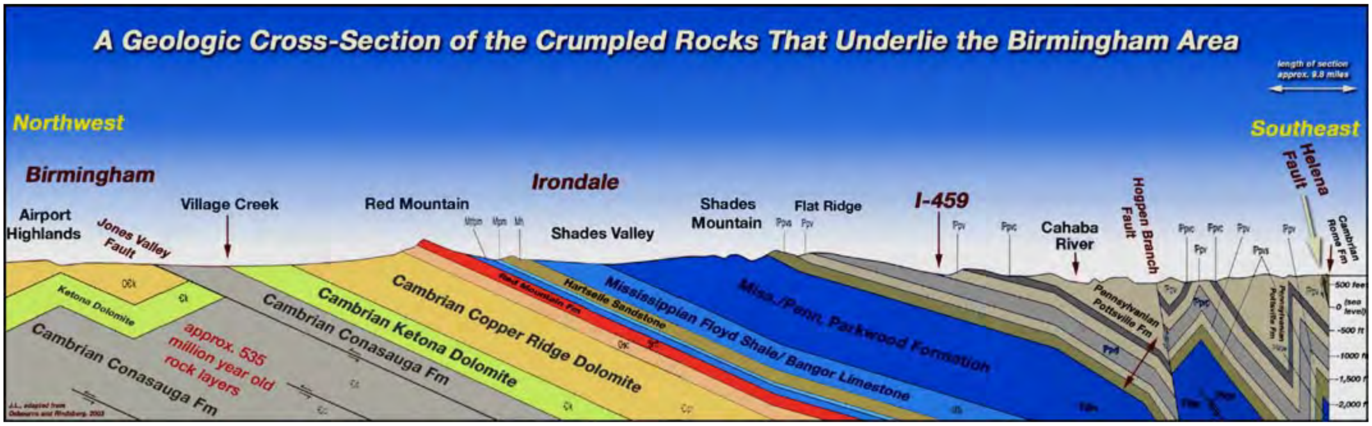


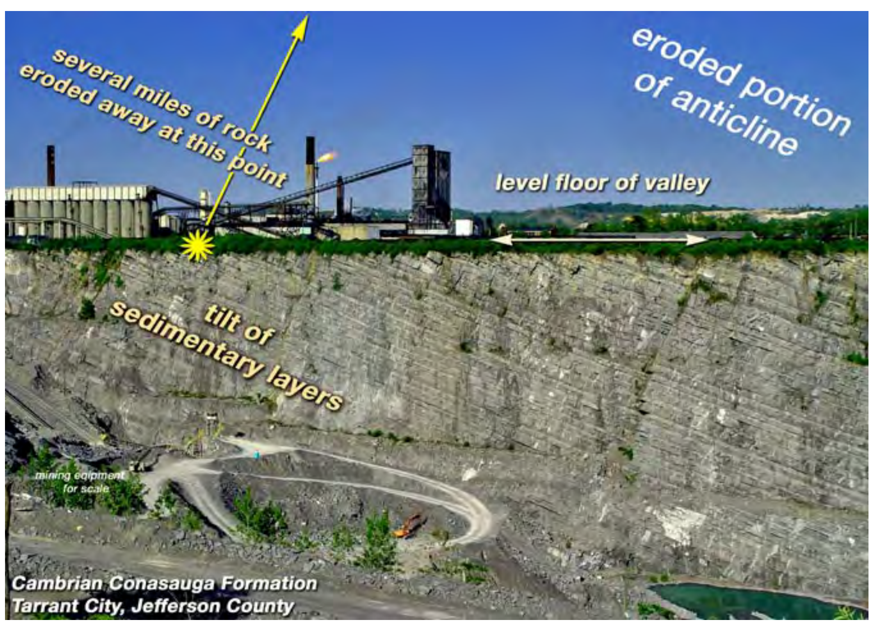
Tortured Rocks Beneath the Birmingham Area With Clues to an Ancient Upheaval

A drive across the Birmingham metropolitan area gives little sense of the remarkable geology that lies just beneath the surface of the land here. Under this otherwise ordinary urban landscape lie rocks that have been crushed, distorted, and torn asunder by immense geologic forces of the distant past. This is one of the best places in the state to get a sense of the incredible damage incurred by ancient Alabama as part of the continental collision with Africa that took place near the end of Paleozoic times.

The Geological Survey of Alabama has recently published a series of geological maps that illustrate beautifully the warped and convoluted stratigraphy of this part of the state. These maps were developed to assist in urban planning and other land-use decisions, but the information in them serves other purposes as well. Geological maps of the Birmingham area offer many spectacular examples of how the sedimentary rocks that sit beneath this part of the state were shoved, squeezed, tilted, and displaced as the Appalachians were being formed.

The diagram at the top of the page depicts a cross section of the rock layers that lie along an imaginary line that **transects** *(or crosses)* a part of the Valley and Ridge province from a point in downtown Birmingham to just north of Lake Purdy, the municipal water reservoir located about ten miles to the southeast. This geologic cross section of the area referred to as the **Irondale Quadrangle** illustrates the tremendous uplift and tilting these once-horizontal sedimentary rocks have undergone. Indirectly, the diagram also offers a sense of the huge volume of land that has been removed here by erosion since Appalachian mountain-building was at its peak. The approximately 9.8 mile geologic cross section follows roughly the route of Interstate 20 from near the Birmingham Airport, across Red Mountain into the city of Irondale, then continues in a southeast direction along Grant's Mill Road into rural Shelby County.

As you begin the route at the left side of the diagram, the rocks underlying the route across the valley floor of Jones Valley are 500-million-year-old limestones and dolostones from the Cambrian Period. Traveling southeast up and over Red Mountain you cross younger sedimentary layers from the Ordovician and Silurian Periods. The general upward tilt of rocks in the Birmingham anticlinorium toward the northwest is visible in the red hematite beds of the Red Mountain Formation in the road cut at the crest of the mountain. Most of the rocks under you as you pass through the city of Irondale are limestones and shales from the Mississippian Period, which lie hidden beneath parking lots, malls, and other urban development. All of these unseen layers underlying Shades Valley still maintain the general tilt upward toward the northwest.



Some of the oldest rocks found at the surface in the Birmingham anticlinorium are exposed in this quarry wall in Tarrant City. The tilt of these Cambrian limestones is easily visible, but the land's surface here has been eroded nearly flat. Where these layers reach the surface several miles of rock have been eroded away.

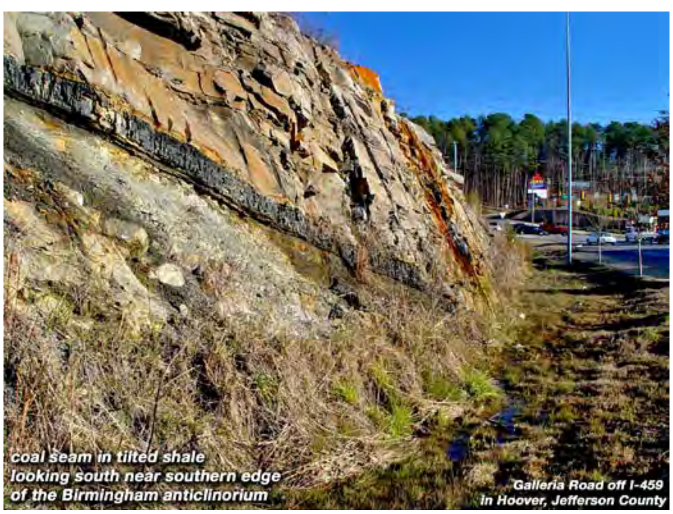
To continue tracing the approximate line of this cross-section by road, you exit Interstate 20 onto Grant's Mill Road in Irondale and drive southeast over the crest of Shades Mountain. Here you begin to cross gray sandstones and dark shales from the Pennsylvanian Period. These Coal Age rocks continue on past the Interstate 459 overpass and later the Cahaba River bridge. Up to this point on the transect all of the rock layers have had a tilt similar to that seen in the Red Mountain cut. However, not far past the Cahaba River bridge you cross a hidden fault (*identified on the diagram as the Hogpen Branch fault*) beyond which the underlying rocks become highly distorted. Upward movement along this fault has uplifted a massive block of crust thousands of feet thick, which has now been eroded down to a nearly flat surface.

Finally, at the southeast end of the cross-section you reach another hidden fault known as the **Helena fault**. Movement along this fault has brought Early Cambrian rocks of the Rome Formation to the surface. The Rome Formation would normally be situated at the very bottom of the Paleozoic rock column of this area. Its exposure at the Helena fault means that the entire column of tilted Paleozoic rocks you have just passed while driving this route has been lifted upward and then eroded away here. This huge stack of sedimentary rocks now lost to erosion spans the time from the early part of the Cambrian Period to the Early Pennsylvanian Period (*more than 220 million years*), and has an approximate thickness that can be measured along the route of nearly 20,000 feet (4 miles!).

During the time this section of crust was being thrust upward a sizable mountain must have stood here. However, its exact height cannot be deduced from the available geologic evidence, because it is impossible to know the rate at which movement along the fault occurred or the speed at which the uplifted rock was eroded away.

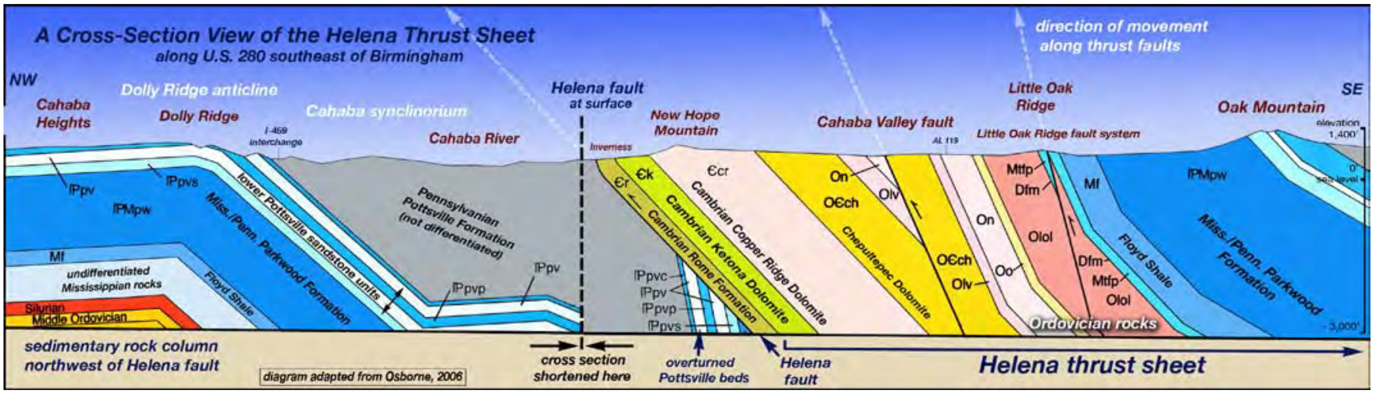
At the Hogpen Branch fault in the Irondale quadrangle Pennsylvanian rocks have been displaced nearly a thousand feet. These upturned sandstone beds are one of the few signs marking the enormous warping of the rock layers beneath.

The rock layers in this cross-section of the Birmingham area are exceptional for several reasons. The rock column here spans the better part of the Paleozoic Era, making it one of the most complete geologic sections for the time frame along any road in eastern North America. The layers hold a record of the major events, environments, and life of this time span. The rocks' twisted and distorted structure provides evidence of the incredible damage the Alabama landscape suffered here as a result of the collision with Africa, even hundreds of miles from where the actual collision occurred. Finally, their broad surface exposure across the area allows the full thickness of the column to be measured with some degree of accuracy, thereby suggesting the immense amount of time it must have taken for erosion to wear them down so flat.



These coal-bearing rocks in Hoover near the south end of the Birmingham anticlinorium are among the youngest layers in the now-eroded fold. The tilt of these layers is similar to that of the much older Cambrian limestones exposed in the quarry wall on the previous page near the north end of the anticline.

Where Early Cambrian rocks of the Rome Formation are exposed along the leading edge of the Helena thrust sheet nearly four miles of overlying rock has been removed by erosion.



The Helena Thrust Sheet: Even More Dramatic Geology Just to the South of Birmingham

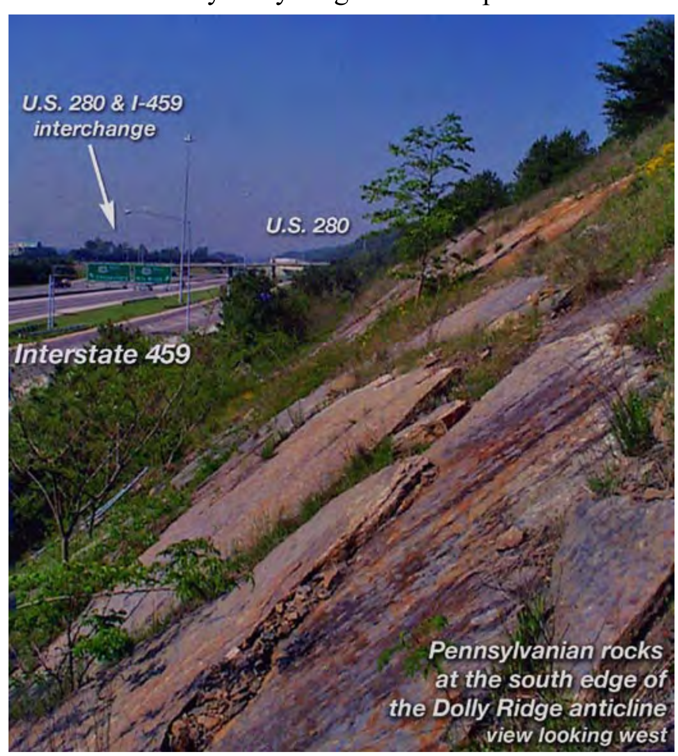
Learning to read the story in rocks provides a way of traveling back in time to see how the land achieved its present form. But there are often surprises that arise from looking beyond the surface of things. On the previous page set we explored the huge stack of sedimentary rocks that sits beneath a cross-section of the Birmingham area. Where the oldest of the tilted rock layers intersects the surface at the northwest end of the anticline geologists assume that all rocks higher up in the geologic column (*the younger layers*) must have been present at one time, but have been removed by erosion. Through measuring the total thickness of the rock column spread across the surface of the Birmingham anticlinorium, it is possible to estimate that a minimum of several miles of rock has been eroded away where Birmingham sits today. The point to all this measurement of rock thickness and position is to provide evidence for a key fact related to Alabama's geologic history—that the surface of the land we see today holds barely a trace of the mountains these rocks suggest existed at this point on the Earth long ago.

Remarkable as it is, the huge fold in the Earth's crust surrounding Birmingham does not tell the full story of how the land of Alabama was affected by the collision with Africa. Even more striking effects of the Appalachian mountain-building episode can be seen in the rocks that lie just to the south of the Birmingham anticlinorium.

The diagram above depicts a generalized cross-section of the rock strata beneath one of Alabama's most heavily traveled highways—U.S. 280. This area, referred to on regional maps as the **Cahaba Heights quadrangle**, is one of the state's most rapidly developing suburban areas. The geologic cross-section contains a section of the **Helena thrust sheet**, a slab of crust many thousands of feet thick that has been shoved northwestward up and over much younger rocks. The base of this Helena thrust sheet was pictured at the far right edge of the Irondale geologic cross section where rocks of the Early Cambrian Rome Formation reach the surface at the Helena fault.

This cross-section of the rocks in the Cahaba Heights quadrangle begins at the left of the diagram *(the northwest)* on a small anticlinal fold known as the Dolly Ridge anticline. This low ridge is located where resistant Pennsylvanian sandstones crop out at the surface. On the edge of this rise, about a mile east of the Birmingham Water Works filtration plant, U.S. 280 intersects Interstate 459—the southern bypass around Birmingham. The highway interchange fronts steeply-tilted beds of ripple-marked sandstone *(photo below)* that plunge downward toward the Cahaba syncline. These Coal Age rocks continue southeast past the Cahaba River and most of the community of Inverness. Just before U.S. 280 reaches the next ridge *(New Hope Mountain)* it crosses a major thrust fault hidden beneath the streets of Inverness. This is the **Helena fault**, certainly one of the most amazing geological features to be found anywhere in the state.

Along the Helena fault Cambrian rocks have been shoved up and over Pennsylvanian rocks that are more than 200 million years younger. In some places the Rome



Pennsylvanian rocks at the south edge of the Dolly Ridge anticline view looking west

A sense of how much land has been moved as part of the Helena thrust sheet can be gained by comparing this photo taken from New Hope Mountain looking northeast toward Oak Mountain with the diagram on the previous page. Rocks of the Helena thrust sheet extend well past the ridge far in the distance.

Formation lies at the leading edge of the thrust sheet, in others the slightly younger Ketona Dolomite marks the boundary. The high point along this part of the route, New Hope Mountain, rises where resistant chert beds of the Copper Ridge Dolomite crop out *(photo above)*.

As you continue following the geologic cross-section diagram to the right *(southeast)* past New Hope Mountain you pass another important feature of the Helena thrust sheet. At least two major thrust faults run through it, where smaller sections of crust have been displaced in relation to adjoining sections. Along one of these, the **Cahaba Valley fault,** a sequence of Ordovician rocks has been doubled where an internal section of the thrust sheet has been broken loose and shoved up and over itself. At the Little Oak fault system, which runs parallel to AL 119 (*Cahaba Valley Road*), thrust faulting has brought resistant beds of the Fort Payne Chert to the surface, creating another small ridge. Finally, U.S. 280 climbs up and over Oak Mountain, a much larger ridge underlain by thick beds of Pennsylvanian Pottsville Formation sandstone.

Strangely, here are important differences in the sequence of rocks in the Helena thrust sheet from those to the northwest in the Birmingham anticlinorium, even though the two sit adjacent to each other across the Helena fault. Silurian-age rocks (*such as the Red Mountain Formation*) are missing completely southeast of the Helena fault. Ordovician rocks in the thrust sheet are also not identical to those northwest of the fault. These differences suggest that this crustal slab has been moved here from many miles distant. Remember from the "Focus" section on page 87 that these rocks have been transported here from far to the southeast, and would have formed in different depositional environments from rocks of the same time period on the northwest side of the Helena fault.

So how did this huge slab of solid crust get here to begin with? As the African portion of Gondwana began its collision with North America the brittle upper crust fractured into a series of thin sheets. These sheets were shoved away from the collision zone along thrust faults that developed in layers of weaker rock such as shale. Because shale typically fractures along parallel, flat surfaces, it offered the least resistance to the forces of compression. Geologists believe the slab of land that makes up the Helena thrust sheet was transported on faults in shale beds of the Rome Formation, which lies at the bottom of the thrust sheet. The Rome shale layers slid against each other with little friction, like a collapsed deck of playing cards, allowing the slab to move as a single unit with no major folding of the layers higher up. Geologists believe movement of the Jones Valley thrust sheet, the core rocks of the Birmingham anticline, was on weak shale layers in the Conasauga Formation. This explains why the Conasauga rocks in the quarry on the earlier page are the oldest of any found at the surface of the Birmingham anticline instead of the Rome Formation.

Geologists at the Geological Survey of Alabama who produced this map of the Cahaba Heights quad have estimated that nearly 20,000 feet *(again, almost four miles)* of rock has been eroded away at the Helena fault, based on the thickness of rock exposed in the thrust sheet as it crops out to the southeast. As before, it is impossible to measure precisely the amount of land lost to erosion here. Movement along faults such as these was slow, probably only inches per year. Other thrust sheets in the region are believed to have been driven between twelve and fifteen miles over the tops of adjoining crustal sections.

The geologic cross-sections on the previous pages help to illustrate how the land in this region of Alabama was transformed during the great mountain-building event that built the Appalachians. Sections of rocks miles in thickness were squeezed and folded in a way that is almost beyond comprehension. Just as striking is the fact that this tortured landscape has had sufficient time to heal these wounds to where only the barest traces these ancient events remain on the face of the land today.

Overthrusts: The Land Turned Upside Down

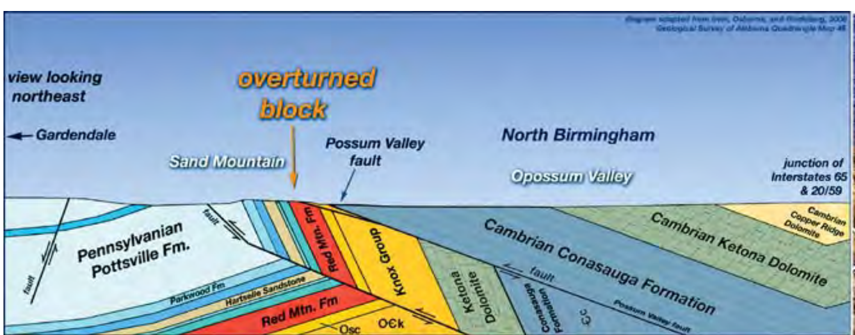
The displacement of such large sections of the Earth's crust during the collision with Africa resulted in another strange geological feature still recognizable in parts of Alabama. Several anticlinal folds along the leading edge of thrust sheets have actually been thrust over themselves. This has caused entire sequences of sedimentary rocks to sit upside-down in relation to the order in which they were deposited. One of the best examples of one of these **overthrust zones** is found at the north limb of the Birmingham anticlinorium on I-65 in North Birmingham.

Traveling north out of Birmingham, Interstate 65 cuts through a small ridge known as Sand Mountain at about mile marker 263.3. In this small ridge, sandstone layers have been overturned at a steep angle toward the northwest, with the underside of the beds facing up. A good exposure of overturned sandstone beds that form the crest of this ridge is visible on 36th Avenue North, just west of where I-65 cuts through Sand Mountain *(photo above)*.

The annotated photograph at the bottom right of this page shows overturned sandstone beds in the I-65 Sand Mountain cut itself, exposed during road construction in 2008 to widen the road's passage through the ridge. The view is looking back southeast toward downtown Birmingham, an angle that shows the original direction from which this enormous anticlinal fold became overthrust.

Using the diagram below, let's focus on the unusual geological dynamics that must have taken place here by examining how anticlinal folds might become overthrust. As the crust began to be compressed by the collision taking place far to the southeast, the land here began to be folded gently upward. As the compression progressed further, the south end of the anticline was shoved over the north limb, passing above the top of the less-mobile section of the fold. Thrusting continued on, finally ripping loose the overturned north limb of the anticline along a major fault—the Possum Valley fault. The north limb of the fold now sits as an overturned block bounded by faults, with only the upside-down sandstone beds marking the overthrust zone. The top of the fold continued to be shoved to the northwest, but how much farther cannot be determined from the geological evidence. More than 200 million years of erosion have removed several miles of rock at this point. Only the overturned sandstone beds at the crest of the ridge and the "dead" fault zones on either side of the overturned block remain to mark the spot where this extraordinary geological event took place.

While driving across this part of Alabama's largest city, it is entertaining to think about the amazing geological events that have taken place here. It would be hard to find a more impressive, or more obvious, example of where the landscape of Alabama has been transformed by the Earth's large-scale dynamics over time.



A Geologic Cross-Section of the Overthrust of the Birmingham Anticline along Interstate-65