

PHYSIOGRAPHIC DIVISIONS  
OF THE EASTERN UNITED STATES

*N.E.*—New England  
*C.P.*—Coastal Plain  
*P.*—Piedmont

*O.A.*—Older Appalachian Mountains  
*Y.A.*—Younger Appalachian Mountains  
*A.P.*—Allegheny Plateau  
*I.L.*—Interior Lowland

## GEOLOGY AND WARS

### A Neglected Factor in Wars Within the Continental Limits of the United States of America

BRADFORD WILLARD\*

**G**EOLGY has had direct and indirect, active and passive influences in winning (and losing) battles and military campaigns within the continental limits of the United States of America. Why should I, a really peaceful individual, write on such a bellicose subject? First, because I have not always been so pacific, having served with the American Expeditionary Force in France during the old war; and, second, I am by profession a geologist. But, what is this geology?

Perhaps it is years since you attended lectures on the subject, or maybe you are one of the lucky ones who escaped such an ordeal. At least a brief recapitulation may be tolerated. Geology is earth lore, a relatively new science among man's explorations of his environment. Modern geology has been developed during the last two hundred years. Its application to human needs is hardly half so old. Concerned chiefly with the surface of the earth and its outer crust, the geologists leave to the geophysicists and to the seismologists the investigation of what lies deeper. There are many subdivisions or ramifications to earth science. Physiography is concerned with the earth's surface features, their origin and characteristics. Through mineralogy and petrology, respectively, the geologist attempts to understand the composition and origin of minerals and rocks. Fossils, evidence of prehistoric life, come under paleontology. Discoveries of useful mineral deposits are made through economic geology. There are many other less familiar branches of the science.

Long before the science was conceived, the earth's crust was here under our ancestors' feet. Nature functioned then just as it

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does today. Whether man realized it or not, terrestrial forces have always affected him directly or indirectly. The more violent manifestations were often attributed to the will of the gods. The horrors of a city demolished by an earthquake, the awful aspect of a volcanic eruption which snuffed out countless lives, were profoundly impressed upon the minds of those who witnessed these disasters. Yet, some there were who recognized the more deliberate processes of Old Mother Nature. Wasn't Isaiah one of these rare observers, when he wrote, "Every valley shall be exalted and every mountain and hill shall be made low?"

Geology has played its rôle in military campaigns, the outcome of battles, strategy and tactics. Compare the defensible positions of such isolated, mountain folks as the Swiss, the Welsh, and the Vikings, with those Europeans who dwell in lowlands where armies have marched and countermarched for centuries. Nevertheless there are few instances of man's application of earth lore during wars even as late as the nineteenth century. Granted that an army's miners and sappers did operate by certain rules of thumb during military tunneling; the early use of stone cannon balls can hardly be called an example of geology applied to military conquest. Until World War I, the part which applied geology took in military matters was essentially nil. With the outbreak of that war, the science saw active duty on the Western Front, where geologists served as advisors with opposing armies. A far wider application came with the Second World War. The present discussion is confined to the earlier, largely passive or unrecognized influences of geology upon those wars which took place within our country's boundaries, up to and including the Civil War.

During the French and Indian, the Revolution, and the Civil Wars, there was little intelligent or conscious application of earth science, even after it became part of man's technical education. Passive influence of physiography showed up in the lay of the land. That topography was indeed appreciated is axiomatic, but how the land acquired its features was taken for granted. Physiography embraces the distribution of highland and lowland, mountain passes and mountain barriers, river courses whether confined between vertical canyon walls or bordered by open (and perhaps swampy) flood plains. The seacoast comes in for its share of study, as, too, do plains, plateaus, lakes, glaciers and glaciation.

Soils, products mostly of rock disintegration, functioned of old, in transportation of men and supplies and the creation of earth-works. Rocky heights became natural citadels, and stone-built forts were common. Rubble walls or hastily built breastworks figured in defenses. Those along the roads at Lexington and Concord are commemorated in Longfellow's lines:

How the farmers gave them ball for ball,  
From behind each fence and barn yard wall, . . .

Speaking of soils, I recall the words of a veteran of the Army of the Potomac, as he graphically alluded to Virginia's mud. "Fust, when it rained a mite, the ground got sticky and you hefted ten or twelve pounds of mud on each foot. Then, if it rained 's more, and it gen'rally did, the ground jest porridged up and you sank in to your knees or better."

#### THE PHYSIOGRAPHIC SETTING

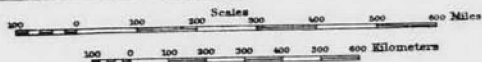
Physiographically, the eastern part of the United States is separable into a number of topographically distinct units. From New York City southward, the COASTAL PLAIN borders the Atlantic Ocean. A region of low relief, it is also one of deeply indented, salt-water estuaries, of meandering, slow-flowing rivers, sandy or clayey soils, here and there a swampy tract. It is a region which could be traversed fairly easily in truly horsepower days. West of the Coastal Plain lies the PIEDMONT. Higher than the Plain, its surface is more rolling, the streams run faster, and bedrock comes oftener to the surface.

The name Appalachian is said to be an Indian expression meaning "endless mountains." So, indeed, might this next physiographic region to the west appear to the foot traveler. The easternmost of these heights (THE OLDER APPALACHIANS of some physiographers), the BLUE RIDGE, is relatively low, rounded-crested mountains worn from granite-like rocks. Far south they reach cloudward in the majesty of the Great Smokies.

West of the Blue Ridge or Older Appalachians, rise the higher YOUNGER APPALACHIANS or the VALLEY AND RIDGE PROVINCE. Shawangunk, Kittatinny, Tuscarora, Bald Eagle, Clinch, and other familiar names designate some of the more prom-

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# UNITED STATES



UNITED STATES  
DEPARTMENT OF THE INTERIOR  
GEOLOGICAL SURVEY

## GEOGRAPHY OF THE EASTERN UNITED STATES

*Note particularly the indented coastline with its bays and estuaries, rivers flowing to the Atlantic, sometimes through mountain ridges, and o'her rivers that run westward across the Allegheny Plateau into the Lowlands as part of the Mississippi System. Here, too, are the Great Lakes and the Hudson-Lake George-Lake Champlain valleys.*

inent ridges. Few of the mountains are over 3,000 feet high. Their straight, even crests may continue as unbroken skylines for miles. But, here and there, as for that matter among the older mountains, too, the ridges are nicked by water gaps where rivers have sawed through them, or by wind gaps, dry valleys which were once river passes but from which those streams have vanished. From the water gaps through the Younger Appalachians, rivers emerge only to cut through the more eastern, lower and older ridges, then wind across the Piedmont and Coastal Plain to tide-water.

Beyond the Appalachian Mountains is the westward-sloping ALLEGHENY PLATEAU, sometimes referred to as the "Allegheny Mountains." Spreading from western New York State to Alabama, the Plateau slopes gently westward to merge into the INTERIOR LOWLANDS. The Monongahela, the Allegheny, the Kentucky and the Cumberland, the Clinch and the Tennessee Rivers, to cite several, cross the plateau in entrenched valleys.

The Younger Appalachians extend up toward the west side of the valleys of the Hudson River, Lake George and Lake Champlain, which in turn open into the St. Lawrence Valley and eastern Canada. These sequential valleys of the Hudson, Lake George, and Lake Champlain, set New England off from the other states. The topography of New England is obviously unlike the states beyond the Hudson. New England has next to no Coastal Plain or Piedmont; the terrain tends to be hilly or mountainous. The surface may rise from the coast inland to merge into mountains. Most New England mountains lack the long, even-crested ridges so dominant in the Appalachians proper. Contrast these lineally wrinkled Younger Appalachians with the more or less haphazard distribution of the White Mountains. Furthermore, the New England mountains show a dearth of those gaps which figure so strikingly in the more southern states.

#### THE EUROPEANS INVADE

By the middle of the eighteenth century, English colonies sprawled along the eastern seaboard. Nearly all of the larger towns were coastal—at river mouths, on estuaries or bays—obviously so distributed because of greater safety from Indian attacks in earlier

days, and for ready access by ships from the old country. Inland, there were smaller settlements, scattered farms and homesteads. To these the Indian menace was still terribly real.

Beyond the mountains? There was a land known to few, but among those few were Frenchmen who had been pushing in along the low-level route of the St. Lawrence Valley, the Great Lakes, and the Mississippi even to that river's mouth. The British, with a few outstanding exceptions, stayed east of the mountain fastness.

Daniel Boone and James Harrod reached "Kentuck," and the Cumberland River Basin became known. River valleys offered ingress. Other restless members of the population left the seaboard and penetrated the great, longitudinal valleys among the Appalachians. Frontiersmen from Pennsylvania found their way up the Shenandoah Valley and so into the valleys of the Watauga, the Holston, and the French Broad Rivers. From North Carolina some crossed the Great Smokies. James Robertson and those to follow or precede him had, by 1770, established the Wilderness Road, a trail blazed by Boone, by way of Cumberland Gap to the future sites of Lexington, Harrodsburg, and other Kentucky towns. Governor William Burnet of New York founded Fort Oswego in 1728 to protect the thin stream of migrants which trickled into the Mohawk Valley and "upper New York."

In 1699 the French built a fort at a place they called Detroit, meaning the strait. This strong point controlled the passage from Lake Erie into Lake Huron and helped to hold the line between Canada and the Mississippi Valley. Fort Detroit was a door bolted against British expansion northwestward. The French modestly claimed the territory from the Appalachians to the Rockies and from the Gulf of Mexico to the North Pole. They established a military grip on the St. Lawrence Valley, the Great Lakes, and the Mississippi.

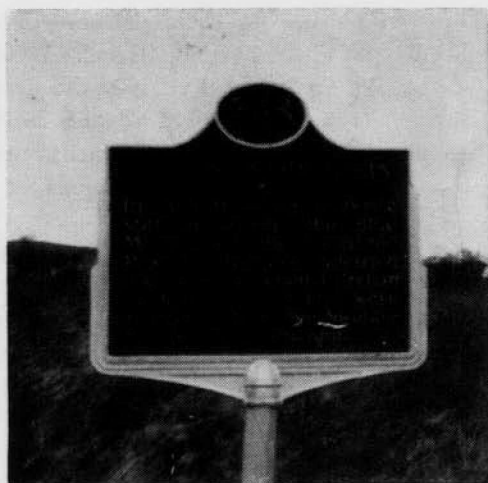
#### THE FRENCH AND INDIAN WAR

Despite the mountain barrier separating them, war between the French and English was inevitable. With the French in possession of such strong points as Detroit and Fort Duquesne (today's Pittsburgh), westward expansion by the English was curtailed. The British campaign against the French in the Maritime Prov-

inces does not concern us geologically. The campaign for the control of the Hudson-Lake George-Lake Champlain artery does. This route stabbed north at the heart of French Canada, and, conversely, pointed south to the midland vitals of the British colonies. Along these three valleys armies might advance without detour, while armed vessels sailed the lakes. The French came down from Fort Frédéric (Crown Point) on the west side of Lake Champlain. Montcalm in 1757 marched against Fort William Henry which guarded the carrying place from Lake George to the Hudson. The following year, General James Abercromby undertook a retaliatory move up the lakes. He failed to take Fort Carillon at Ticonderoga, whose walls lowered over the portage from Lake Champlain to Lake George, but Jeffrey Amherst accomplished the task in 1759. The French withdrew before him and abandoned Isle aux Noix to the English arms. Amherst moved to Crown Point, which also capitulated so that he was free to continue north. The Hudson-Lake George-Lake Champlain route was won by the British, and the bisection of their colonies circumvented.

There were other less spectacular activities influenced by the physiography. George Washington had been up the Allegheny Valley in 1753 and made contact with the French at their headquarters at Fort LeBoeuf in northwestern Pennsylvania. Washington the next summer surprised Jumonville and a French scouting party off the Monongahela River in southwestern Pennsylvania and defeated them at a rocky cliff under which they were camped. In 1755, Braddock marched west across Pennsylvania to try to dislodge the French from Fort Duquesne at the forks of the Ohio. The troops cut through the wilderness, taking some advantage of hill gaps. Parenthetically, Braddock had been supplied with Lewis Evans's map of Pennsylvania, New York, New Jersey and Delaware. Good as this map is, it shows little detail which could have advantaged Braddock. After entering the Monongahela watershed, the British were soundly whipped by the enemy among the rocky cliffs of that valley. Later, in 1758, General John Forbes moved against the French at Duquesne, took the fort, and unlocked the Ohio Valley. Forbes established a road through the gaps, in part past Fort Bedford along the Raystown Branch of the Juniata River and so westward to the "Great Crossing" of the Youghiogeny River (cf. James Burd, *post*).





*Marker near Indiantown Gap, Pennsylvania, commemorating the string of forts or blockhouses established during the French and Indian War to protect the settlers from Indian raids.*



*"Indian Fort." A French and Indian War blockhouse still standing in northern Berks County, Pennsylvania.*

After Braddock's defeat the Indian allies of the French raided the British colonies east of the Appa'achians. The water and wind gaps through those mountains marked defiles long known to the savages, who had threaded them on foot or passed through the water gaps by canoe. It was a relatively simple matter for the red men to sneak in upon the settlers. Largely at the instigation of Benjamin Franklin, a string of forts or blockhouses was built to defend the gaps across Pennsylvania. The forts kept the Indians bottled up behind the ridges. Fort Augusta at the forks of the Susquehanna (today's Sunbury) was an advanced outpost. The Delaware Water Gap was defended by two forts near the present Stroudsburg north of the Gap. There were raids into Berks County north of Reading, by way of the gap of the Schuylkill, where Fort Franklin was erected in 1756. Gaps east thereof were defended. Tweed's Blockhouse protected the Wind Gap, and at Smith's Gap, Peter Doll's Fort stood sentry. The Lehigh Valley was watched over by a blockhouse south of the Lehigh Water Gap, and by fortifications to the north where Weissport now stands. Some forty years ago, there was pointed out to me what purported to be the remains of a blockhouse on Hokendauqua Creek below the Lehigh Gap. At Weissport, the Gnadenhütten massacre in 1755 had hurried the erection of Fort Allen in 1756. There were still other blockhouses, as on Swatara Creek west of the Schuylkill. Fort Hunter above Harrisburg guarded the Susquehanna approach. Still farther west were Fort Shirley, 1755, near Shirleysburg on Aughwick Creek, Huntingdon County, and McAlvey's Fort on Standing Stone Creek. Fort Littleton is remembered in the present village of that name.

One other topographically influenced incident of the French and Indian War is worth mentioning because it was off the beaten track. Old Fort No. 4 at Charlestown, New Hampshire, saw action in the summer of 1746 and later. Because this fort was in the valley of the Connecticut River, it had a somewhat analogous defensive position to those of the Pennsylvania blockhouses opposite the mountain gaps.

So, during the French and Indian hostilities, physiography was functional as a passive influence. The thoroughway up the Hudson was the locale of an offensive war by the British against the French.

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The water and wind gap country to the southwest was the theatre of defensive engagements by the British settlers against the Indians.

### THE AMERICAN REVOLUTION

Prior to or during the American Revolution, several "roads" or "paths" were established from the seaboard across the mountains. The Connecticut Path from Boston to Albany via Hartford is not particularly significant topographically. The Cumberland Road from southeastern Pennsylvania gave access to Ohio, while the Wilderness Road from the Virginia-Tennessee line led northward into Kentucky. There were other, shorter "paths" or "trails," some of Indian origin, some established by the whites either for military maneuvers or for peaceful migrations. The routes showed considerable selectivity. Wherever possible they utilized the hill gaps or followed transmontane valleys. Again, Lewis Evans's map perhaps served handily. Colonel James Burd in 1755 originated a path from the subsequent site of Fort Loudon, on Conococheague Creek in Franklin County, Pennsylvania, west to Turkey Foot in Somerset County, passing through Raystown (later Bedford). In this route he anticipated Forbes (cf. *ante*). Part of this old road, by the way, was incorporated into the Lincoln Highway.

At the time of the Revolution, the red menace was much abated. Most of the country east of the Appalachians was settled. Population was slowly growing. That the Indian threat was not entirely eradicated is witnessed by the Wyoming massacre of July 3, 1778, in northeastern Pennsylvania. This inroad was engineered by the British under John Butler and originated from Fort Niagara, New York. With Indian allies, Butler slipped down the open valley of the canoe-navigable Susquehanna and attacked the settlers about five miles northeast of the present city of Wilkes-Barre. Some survivors fled for safety to the settlements along the Delaware and Lehigh Valleys, while others, less fortunate, entered a nearby gap and perished. This dismal place has ever since been known as "the shades of death." The Wyoming Massacre touched off General John Sullivan's retaliatory expedition the following year, 1779. This raid into New York essentially ended further embarrassment from the Indians of that quarter. After assembling



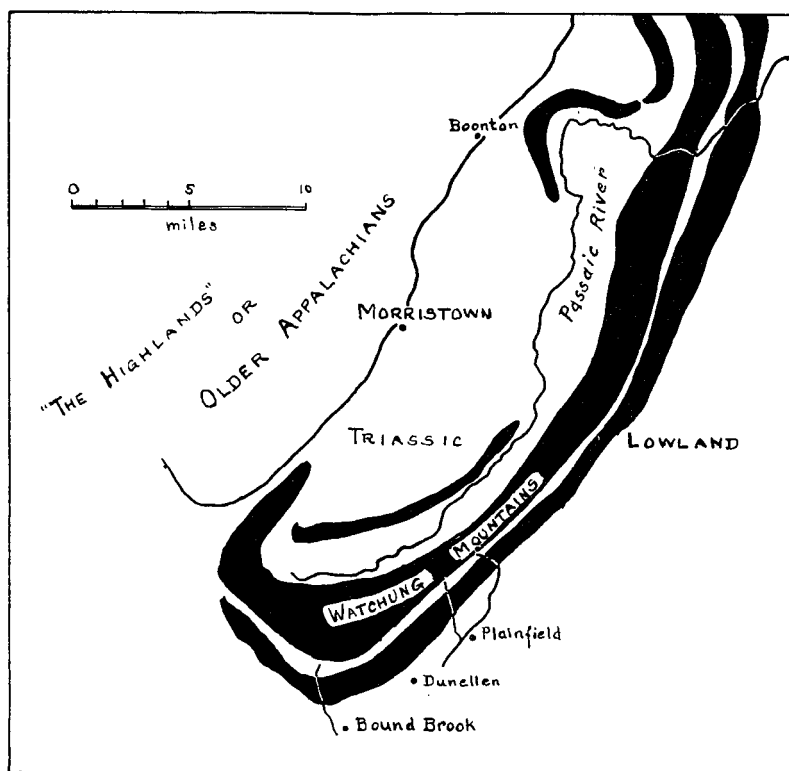
*The Wind Gap, Kittatinny Mountain, Northampton County, Pennsylvania. Through this gap General Sullivan marched on his expedition against the British and their Indian allies in New York, 1779.*

troops at Easton, Pennsylvania, Sullivan led them north through *The Wind Gap* in Kittatinny Mountain. Thence the army entered more open country and climbed over the Pocono Plateau (please, not "Pocono Mountains"; this feature is an outlier of the Allegheny Plateau farther west), to Fort Wyoming (Wilkes-Barre) and so up the North Branch of the Susquehanna into New York. Sullivan in part reversed the line of advance of Butler's men, and routed the British at Newtown, near present Elmira. While Sullivan was attacking, a smaller force under Colonel Daniel Brodhead moved up the Allegheny Valley in northwestern Pennsylvania toward southwestern New York.

Repeatedly during the Revolution, the British assayed to divide the colonies along the Hudson-Lake George-Lake Champlain line. Rival armies backed by fleets fought to control the lakes. General Guy Carleton dropped down from Canada in 1776 and approached Ticonderoga, only to be delayed so much by Benedict Arnold in the naval battle off Valcour Island that he could accomplish nothing that year. General John Burgoyne in 1777 occupied Ticonderoga, but subsequently surrendered at Saratoga.

Where Washington Irving's "lordly Hudson" breaks through its ancient highland barrier toward the sea there stood fortified West Point. Its military occupancy meant command of the

navigable river. In 1780 Benedict Arnold commanded West Point. Recall that it was the planned surrender of West Point that figured so largely in Arnold's treason and the hanging of Major John André. The Patriots kept their grip on the mid-Hudson Valley.



*Map of a part of north central New Jersey, showing the strategic and defensible position of Morristown.*

When Washington went into winter quarters at Morristown, New Jersey, in 1777 and again in 1779-1780, he selected an easily defended retreat, and at the same time one from which he could menace the British in New York City and northern New Jersey. Look for a moment at the topography. The normal character of the Piedmont is interrupted by a northeast trending strip of low country floored by red sandstone and shale. This is the geologist's Triassic Lowland, named for those red rocks which were formed during the Triassic Period of earth history when the dinosaurs

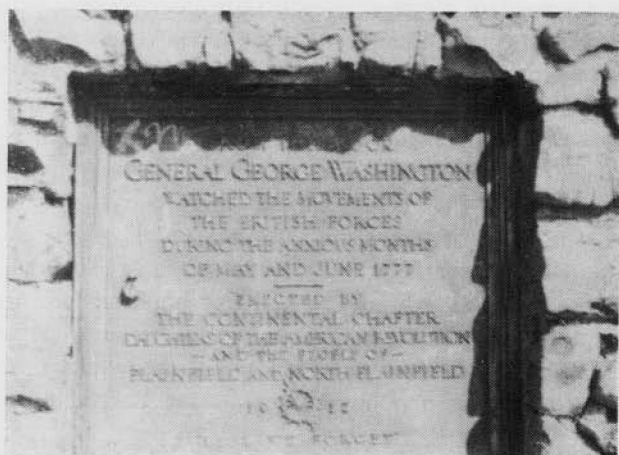
were commencing to take over as lords of creation. The Lowland extends from New York to North Carolina. We shall meet this feature again because it figured in the Civil War.

The topographic monotony of the Triassic Lowland is relieved by small mountains. In New Jersey some of these form the eastward bowing Watchungs. The ridges are composed of the so-called "trap rock" (basalt or diabase). This was forced up when in a molten state through other rocks and there cooled and solidified. Because the trap is so resistant to wear, the ridges have been etched out by differential erosion from the less resistant, adjacent sandstones and shales. Rising only a few hundred feet, the Watchungs have steep eastward faces and gentle western slopes. They are breached by small water gaps along the Passaic River, at Chimney Rock west of Bound Brook, near Plainfield, and at a few other places.

Washington's choice of winter quarters at Morristown behind those natural redouts was a stroke of genius. It is perhaps worthy of speculation whether or not he had access to Lewis Evans's map which first appeared about 1749, was revised by Thomas Pownall near the beginning of the Revolution, and shows the lay of the land in the Morristown section. Although a strong British force under Sir William Howe lay to the east, no serious attack was implemented against the Patriots. The King's men could conceivably have advanced on Morristown by a route south of the Highlands of the Hudson along the Ramapo "Clove" (i.e. valley) and attacked the camp by bypassing the north end of the Watchung Mountains. But Howe did nothing of the sort. The steep-fronted ridges were too forbidding for direct assault, particularly in winter, and the narrow gaps could be easily defended by small Patriot forces.

Some of the ridges were high enough to afford vantage points for observing the movements of the Redcoats. One of these observation posts is commemorated in Washington Rock State Park at the crest of the First Watchung Mountain above Dunellen. The place was little known in my boyhood, when I often visited it. From it one could then see, before the building of the New York skyscrapers, the piers of Brooklyn Bridge and the spire of Trinity Church in the city.

Bowman's Hill is an inconspicuous, east-west trending trap-



*Washington Rock, at the crest of First Watchung Mountain west from Dunellen, New Jersey. From this vantage point, General Washington is said to have observed the movements of the British. The area is now a state park.*

rock ridge which rises some 300 feet above the Delaware River on the Pennsylvania side, twelve miles north from Trenton, New Jersey. Washington's troops encamped directly north of this hill and on the west bank of the river in the early winter of 1776. The situation was strategically ideal. The hill was a rampart to the south; the river protected the camp on the east. From the summit of Bowman's Hill it was possible to watch Colonel Johann Rall and his Hessians who occupied Trenton. Probably, the Hessians considered themselves safe beyond the river, but the Patriot army proved the assumption false when at Christmas Gloucester fishermen ferried Washington and his men across the Delaware for their surprise march on the unprepared German mercenaries.

As in the French and Indian conflict, likewise during the War for Independence, physiography was influential. Topography played its rôle, and, at least in the Watchung Mountains of New Jersey, the bedrock indirectly moulded military strategy. To be sure, there were other instances of geologic effects during the Revolution. But enough has been cited to demonstrate the influence of earth features during the War.

The War of 1812 is unimportant to my thesis. What land operations there were, were mostly in areas of minor relief, as for example, at the Battle of New Orleans. The Mexican War was extraterritorial, and so for that matter was the Spanish-American War a half century later.

#### THE CIVIL WAR

By the flow of the inland river,  
Whence the fleets of iron have fled,  
Where the blades of the grave-grass quiver,  
Asleep are the ranks of the dead :—

Much of the Civil War was a naval war fought on those "island rivers." Here the characteristics of the streams and of their valleys were vital. Though subject to both floods and low water stages, many of the rivers of the Mississippi system are at least seasonally navigable; witness the gunboats paddling up the Cumberland River. Steam navigation had matured; troops and ironclads could coöperate closely. One recalls other topographic influences. There was General Joseph Hooker scaling Lookout Mountain. Vicksburg



was besieged where it perched on its 250-foot bluff above a sharp bend in the Mississippi. The troops invested the city from the land; Yankee ships pounded it from the river. The Army of the Potomac and the Army of Northern Virginia sloshed across the lowlands of the Wilderness, while contending horsemen ranged the valleys and broke through the gaps of the Appalachians to the west.

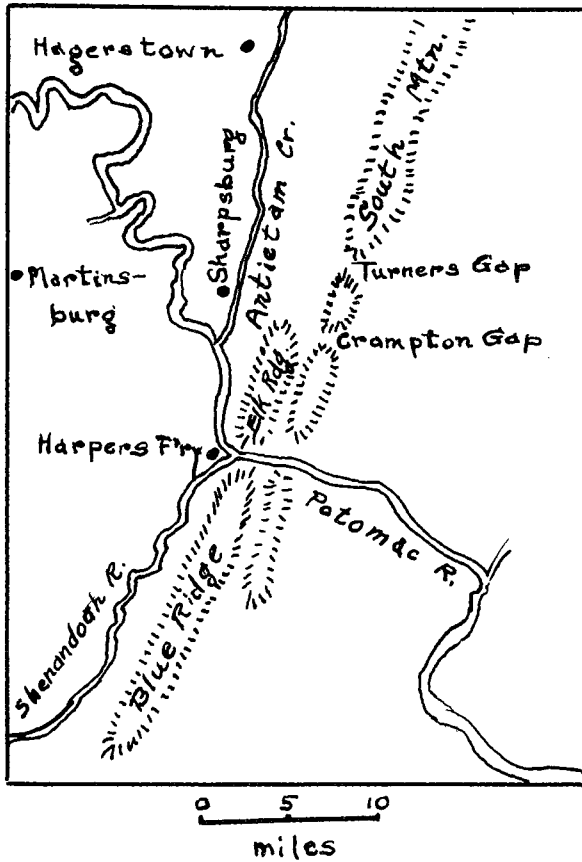
On that pleasant morn in the early fall  
When Lee marched over the mountain-wall,

Over the mountains winding down,  
Horse and foot into Frederick town.

The Appalachian Mountains' longitudinal valleys figured large both strategically and tactically. Because of the north and south distribution of the armies in the East, the mountains no longer functioned so much as barriers as they had in the older wars. Rather, their valleys funneled invading Southern cavalry and foot soldiers into Maryland and Pennsylvania. From the antebellum days of John Brown's escapade at Harpers Ferry, the mountains echoed to intermittent gunfire. "Stonewall" Jackson's 1862 activities in the Shenandoah and his threat at Washington are well remembered. Conversely, Yankee cavalry raided south along these several intermontane troughs. Here General Philip Sheridan in 1864 administered punishment on the inhabitants and feuded with General Jubal Early.

Confederate bands again and again tore up the Baltimore and Ohio tracks where its trains puffed along the Potomac Valley as that river threads its way through a succession of water gaps. The Baltimore and Ohio main line through Harpers Ferry, Cumberland, and Wheeling was a tempting bait. The Rebels at one time or another are said to have controlled as much as a hundred miles of its tracks. They carted off rolling stock and disrupted troop movements and rail traffic in livestock, coal, lumber, flour, and other staples from the West to Baltimore and Washington. Although the Chesapeake Canal had passed its heyday, it was still of some military value as it, too, followed the Potomac Valley.

Harpers Ferry marks a prominent water gap which was probably the most strategic place in the whole Potomac Valley. It is

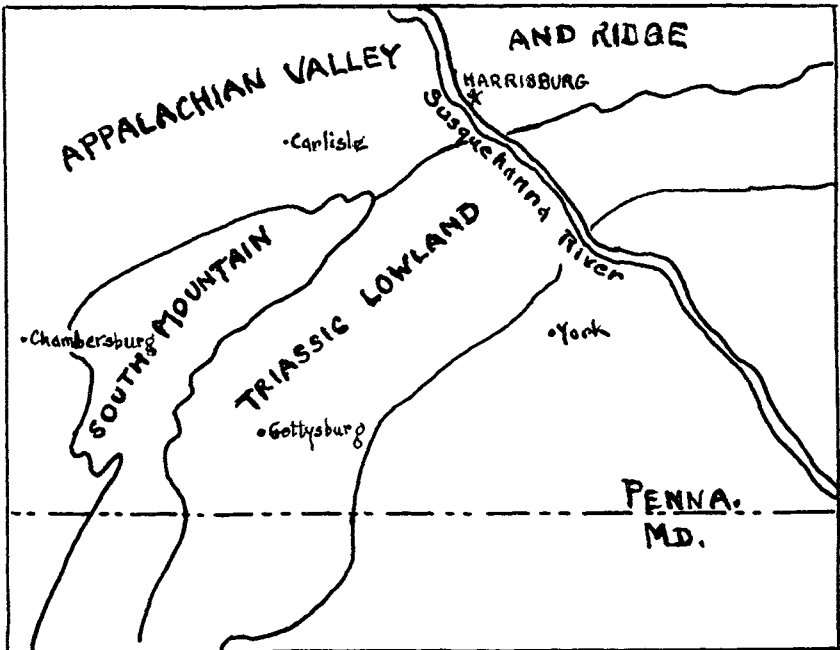


*Sketch map of vicinity of Harpers Ferry and Antietam Battlefield.*

only twenty miles from Frederick, Maryland, fifteen from Martinsburg, West Virginia. Antietam Creek joins the Potomac about ten miles northward from Harpers Ferry. In the fall of '62, Jackson attacked Harpers Ferry and cut the rail line while Lee marched north beyond Jackson's left to Hagerstown. Antietam battlefield is at Sharpsburg, between the Potomac River on the west and Antietam Creek on the east. East of the battlefield is Elk Ridge, a northern spur of the Blue Ridge which rises south of the Potomac. South Mountain, next east of Elk, is breached by Turner's and Crampton's Gaps. The Confederates in their northward thrust had advanced as far as Hagerstown. Union men came on from the east and poured through the gaps. Access to "Bloody"

Antietam was largely influenced, if not controlled by stream distribution, mountain ridges, and mountain gaps.

In the final year of the war, Sherman moved from Chattanooga to Atlanta past Kennesaw Mountain. Passes in the subdued southernmost Appalachians influenced the line of march. But of all the military operations of the Civil War in which geology helped win or lose a campaign, there is none to parallel Gettysburg. That campaign of June and July, 1863, transcends all others. Not only was physiography influential, but there is evidence that geology as an applied science may have been used by those who had the "know how." Not that any geologist on either side, insofar as I am aware, has been shown to have officially advised the military. Does it not seem odd that Joseph LeConte, who was chemist for the Confederacy and subsequently became professor of geology at the University of California, appears to have proffered no advice? No doubt there are other instances as baffling, but, on to Gettysburg!



*Sketch map of south central Pennsylvania showing the position of Gettysburg, Harrisburg, and other pertinent features.*

Look for a moment at a map of south central Pennsylvania. Mark how the Younger Appalachians come a great quarter circle from the Susquehanna River above Harrisburg, west, southwest, then south into Maryland. Near the center of this arc is a north-northeast pointing finger of the Older Appalachians known as South Mountain. East of this prong lies Gettysburg. Recall what was said about the Triassic Lowland and the advantages its topography offered the Patriot army in northern New Jersey during the Revolution. North of Trenton that same band of Triassic terrain crosses the Delaware River into Pennsylvania, then curves southward, more or less concentric to the bow of the mountains. Gettysburg sits squarely within this depression. Here and there in Pennsylvania as in New Jersey, the lowland is interrupted by small trap-rock ridges. This rock may break down into lines and patches of loose boulders. The soil on the ridges is often stony, and so infertile or difficult to farm that it may be left in woods.

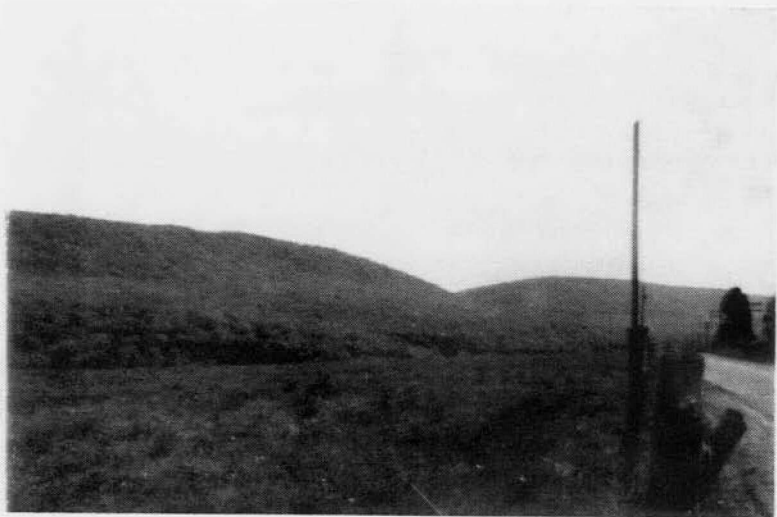
The even crest-line of Kittatinny Mountain, the front range of the Younger Appalachians, is broken by the water gap of the Susquehanna River north of Harrisburg. West thereof all the way to the Potomac on the Virginia-Maryland boundary, the mountain is notched only by a few relatively shallow wind gaps. Among these, Sterrett's, northward from Gettysburg, figured in the campaign.

In the eighteenth century John Harris established a ferry across the Susquehanna below the gap and so gave his name to the future capital of the Commonwealth. The ferry was a monopoly during high water, but when a long, dry summer dragged out, the shrivelled river was fordable and John twiddled his thumbs. There is a story of years ago about a visitor who asked one of the local people if the river was navigable. "Navigable, lady?. Say, half the year the biggest steamboats in the world can come a-woopin' and a roarin' up here, and the other half of the year, a long-legged rooster can walk across without wettin' his tail feathers." Such was truly the situation a century ago before dam construction raised the river level. Even so, during the "dry summers" of the early 1930's, one could *almost* wade the river.

By 1860 Harrisburg had become a rail center. Trains pulled out north, south, east, and west from the state capital. Less than



*Susquehanna Water Gap north of Harrisburg. The present stone arch bridge of the Pennsylvania Railroad replaced the older one of Civil War days.*



*Sterrett's Gap (a wind gap) from the south. This was truly the "high water mark of the Confederacy."*

a decade earlier, the Pennsylvania Railroad had been completed north and west up the valley of the Juniata River, which joins the Susquehanna from the west some fifteen miles north of Harrisburg, and over the Allegheny "Front" (the rim of the Plateau), into Pittsburgh. The same railroad extended east from Harrisburg to Philadelphia. The Cumberland Valley Railroad ran west, and the Northern Central drove south to Baltimore and, to the north, tied Harrisburg in with the Susquehanna River towns above the confluence with the Juniata. The Philadelphia and Erie Railroad met the Northern Central at Sunbury and continued north and northwest as an important link. Except for the Cumberland Valley line, the tracks of all these roads followed routes that were topographically convenient. They were the same routes which had been picked by the railroads' predecessors, the canals, which in turn followed the old trails of the white settlers and even earlier Indians, in canoe or on foot, along the river valleys.

During the Civil War the Pennsylvania Railroad was one of the three major east-west ironbound life lines of the Union. I say one of the three advisedly. The New York Central and Hudson River Railroads formed a second, and the none-too-dependable Erie of Daniel Drew the third. The Baltimore and Ohio was quite unreliable because, as already hinted, the "Johnny Rebs" had an embarrassing habit of disrupting train schedules between Baltimore, Washington, and points west.

All of these items of course were known to the Confederates—the fordability of the Susquehanna in summer, the lay of the land across south central Pennsylvania, the Appalachian Mountain barrier and its gaps, and the railways converging at Harrisburg. If the river could be forded (presuming that the Federals had destroyed the bridges) and the rail lines cut, what a splendid prospect would unfold to strike Philadelphia, Baltimore, and Washington from the rear!

In June, 1863, General Lee had crossed the Potomac and was on the move into Pennsylvania. The Gettysburg campaign was afoot. For the time, Confederate progress northward was little impeded. On the eve of the battle, a small force of Confederates actually penetrated as far north as Sterrett's Gap about twelve miles west of the Capitol at Harrisburg. Finding the pass strongly defended, the detachment withdrew southward to join the main



*Sterrett's Gap. The Pennsylvania highway marker is approximately at the point held by Federal troops on eve of Gettysburg. The "Blue Mountain" of the marker is incorrect or rather o'd-fashioned; it should read Kiltatinny Mountain.*



*Marker at Sterrett's Gap commemorating its part in the Gettysburg Campaign.*

army. This gap, not Bloody Angle at Gettysburg, might better be called "the High Water Mark of the Confederacy," because it is the farthest north reached by an organized body of Confederate troops (though John Morgan's irregulars penetrated farther north in their raid into Ohio).

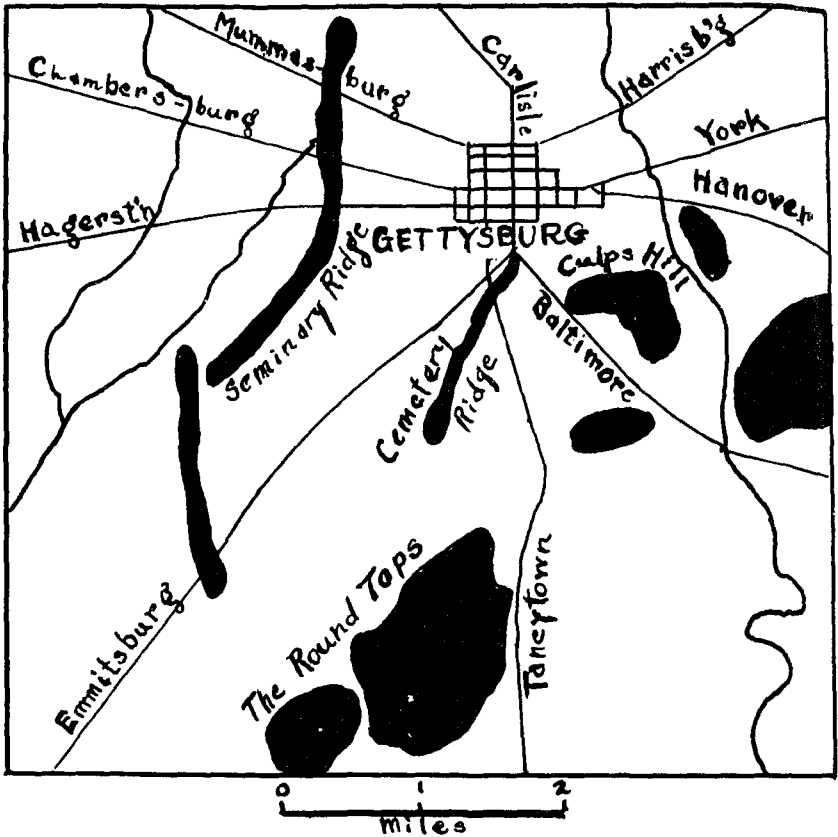
What consternation the Rebel advance caused in threatened Harrisburg! The hill across the river from the city owes its existence to underlying resistant rocks which overlook a low, limestone floored valley on the south. The height was fortified in anticipation of an attack. One can still trace some of the old earthworks on the hill.

Now, Lee was over the Potomac. His deployed army advanced in a crescent from Chambersburg to Carlisle and York and menaced Harrisburg. General George G. Meade's Union army had also crossed the Potomac and was marching from the east or southeast in a belated attempt to head off Lee. Indeed, the advance of the Northern troops promised at first to isolate the invaders by cutting in south of them. Lee turned back, and the two armies converged on Gettysburg. Recitation of these eve-of-battle details may seem superfluous, until one looks at the terrain, the significance of troop movements, and the positions assumed by the two armies with relation to the physiography

Running nearly north-south to the south and southeast of Gettysburg is a series of small trap heights which includes Culp's Hill, Cemetery Ridge with Cemetery Hill, and Big and Little Round Tops. West of the town, a less prominent ridge partly of the same and partly carved from other resistant rock, runs nearly parallel to the first line of hills. This is Seminary Ridge. As the lines of battle resolved themselves, the Union army held the eastern heights, the Confederates those to the west. Between the ridges lay a mile or so of low-lying farm land, in part known as the Peach Orchard and the Wheatfield. The measured relief or difference in elevation between the cultivated fields and the hills held by the Union line is not great, but it was enough to be reckoned with, nonetheless. On the more precipitous heights, particularly the Round Tops, loose boulders of trap lay conveniently for construction of breastworks. That the boulders were used is demonstrated in wartime photographs. These same photo-

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*Sketch map of Gettysburg neighborhood. Ridges and hills supported by trap or other resistant rock shown in solid black.*

graphs substantiate the point already mentioned, that the ridges tended to be tree-covered. They are little changed today.

Pickett's charge started eastward from Seminary Ridge. The troops gained momentum as they advanced into the lower terrain, then started *up hill* against Federal artillery and small arms fire. Whoever has endured the heat of a south central Pennsylvania summer will appreciate what even a little hill climbing under favorable conditions may mean. Imagine what it was at Gettysburg that July day! Pickett's charge failed, but one may speculate that, had the ground been level, it might have succeeded. The ground was not level; geology had contributed indirectly to the Confederates' loss of the campaign.



*As in '63, so today, boulders strew the top of Little Round Top at Gettysburg.*

On the day preceding Pickett's Charge, July 2, the Confederate General Hood seems to have had an eye on the steep, rocky Round Tops which together are higher than Cemetery Ridge and in line therewith. With the Union army was General G. K. Warren, experienced topographer trained in long service in the New West. He was Meade's chief engineer. Warren at once sized up the topographic situation and the danger to the Union lines, should the Round Tops fall to Hood. With a hastily commandeered contingent from the V Corps, Warren occupied Little Round Top. Had he not done so, and had the Rebels taken the Round Tops, the invaders would have been able to inflict an enfilading fire to rake the Union lines to the north on Cemetery Ridge.

One geological enigma at Gettysburg is unsolved, and so far as my researches have carried me, remains an interrogation point. By mid-nineteenth century, the science of geology was fast expanding in North America. The excitement of the era of exploration of our West, especially the search for mineral deposits sparked by the California gold rush, swept the land. New and growing industry cried out for coal and iron. In 1859, "Colonel" Edwin Drake drilled the reputedly first successful oil well in North America—the famous boring at Titusville, Pennsylvania. Several



*General Warren still stands watch on Little Round Top.*

of the states authorized official geologic surveys. Among them, Pennsylvania pioneered. Because of this early foresight, the Commonwealth printed in 1858 a voluminous report on the geology of the state. It was accompanied by a large, accurate, colored geologic map. The report and map had been prepared under the authorship of Henry D. Rogers, Pennsylvania's first State Geologist. Copies of the map could have been in the hands of the Union officers—Warren would have understood and used it. One may offer a like speculation about the Confederates. Truly coincidental, it so happened that Rogers's own brother, William B. Rogers, had been State Geologist of Virginia before the war. He left Richmond about 1853, never to return officially, and be-

came the first president of the Massachusetts Institute of Technology. Whether he had an immediate successor in office in Virginia is not clear. Nevertheless, copies of Henry Rogers's report and map could have been on file in the Confederate Capitol or at the University of Virginia where William Rogers had taught. Reading and correspondence have turned up no confirmation that they were. Yet, it can be surmised that if either or both sides had access to the Rogers map, still more if men on either side knew how to interpret it, the publication showed so much about geology at and near Gettysburg that it should have been extraordinarily helpful to the military.

Today we speak of military geology. The terms bacterial warfare and chemical warfare are also familiar in modern parlance. In fact, one might be tempted to deduce that our "military men" are fast emulating W. S. Gilbert's Major General Stanley, "the very model of a modern major general," who knew all manner of things other than those pertaining to soldiering. Of course, these remarks are facetious. Modern war requires the application of science to the utmost.

Applied geology is no exception. It has joined the other sciences in its contributions to winning twentieth-century wars. During the First World War a few geologists were commissioned and active professionally with the American Expeditionary Force on the Western Front. The numbers and the assignments of geologists in World War II multiplied many fold over the previous conflict. They interpreted maps and aerial photographs, reported on bedrock and soil conditions, and carried out other tasks which helped the Allies to a successful finish. What a contrast from those earlier wars when the topography was taken for granted and the rocks, except for defense building, were largely ignored as such.