# HISTORY AND GEOLOGY OF THE RED MOUNTAIN EXPRESSWAY ROADCUT

## A NATIONAL NATURAL LANDMARK

## BIRMINGHAM, ALABAMA

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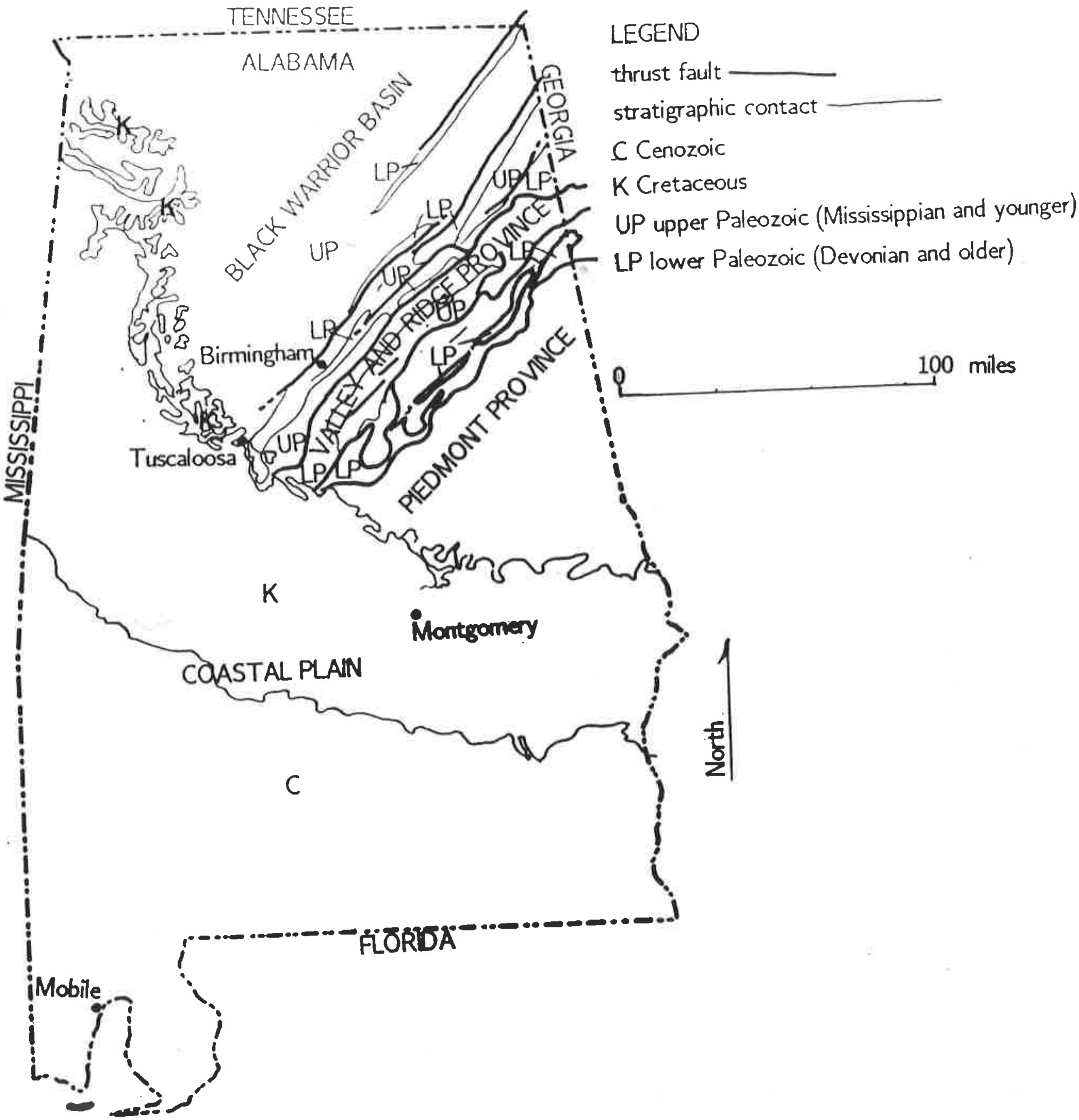
TENNESSEE
ALABAMA
GEORGIA
MISSISSIPPI
FLORIDA
BLACK WARRIOR BASIN
VALLEY AND RIDGE PROVINCE
PIEDMONT PROVINCE
COASTAL PLAIN
Birmingham
Tuscaloosa
Montgomery
Mobile
K
UP
LP
C
LEGEND
thrust fault
stratigraphic contact
C Cenozoic
K Cretaceous
UP upper Paleozoic (Mississippian and younger)
LP lower Paleozoic (Devonian and older)
0
100 miles
North

# The History And Geology Of The Red Mountain Expressway Cut, Birmingham, Alabama: A National Natural Landmark

The Red Mountain (Elton B. Stephens) Expressway cut through Red Mountain, Birmingham, Alabama (Fig. 1) is designated as a National Site of Geologic Interest by the American Geological Institute, and as a National Natural Landmark by the United States Department of Interior. The Cut was completed in 1970 to expedite traffic flow on U.S. Highway 280 to the interstate highway system in Birmingham. The Cut is 210 feet (63 meters) deep and approximately 2000 feet (600 meters) long. It trends perpendicular to strike of the formations comprising Red Mountain, and it exposes a stratigraphic thickness of 700 feet (210 meters) of Paleozoic formations ranging in age from Late Cambrian (510 million years ago) to Early Mississippian (350 million years ago).

Birmingham is located in the Valley and Ridge province of the Southern Appalachian fold mountain belt (Fig. 2). The Paleozoic strata underlying Birmingham form a thrust-faulted anticline (Fig. 3, Birmingham anticlinorium) that developed in Alleghanian (Carboniferous) time as a fault-bend fold associated with a thrust fault ramp. The location and configuration of the ramp were probably controlled by an older basement fault system (Thomas and Bearce, 1986).

The Paleozoic formations exposed in the Red Mountain Expressway Cut and in numerous other natural and man-made exposures in the Birmingham metropolitan region have provided the mineral resources enabling the development of the major industrial center and also reflect a variety of environments that existed here during Paleozoic time. During early and mid Paleozoic time a shallow marine stable shelf environment resulted in deposition of limestone, dolostone, and shale. During the Silurian Period sandstone and shale of the Red Mountain Formation were deposited, reflecting a source of clastic sediment to the east. The hematite-rich sandstones of the Red Mountain Formation, the basis of Birmingham's iron industry, were probably derived from the weathering of basaltic and andesitic rocks of a volcanic arc that either existed along, or collided with, the eastern margin of the North American continent during Ordovician to Silurian time (Hatcher, 1972). Reduced iron was initially deposited as chamosite in mud in quiet marine water of the shelf to the west of the volcanic arc. This mud was later subaerially reworked, the clay was winnowed out, and chamosite pellets were oxidized in lag deposits to hematite which coated quartz grains and shell fragments. Concurrently, this hematite-rich sand was concentrated on beaches, probably during storms (Cotter, 1990, and A. Foos, 1991, personal communication). In Pennsylvanian time a fluvial-deltaic environment prograded over the shallow marine shelf. Delta swamps accumulated thick deposits of peat which were subsequently buried under thousands of feet (meters) of mud and sand, and converted into coal. Folding and thrust faulting accompanied and followed growth of the delta. During post-Paleozoic time uplift and erosion breached the thrust-faulted folds, resulting in surface exposures of limestones, hematitic sandstones, and coal beds, all of different ages, but all now juxtaposed at approximately the same elevation due to the crustal shortening that was accomplished with the folding and thrusting of the Alleghanian Orogeny. Convenient access to these essential ingredients of the iron industry in the late 1800's was the major factor in the siting and rapid growth of Birmingham.

Red Mountain is a cuesta formed in gently southeast-dipping strata on the southeast limb of the Birmingham anticline. Beds from Cambrian to Mississippian age are exposed in the Red Mountain Expressway cut (Fig. 4) dipping approximately $20^{o}$ to the southeast. Steep normal faults, down to the southeast, with variable displacement, offset the strata as much as 20 feet (6 meters).

The oldest strata exposed in the cut are dolostone and chert of the Upper Cambrian Copper Ridge Formation of the Cambrian-Ordovician Knox Group (Figs. 4 and 5). These beds are located approximately 100 feet (30 meters) northwest of the northwest end of the paved walkway; however, the exposure is poor because of vegetation. A fault zone at road level in the Copper Ridge Formation is a few inches (centimeters) wide and is filled with gouge of silty clay containing chert fragments. The fault ends about 10 feet (3 meters) above road level, below the top of the Copper Ridge. Nature of movement on the fault is unclear, although it would appear to be of Late Cambrian age.

The Copper Ridge Formation is overlain disconformably by Middle Ordovician strata of the Chickamauga Group. On the northeast side of the cut, the unconformity has more than 5 feet (1.5 meters) of relief filled with a clay and limestone matrix-supported breccia of gray mottled chert (Attalla Chert Conglomerate Member, the basal member of the Stones River Formation of the Chickamauga Group, (Drahovzal and Neathery, 1971), (Fig. 5). Differences in thickness of the lower part of the Chickamauga indicate more than 30 feet (9 meters) of paleotopographic relief between the northeast and southwest sides of the Red Mountain Expressway cut. The lower part of the Knox (Chepultepec, Longview, and Newala Formations), regionally extensive elsewhere in Alabama and the southern Appalachians in general, is unconformably absent along the Birmingham anticlinorium (Butts, 1926). The local, anomalous, stratigraphically deep truncation of the Knox Group suggests differential relative uplift and erosion of more than 2000 feet (600 meters) of section in a narrow region along the Birmingham anticlinorium before Middle Ordovician.

The Chickamauga Group at Birmingham is predominantly shallow marine limestone (Fig. 5). On the southeast limb of the Birmingham anticlinorium the Chickamauga is 247 feet (75.3 meters) thick. Regionally, both to the southeast and northwest, the equivalent section is more than twice as thick. Regional thickness distribution suggests paleodips of approximately 75 feet per mile (15 meters per kilometer) away from the crest of a synsedimentary structure coincident with the present southeast limb of the anticlinorium. Locally, on the southwest side of the Red Mountain Expressway cut, the Chickamauga Group is overlain by a thin interval (less than 3 feet, 1 meter) of limestone and siltstone of the Late Ordovician Sequatchie Formation (section measured by W. A. Thomas, D. N. Bearce,and J. A. Drahovzal, p. 231-240, *in* Drahovzal and Neathery, eds., 1971). Elsewhere in the cut the Sequatchie is unconformably absent.

Regionally, Ordovician rocks are truncated by a pre-Silurian unconformity that is reflected by the absence of the Sequatchie Formation in most of the Red Mountain Expressway cut. Detailed measurements made possible by the complete exposure in this deep cut reveal truncation of beds up dip in the upper part of the Chickamauga Limestone as well. The truncation indicates an angular discordance of approximately $1.6^{0}$ between Ordovician beds and the Silurian Red Mountain Formation (Fig. 6). The direction of angular discordance coincides with present dip direction of the southeast limb of the anticlinorium and demonstrates an incremental increase in paleodip from Middle Ordovician to Early Silurian.

The Silurian Red Mountain Formation contains units of coarse-grained, massive, cross-bedded sandstone consisting of variable amounts of quartz sand, bioclasts, and hematite ooids and matrix. These beach and intertidal sandstones contain conglomerates of discoid limestone clasts that were reworked from thin lenses and interbeds within the formation (Bearce, 1973). Distribution of the intraformational conglomerates and paleocurrent directions derived from cross beds and ripplemarks suggest a shoal coincident with the crest of the anticlinorium during the Silurian (Bearce, 1973). A thick-bedded, coarse-grained sandstone of Late Silurian age (Ferrill, 1984) at the top of the Red Mountain Formation (Figs. 5 and 7) locally contains hematite that was probably reworked from hematite-bearing sandstone beds lower in the Red Mountain Formation. Synsedimentary relief during the Silurian is suggested but cannot be quantified.

Down-to-southeast normal faults offset strata in the Red Mountain Expressway cut (Fig. 4). One of the faults, exposed near the center of the cut, has approximately 20 feet (6 meters) of stratigraphic separation and juxtaposes basal beds of the Red Mountain Formation on the southeast side with uppermost beds of the Chickamauga Group on the northwest side at the level of the walkway. It is a brittle fault, transecting lithified beds with local drag in thin-bedded intervals, and containing a gouge of cobble-size rock fragments. The fault appears almost vertical over most of its exposure on the southwest wall of the cut, due to Alleghanian folding. However, just above road level, the fault flattens into the bentonite bed about 20 feet (6 meters) below the top of the Chickamauga (Fig. 4). The second fault, exposed near the southeast end of the Red Mountain Expressway cut, displaces the sandstone at the top of the Red Mountain Formation as well as underlying strata (Figs. 4 and 7). In strata beneath the sandstone, the fault appears as a brittle, post-sedimentary fault that intersects bedding at an angle of $60^{0}$ and has approximately 10 feet (3 meters) of stratigraphic separation. In contrast, near the fault, the sandstone at the top of the Red Mountain Formation exhibits soft sediment deformation, slump faults, and local thickening on the downthrown fault block. Detailed measurements on the fault shown in Figure 7 indicate approximately 3 feet (.9 meters) of synsedimentary displacement in Late Silurian time and an additional 7 feet (2.1 meters) of post-Silurian movement. The normal fault extends upward into the lowest beds of the Mississippian Fort Payne Chert. Approximately 6 feet (1.8 meters) above the base of the Fort Payne, chert beds are draped monoclinally across the fault (Fig. 7).

The two normal faults are similar in attitude and stratigraphic separation. Although synsedimentary movement cannot be demonstrated on the northwesternmost fault, because of exposure in a deeper part of the section, it is reasonable to assume that it, like the fault at the southeast end of the cut, was active at least as early as Late Silurian and became inactive in Mississippian time, prior to Alleghanian folding in the Birmingham area. We may speculate that the normal faults developed in response to down-to-the-southeast movement on one or more basement faults known to exist southeast of the Birmingham anticlinorium; perhaps the same basement fault system that localized the thrust fault ramp on which the Birmingham anticlinorium developed (Fig. 2). Tull and Telle (1989) have set forth stratigraphic evidence in the Talladega slate belt of the Alabama Piedmont province southeast of Birmingham (Fig. 2) of major basement faulting during Silurian time.

The Mississippian Fort Payne Chert is the youngest formation in the Red Mountain Expressway cut. Below the Fort Payne, 7 inches (18 centimeters) of light green-gray, fossiliferous, and dark purple clay shale constitutes the Lower Mississippian Maury Shale which rests unconformably on the Red Mountain Formation. The Upper Devonian Chattanooga Shale, present elsewhere in the Birmingham area and to the north, is unconformably absent in the Red Mountain Expressway cut.

A narrow, strike-parallel valley lies southeast of Red Mountain's dip slope. The valley is on the outcrop trace of the Mississippian Tuscumbia Limestone, conformably overlying the Fort Payne Chert, and the Mississippian Pride Mountain Formation (Fig. 1), composed of mudstone, with thin, discontinuous sandstone beds.

Sandstone Ridge, the low ridge visible from the cut a few hundred meters southeast of Red Mountain, is formed on the Mississippian Hartselle Sandstone, a quartzose sandstone deposited in a barrier island and shelf bar system overlying the Pride Mountain mudstones (Thomas and Mack, 1982). In the cut for the Red Mountain Expressway through Sandstone Ridge, the lower part of the Hartselle Sandstone is displaced by synsedimentary rotational down-dip slump (listric normal) faults (Fig. 9). The synsedimentary faults indicate slumping and rotational down-dip sliding on paleoslopes in the direction of present structural dip on the southeast limb of the anticlinorium (Thomas, 1968). The listric faults apparently flatten downward into mudstones of the Pride Mountain Formation and do not extend down into older rocks. Thus, the slump faults differ in origin from the normal fault that was active during deposition of the upper part of the Red Mountain Formation.

Mississippian and Pennsylvanian rocks crop out southeast of Red Mountain on the southeast limb of the Birminghan anticlinorium and in the Cahaba synclinorium to the southeast. Shades Mountain, locally visible to the south from the Red Mountain Expressway cut, is formed on sandstone and quartz pebble conglomerate that define the base of the Pennsylvanian Pottsville Formation. Between the Hartselle Sandstone on Sandstone Ridge and the Pottsville on Shades Mountain, the succession includes a southwestward-thinning carbonate facies (Mississippian Bangor Limestone) and a

Sandstone Ridge and the Pottsville on Shades Mountain, the succession includes a southwestward-thinning carbonate facies (Mississippian Bangor Limestone) and a northeastward-prograding clastic facies (Mississippian Floyd Shale and Mississippian-Pennsylvanian Parkwood Formation sandstone and mudstone) (Thomas, 1972). The Mississippian section is thicker to the southeast of than to the northwest of the Birmingham anticlinorium. The clastic facies also extends farther to the northeast on the southeast side of the anticlinorium than on the northwest side. The greater thickness and greater northeastward progradation of the clastic facies on the southeast side of the the Birmingham anticlinorium suggest synsedimentary differential subsidence in the Cahaba synclinorium during Mississippian time.

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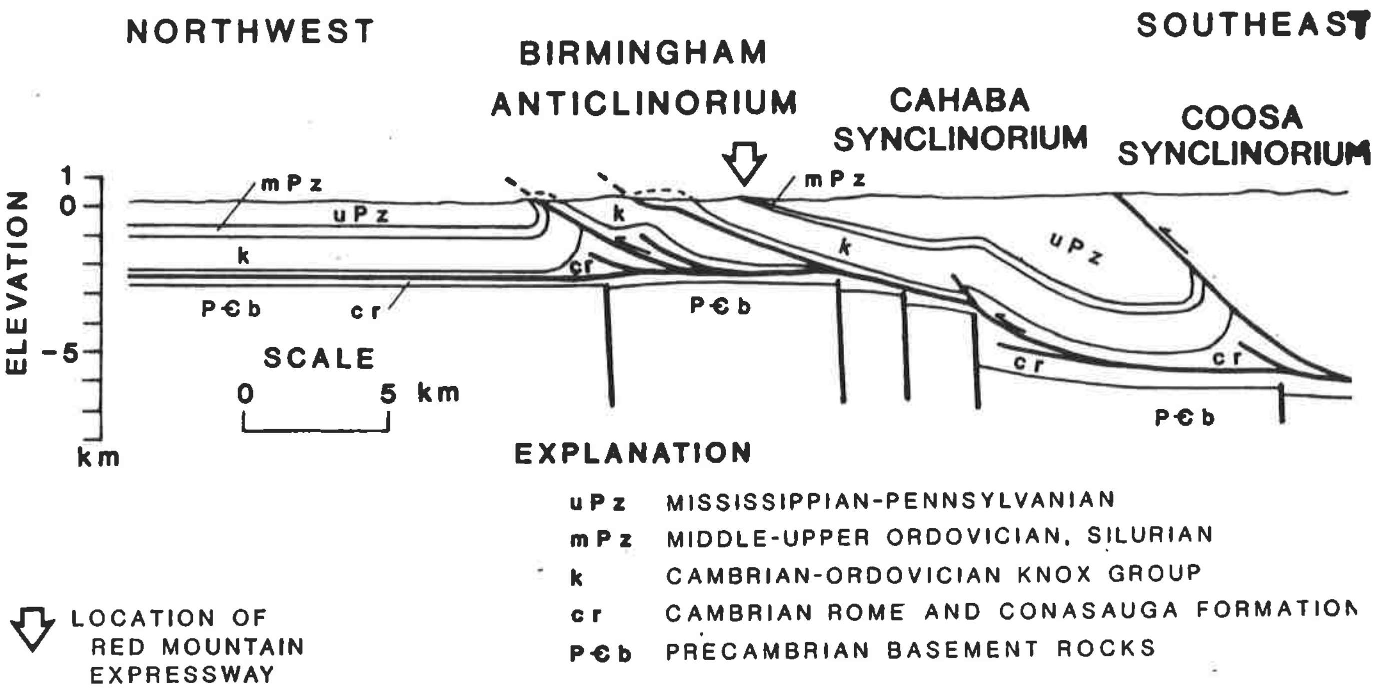


Figure 3. Structural cross-section of Birmingham anticlinorium. Location of cross-section line on figure 2. Modified from Thomas and Bearce, 1986.

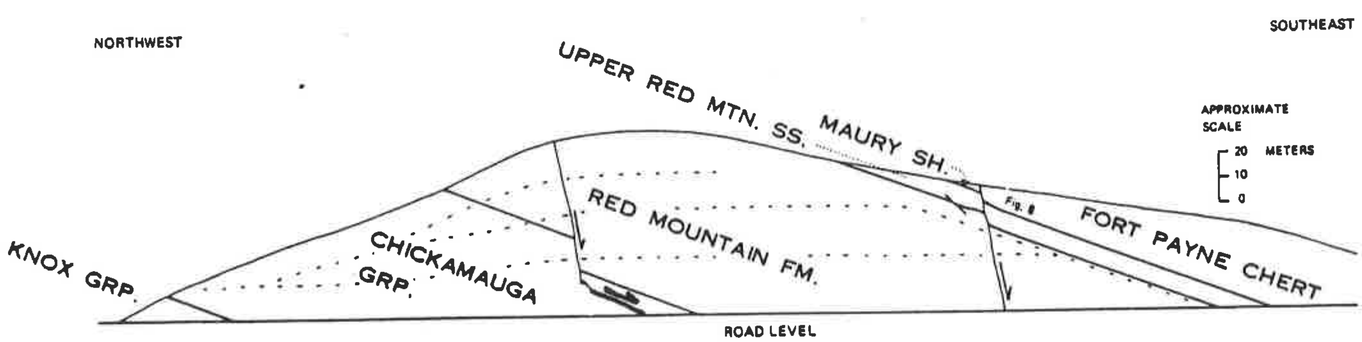


Figure 4. Sketch cross-section of northeast face of Red Mou8ntain Expressway cut. Light dashed lines show bench levels on cut face; Red Mountain Museum walkway is on lowest bench above road level. Modified From Thomas and Bearce, (1986).

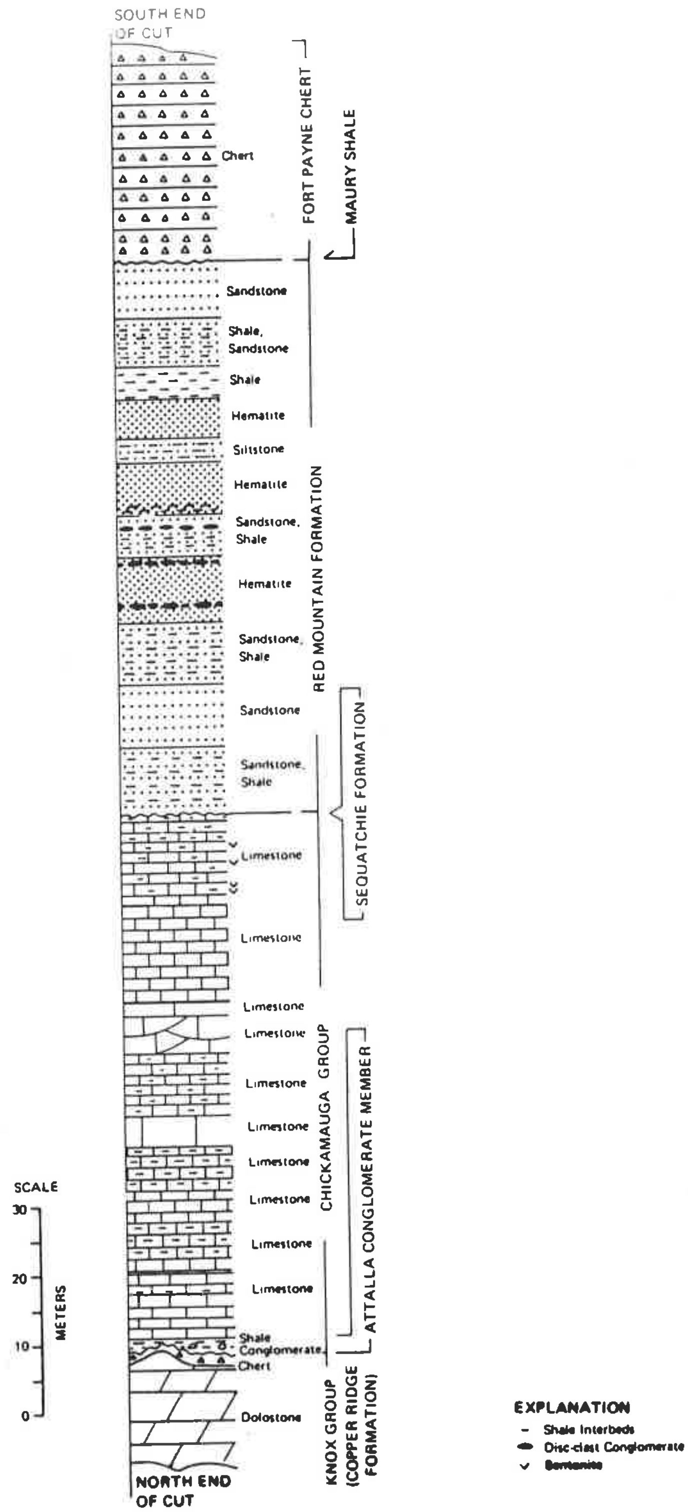


Figure 5. Stratigraphic section in the Red Mountain Expressway cut (from measured section by W. A. Thomas, D. N. Bearce, and J. A. Drahovzal, p. 231-240, *in* Drahovzal and Neathery, eds., 1971). From Thomas and Bearce (1986).

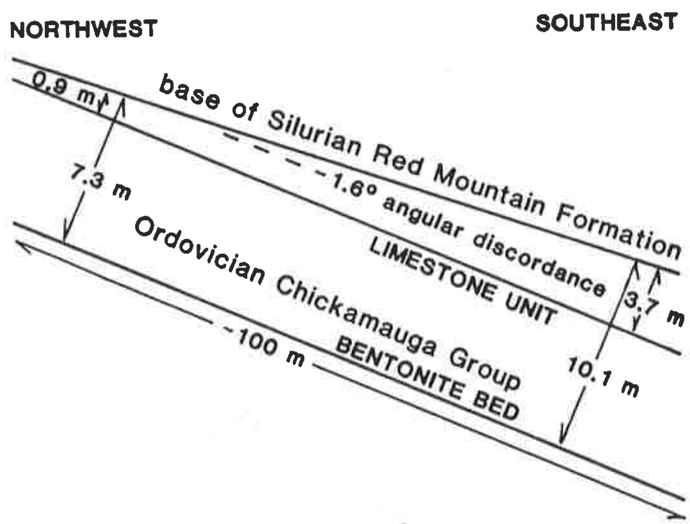


Figure 6. Diagrammatic cross-section of angular unconformity between Ordovician and Silurian rocks on southeast limb of Birmingham anticlinorium (measured on northeast face of Red Mountain Expressway cut). From Thomas and Bearce (1986).

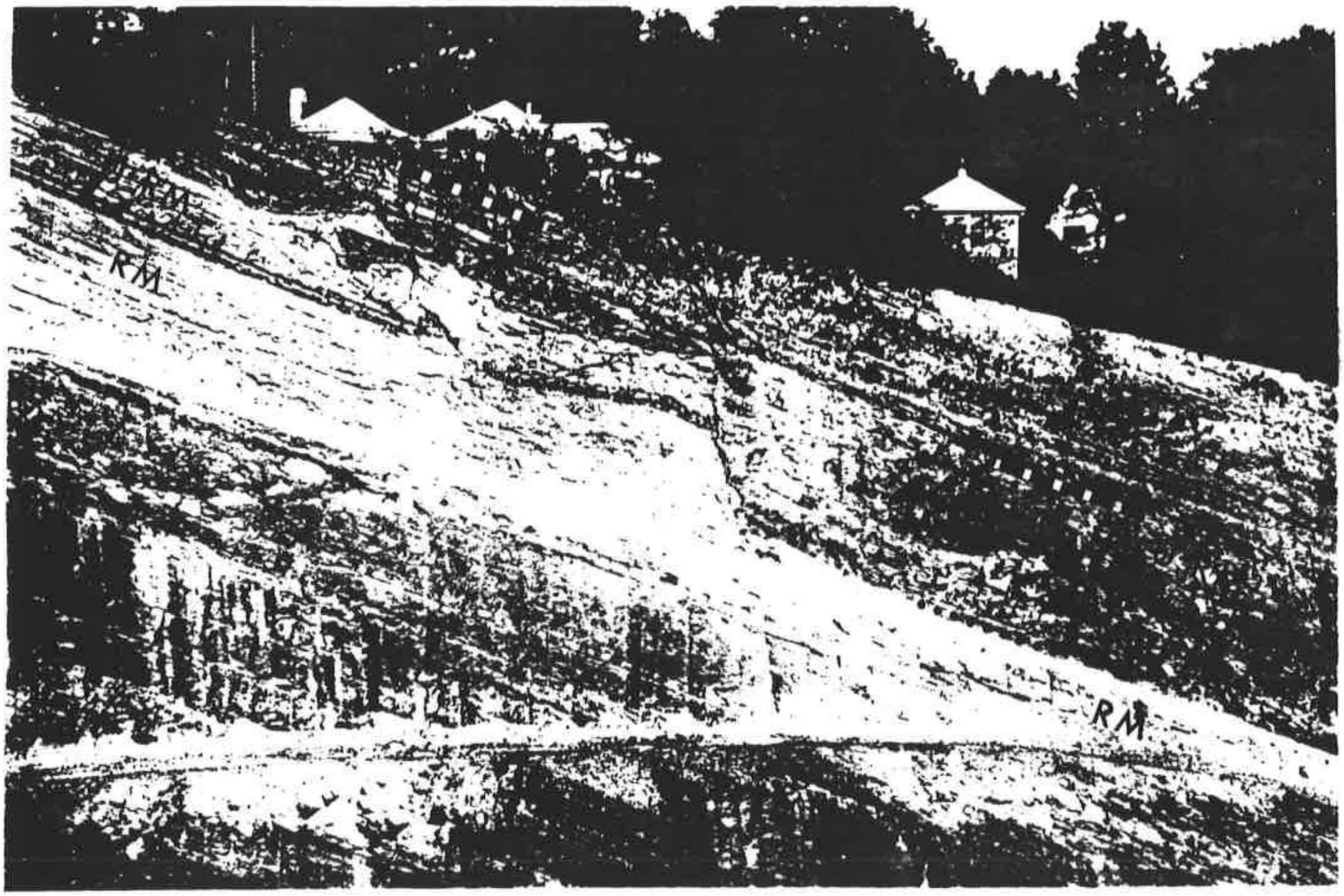


Figure 7. Normal fault at southeast end Red Mountain Expressway cut, associated with slump structures and local downthrown thickening in sandstone designated U-RM. RM: Silurian Red Mountain Formation, FP: Mississippian Fort Payne Chert. Dashed line: thin variegated claystone interval at Silurian- Mississippian contact. From Thomas and Bearce (1986).

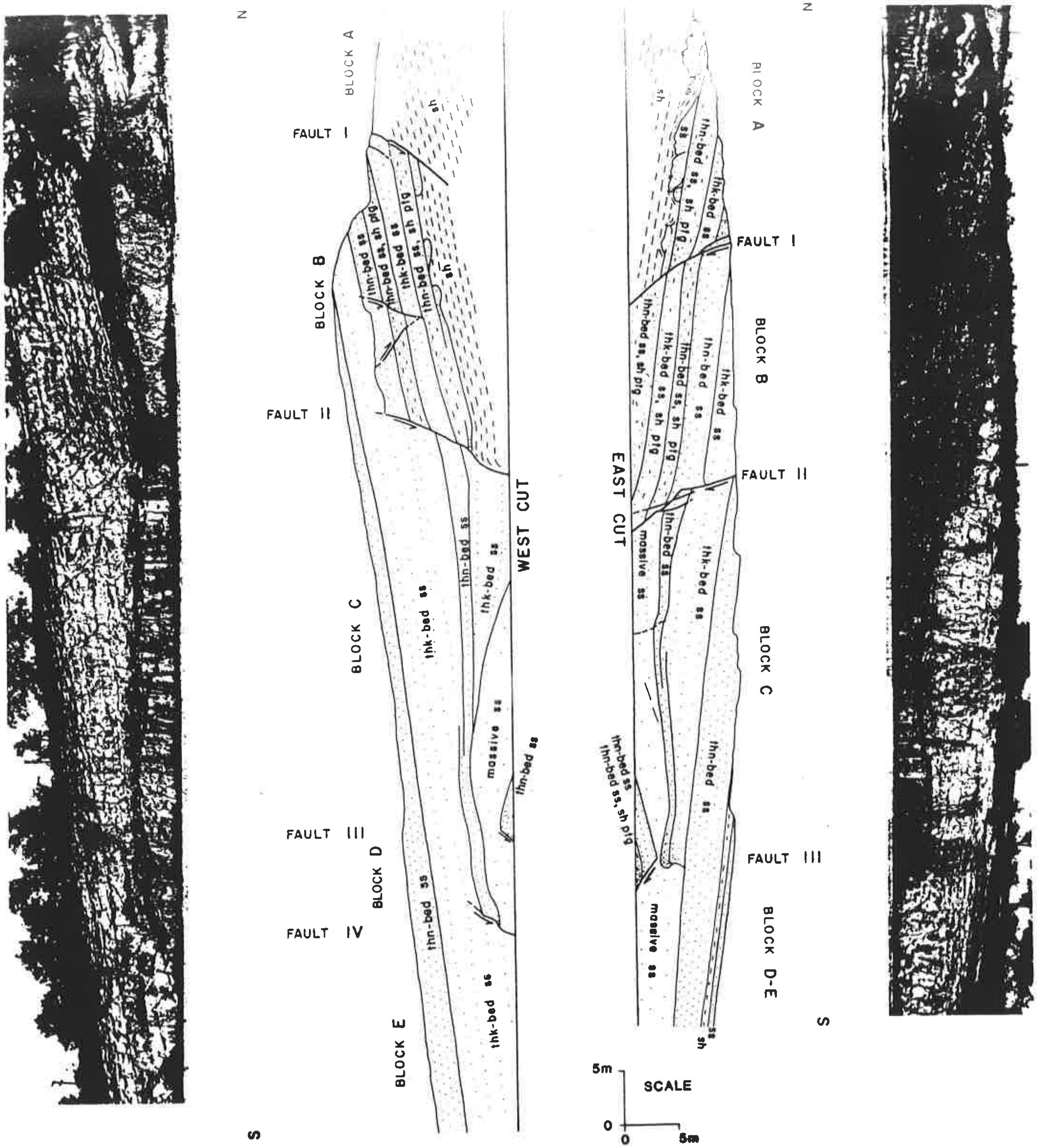


Figure 8. Cross-sections and photographs (from Thomas, 1968) of synsedimentary rotational downdip slump faults in Hartselle Sandstone on southeast limb of Birmingham anticlinorium on opposite sides of cut for Red Mountain Expressway through Sandstone Ridge southeast of Red Mountain (vertical cuts are approximately 150 feet (50 meters) apart). Explanation: ss = sandstone; sh = clay shale; thn-bed = thin bedded; thk-bed = thick bedded, average more than 1 foot (0.3 meters thick; massive = unit in single bed; ptg = partings, thin interbeds of clay shale within sandstone; areas not patterned are covered. Parts of these cuts are now covered with concrete. From Thomas and Bearce (1986).