedded, tan and gray-green, clay rich sandstones, gray-green to dark-gray, silty shales, and gray to dark-gray, sandy siltstones with several intervals of red-brown claystone near the top. In places, thin shaly coals and coaly shales are interbedded with shales and siltstones. These coals are interesting in that coal is typically not common in Lower Mississippian strata. An even rarer and indeed unusual lithology, termed diamictite, is present approximately 70 feet above the base of the section. A diamictite is a very poorly sorted to unsorted rock composed of clay, silt, sand, and pebbles or cobbles. The larger pebbles and cobbles consist of a multitude of lithologies including granite, graywacke, chert, and quartzite. The origin of such diamictites is highly debatable and no generally accepted theory has yet been proposed.

Fossils are moderately common in the Rockwell Formation, but almost all are plant fragments and imprints. Marine fossils are present within the black silty shale 165 to 178 feet above the lowest exposed strata.

The fossils are generally rare within these intervals and consist of brachiopods and bivalves. A similar marine unit has been recognized in correlative rocks in central Pennsylvania, where it has been termed the Riddlesburg Shale. The Sideling Hill exposure is the first recognition of this zone in Maryland.

The Rockwell Formation in the area of Sideling Hill was probably deposited in an alluvial plain environment near sea-level. The Riddlesburg Shale records a major shift of the shoreline which submerged an area from eastern Ohio to western Maryland.

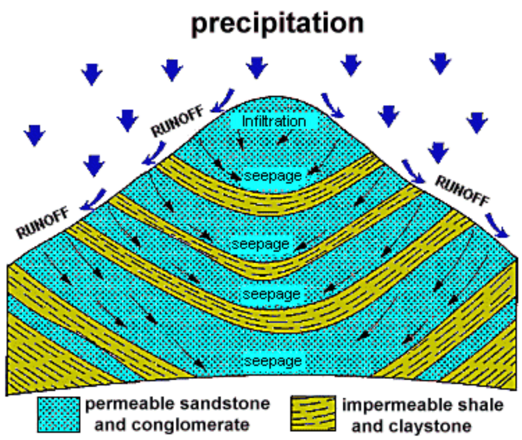
- A. Shallow marine waters and adjacent shoreline swamps of the Riddlesburg sea.
- B. River systems of the Purslane.
- C. Folding during the Alleghenian mountain-building episode.
- D. Post mountain-building erosion to the ridges and valleys seen today.



Overlying the Rockwell Formation is the Purslane Formation, typified by gray-green, tan, and white, cross-bedded sandstones and quartz-pebble conglomerates with interbedded gray siltstones, shales, and coaly shales. Only about 350 feet of the formation occur on

Sideling Hill, the remainder, an unknown thickness, having been removed by erosion. Individual sandstone units range in thickness from 25 to 75 feet.

Near the top of the exposure are 45 feet of dark-gray siltstones and shales in which numerous thin shaly coal beds are present. Analysis of one of these coals shows it to be semianthracite in rank. This same shaly sequence may be observed more closely at the sharp turn in old U.S. 40 (now Scenic 40) as it crosses the crest of Sideling Hill, 1.5 miles south of this road cut. The only fossils found in the Purslane Formation are plant remains common in the lower part of many of the thick sandstone units, and in the upper coaly sequence.



The prominence of thick sandstone units with quartz-pebble conglomerates plus the lack of marine fossils also suggest an alluvial plain environment of deposition for the Purslane Formation in the area of Sideling Hill. The sandstones and conglomerates represent channel deposits of sand and gravel laid down by rivers. The coal beds may have formed in swamps on flood plains adjacent to the fluvial channels.

The Sideling Hill road cut exposes a section through the axis of a tightly folded syncline. A syncline is a fold in which the strata on either side dip inward toward the axis. Such folding resulted from the enormous compressional stresses developed in the Earth's crust by the collision of the North American and African continents. This episode of mountain-building is termed the Alleghenian Orogeny and reached its maximum during the late Permian or early Triassic, approximately 230 to 240 million years ago.

Moreover, these same stresses produced differential slippage between the strong or highly competent sandstones and the weak or less competent carbonaceous siltstones and shales. Such slippage resulted in the development of two types of fractures -- faults and cleavage. Cleavage can form where two competent units (e.g., sandstone) surround a relatively thin incompetent shale. The result is an abundance of small subparallel fractures within the shale. Numerous small faults can be observed in the shaly sequence near the top of the Purslane Formation. Here compressional stresses near the axis of the syncline have caused offsets along fractures in several of the siltstone beds.

During the spring, summer, and fall, water can be observed seeping out from along fractures in the rock along the axis of the syncline. This water has its origin as rain which infiltrates the permeable and porous sandstone and conglomerate, and runs down through the rock until it reaches a barrier such an impermeable layer of clay. When it reaches this barrier it runs down the dip of the beds to the axis of the fold and then is emitted at the exposed rock face (Figure 4). During the winter such places of outflow of water serve as points from which layers of ice originate and grow to cover much of the exposed face.

Suggested Readings:

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Stop 6: Needmore Formation at Timber Ridge Camp, near High View, WV
Senior Lecturer John Merck

The Lower Devonian Needmore Formation overlies the Oriskany sandstone and is overlain by the Early – Middle Devonian Marcellus Shale (stop 3). Its outcrops extend from NY into MD, WV, and VA. It is composed of sediments shed into the Catskill foreland basin from highlands of the Acadian Orogeny forming contemporaneously to the east. The Needmore Formation is composed of argillaceous shallow marine shale deposited in oxic to dysoxic environments.

The “fossil pit” outcrop at Timber Ridge Camp near High View, WV is a hillside cut created during the excavation of a go-cart track. It resembles other Needmore outcrops of the Cacapon River valley in containing fossils indicative of oxygenated environments of the photic-zone, but unlike them, results from recent excavations on private land, and is not especially picked over. It therefore represents an excellent opportunity for familiarization with characteristic fossils of the marine environments surrounding Euramerica, the “Old Red Sandstone continent.”

We will see copious remains of the spiriferid brachiopod *Mucrospirifer*. On previous visits the big task has been to get the *Mucrospirifer* search image in order to be able to look past it, whereupon several other brachiopod genera, crinoid columnals and calyces, trilobite fragments (including Devonian poster-child *Phacops rana*), bivalves, and small coiled cephalopods have often come to light.

Parking: In the grassy parking area to the left of the road just past the entrance to the "fossil pit" track.

Getting there: From Hancock, MD, take Rt 522 south VA State Rt 600. Take this south toward Hayfield and Rt 50. Proceed west on Rt. 50 past Gore VA to Rt. 259. Take this south just barely past High View, WV. Rt. At Christian Church Rd. Left at Hooks Mill Rd., then follow signs to Timber Ridge Camp. This locality is available by reservation only, so please do not attempt to go here without first discussing with John Merck for the appropriate contact information.

Outcrop location: N 39°13'36.90", W 78°27'55.45"

Alternative locality: Access to the Needmore Fm. can be had along Rt 259 at a small quarry 0.2 mi. south of the Village of Capon Lake. While lacking copious *Mucrospirifer*, this site is also fossiliferous.

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Stop 7: Return to College Park, MD Department of Geology