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STRUCTURAL DEVELOPMENT OF THE ALABAMA PIEDMONT NORTHWEST OF THE BREVARD ZONE

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ABSTRACT. The region between the Brevard Zone and the Valley and Ridge province in Alabama, referred to as the Northern Alabama Piedmont, consists of three major lithotectonic units or blocks bounded by major reverse fault systems and represented by unique internal stratigraphies and structural frameworks. Each of the lithotectonic units is composed largely of pelitic lithologies but also contains other distinctive rock types. A number of deformational phases have affected the rocks of the region and resulted in a complex tectonic history. An early phase of prograde regional dynamothermal metamorphism (D_1–M_1) resulted in lower greenschist facies assemblages in the northwestern lithotectonic unit and middle to upper amphibolite facies assemblages in units to the southeast. This phase also produced a pervasive foliation (S_1) which parallels the axial planes of early generation flow folds (F_1) in all three lithotectonic units. Events associated with this phase are believed to have occurred between 500 and 348 m.y. ago. A second dynamic phase (D_2–M_2), which was most intense in the southeastern lithotectonic unit, resulted in retrogressive fabrics and mineral assemblages including local transposition of S_1 foliation into S_2. A third dynamic phase deformed the S_1 and S_2 foliations into tight flexural slip folds (F_3). The orientations of the respective linear and planar structural elements produced during these phases vary among the three lithotectonic units. Fabrics, structural elements, and lithologic belts in the region were disrupted along southeast dipping reverse faults to form the three lithotectonic units. This faulting, believed to be Alleghenian in age, occurred in at least two stages separated by a period of cross-folding (F_4). Transport of the central lithotectonic unit over the northwestern unit during the early stage of faulting resulted in a minimum horizontal displacement of 18 km (12 miles). Following the emplacement of the central unit it was folded (F_4) along with the northwestern unit. At a later stage the two units became overthrust by the southeastern unit in Alabama and western Georgia and are not known to exist in the north Georgia and North Carolina Blue Ridge.

INTRODUCTION

The Northern Alabama Piedmont occurs to the northwest of the Brevard Zone and lies immediately southeast of the Valley and Ridge physiographic and structural province, encompassing an area of some 8800 sq km (3400 sq miles; see fig. 1). The rocks of this region, largely metasedimentary and metavolcanic in nature, have undergone a number of periods of deformation, metamorphism, and plutonism. Their highly deformed nature has been recognized by a number of workers, but the sequence, timing, styles, and degrees of deformation have never been described in detail. Additionally, problems have arisen because much of the regional stratigraphy is known only in a general fashion. The nature of the major contacts and correlations between the various units are in debate. The interplay of these events during a large period of Earth history has resulted in an extremely complicated orogenic belt which we are only now beginning to understand.

In this paper an attempt is made to describe the structural history of this region as it is presently understood and to resolve some of the existing confusion concerning the regional stratigraphy.

PREVIOUS WORK

The geologic information accumulated to date on the Northern Alabama Piedmont has been largely due to work undertaken or sup-

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ported by the Geological Survey of Alabama. A number of early workers, including E. A. Smith (1888), G. I. Adams (1926, 1933), and W. F. Prouty (1923) made significant and fundamental contributions in the late nineteenth and early twentieth centuries, but additional geologic studies of the region were rare until the current interest began in the late 1960's. Following a rather extensive geologic mapping program in the late 1960's and early 1970's, a sizable body of knowledge was accumulated on the stratigraphy of the region and the general distribution of rock units. More recently, specific studies dealing with igneous petrology, geochemistry, structure, and geochronology have been undertaken. A series of guidebooks published by the Alabama Geological Society summarizes the

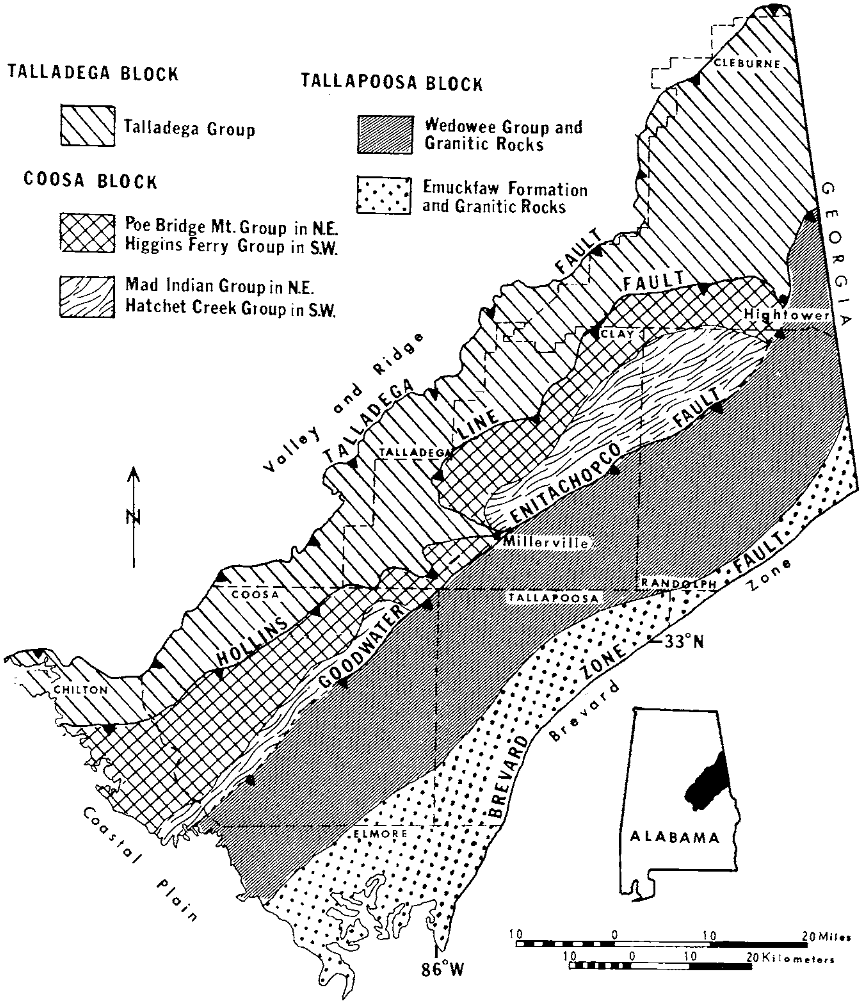


Fig. 1. Lithotectonic units of the Northern Alabama Piedmont.

regional geology (Bentley and Neathery, 1970; Carrington, 1973; Neathery and Tull, 1975). Neathery and Reynolds (1973, 1975) published descriptions of the regional stratigraphy and outlined a structural history.

GENERAL DESCRIPTION OF LITHOTECTONIC UNITS

Structural Setting

The crystalline rocks northwest of the Brevard Zone in Alabama can be subdivided into three major lithotectonic units or blocks bounded by northeast striking, southeast dipping reverse faults. These blocks, arranged respectively from northwest to southeast, are the Talladega, Coosa, and Tallapoosa (see fig. 1). The Talladega block is bounded to the northwest by Paleozoic sediments of the Valley and Ridge province. The Talladega Fault system is believed to mark this boundary (Bearce, 1973; Carrington, 1973). The Hollins Line Fault system forms the boundary between the Coosa and Talladega blocks. The Tallapoosa block is separated from the Coosa block along the Goodwater-Enitachopco Fault system. The southeastern boundary between the Tallapoosa block and rocks of the Brevard Zone is believed to be a fault (Abanda or Brevard Zone Fault) which traces at least as far south as Horseshoe Bend on the Tallapoosa River (Bentley and Neathery, 1970). Each block contains a unique structural framework and internal stratigraphy composed dominantly of pelitic metaclastic units.

These blocks may be grouped further into metamorphic belts, the low-grade Talladega and the high-grade Ashland-Wedowee. The Talladega belt comprises rocks of lower greenschist-facies which crop out entirely within the Talladega block. The Coosa and Tallapoosa blocks, containing middle and upper amphibolite-facies rocks, together constitute the Ashland-Wedowee belt.

Stratigraphic Framework

Talladega block.—The bulk of the stratigraphy in the Talladega block is known only in a general fashion. This block contains a thick sequence of slaty and phyllitic metasediments with numerous distinctive and mappable units of conglomerate quartzite and marble. These rocks are noteworthy because locally they contain the youngest fossils reported from Appalachian metamorphic rocks southwest of the New England area (Rodgers, 1970). Early Devonian fossils have been reported from the Jemison Chert in the extreme southwestern portion of the belt in Chilton County (Butts, 1926), and Mississippian and Pennsylvanian plant spores have been reported from low-rank metamorphic rocks in fault blocks northwest of the Talladega block (Carrington, 1973).

A gross stratigraphy has been worked out in the northeastern area of the block by Bearce (1973), but correlation of these units southwestward to the area of the Jemison Chert has never been established. Most workers in the region have assumed an upright sequence for most of the area, though facing data are not abundant in the Talladega block. This assumption is certainly justifiable for the limited portions of the belt where facing criteria have been found but may not apply to the belt as a whole.

The southeast part of the Talladega block is bounded by a unique mafic metavolcanic sequence known as the Hillabee Chlorite Schist (fig. 2). This unit marks a significant period of extensive basic volcanism in this region. Unfortunately, we do not yet understand the stratigraphic relations between the Hillabee and the Lower Devonian Jemison Chert. If the sequence is upright and in normal stratigraphic order in Chilton County, then the basic volcanic sequence must be Lower Devonian or younger. The southeastern margin of the Hillabee is marked by a system of major reverse faults, the Hollins Line (fig. 1). In places the Hillabee is completely faulted out along this line, but in other localities it reaches a thickness of 2.7 km. The true thickness is unknown because of the tectonic nature of its upper (southeastern) margin. Consequently, rock units stratigraphically above the Hillabee are unknown.

Rocks within the Talladega belt contain mineral assemblages representative of the lower greenschist facies of regional metamorphism. Typical assemblages include quartz–albite–muscovite–chlorite, chlorite–albite–epidote–actinolite, and quartz–epidote–chlorite–zoisite–actinolite. No rocks of higher grade have been reported from this belt.

Coosa block.—The Coosa block rocks exhibit the highest metamorphic grade (upper amphibolite) in the Northern Alabama Piedmont. As in the other structural blocks in the Northern Alabama Piedmont, pelitic rocks dominate the stratigraphy in this block, though migmatitic schists, small granitic lenses, and pegmatites are quite common. Two correlative sequences occur in separate salients, one to the northeast and the other to the southwest, separated by a half-window in the Millerville area (fig. 1). The northeastern sequence in Clay, Randolph, and Cleburne Counties is represented by the Poe Bridge Mountain Group (Neathery, 1975) to the northwest and the Mad Indian Group (Neathery and Reynolds, 1975) to the southeast. The correlative sequences to the southwest in Coosa and Chilton Counties are the Higgins Ferry and the Hatchet Creek Groups, respectively (Neathery, 1975). The Poe Bridge Mountain and correlative Higgins Ferry Groups comprise a distinctive sequence of interlayered, coarse-grained, graphitic feldspathic mica schists, gneisses, quartzites, and amphibolites, presumably derived from a thick volcaniclastic protolith. To the southeast are the Mad Indian and Hatchet Creek Groups (Neathery, 1975), which are much more homogeneous than the groups to the northwest. They are composed dominantly of feldspathic quartz–muscovite schist, but feldspathic biotite gneiss, biotite schist, and micaceous quartzite are common as well. Amphibolites are very rare. The contact between the Mad Indian and Poe Bridge Mountain Groups and between the Higgins Ferry and Hatchet Creek Groups appears to be stratigraphic rather than tectonic, but no facing evidence has yet been discovered to determine the relative age of these units. The units of the Coosa block were originally designated as a part of the "Ashland Mica Schist" by Adams (1926), and it is proposed here that the term "Ashland"

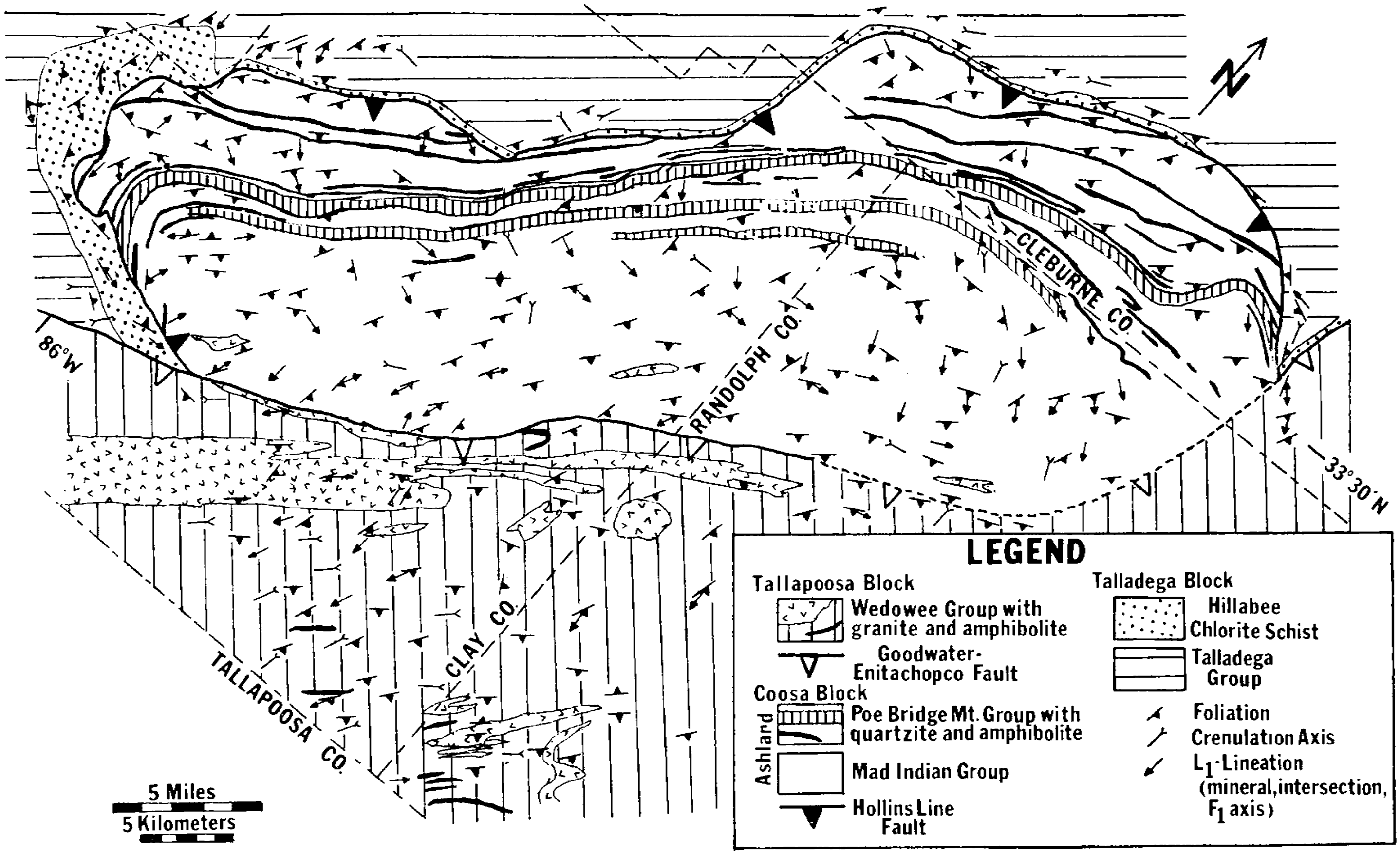


Fig. 2. Structural and stratigraphic relations in Clay, Randolph, and Cleburne Counties, Alabama.

be retained and elevated to supergroup status to incorporate the groups that have been designated above.

Tallapoosa block.—The Tallapoosa block contains two distinctive metasedimentary sequences, the Wedowee Group (Adams, 1926) and the Emuckfaw Formation (Neathery and Reynolds, 1975). A number of different granitic rocks, ranging from granite to quartz diorite, also crop out over an area of several hundred square kilometers in this tectonic unit (Gault, 1945). In most instances the original contact relationships between these igneous and igneous-appearing rocks and the surrounding metasediments appear to have been intrusive, though their exact nature has not been established in all cases. Deininger (1975) has suggested that a number of the contacts may be unconformities, and that some of the granitic rocks may be paragneisses. The polydeformational nature of these contacts commonly obscures the relationships, so that the original features are not recognizable.

The Wedowee Group is composed of schistose and phyllitic metapelites which commonly contain graphite. Amphibolites and quartzites are minor members of this assemblage. The Emuckfaw Formation is made up dominantly of mica schists but also contains amphibolite and quartzite and minor gneiss. Mineral assemblages in the Wedowee and Emuckfaw rocks are representative of the middle to upper amphibolite facies of regional metamorphism (Muangnoicharoen, ms).

STRUCTURAL DEVELOPMENT

A number of deformational episodes have affected the Northern Alabama Piedmont and have resulted in a polyphase structural framework which locally exhibits rather complicated geometries. A general similarity of sequence of structural events and associated styles has been recognized by this worker in each of the lithotectonic units described above, as well as within rocks of the Brevard Zone. These events are presumed to be roughly correlative from one structural block to another. The development of the large reverse fault systems that bound the structural blocks postdates the majority of the structural episodes to be discussed here. Lithotectonic units now juxtaposed were once probably separated by considerable distances. Thus, the lateral extent of this polydeformed and metamorphosed geosynclinal succession has been considerably shortened by thrusting along these faults. The intervening strata have been removed by erosion of large portions of the upper plates or have been overthrust by the upper plates.

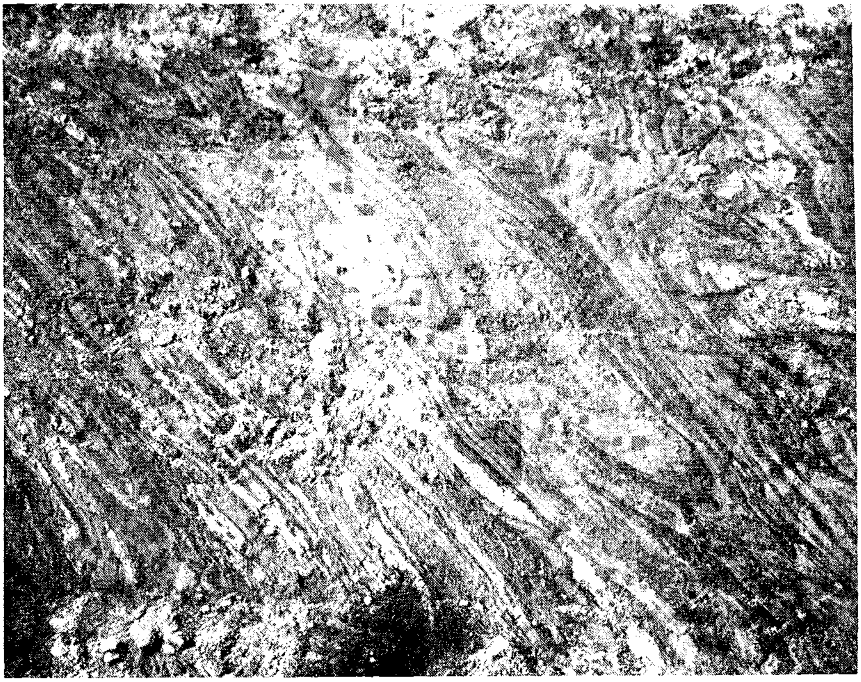
The separate deformational episodes have been recognized and defined on the basis of individual structural styles and relationships to one another and to regional metamorphic and magmatic events. This ordering of structural events assumes: (A) that these events at a given locality are separated by some time period, if no mutual cross-cutting relationships can be recognized; (B) that magmatic and regional metamorphic events can be treated essentially as points in time as far as assigning a "pre-", "syn-", or "post-" relationship to the structural event; and (C) that changes in structural style from point to point in space within a similar lithology are gradual enough to be recognizable in the field.

Deformation phase one (D_1).—The first major deformational phase recognized in the Northern Alabama Piedmont was an intense dynamothermal deformation (D_1) and recrystallization (M_1) within each lithotectonic unit. This phase is associated with the only period of progressive regional metamorphism known to affect the rocks. Later phases are retrogressive in nature. Earlier phases of metamorphism may have occurred, but mineral assemblages associated with these phases must have been converted to higher-grade assemblages. This period of prograde metamorphism (M_1) occurred under conditions of regional medium-pressure Barrovian facies series. The principal fabric element produced during this event was a foliation (schistosity), S_1, defined by preferred orientation of mineral assemblages of various grades depending on the location in the deformed belt. Neathery and Reynolds (1975) suggested, on the basis of textural criteria, that three separate periods of high-grade progressive metamorphism have occurred in this region. Confusion has arisen because of the complex interplay of retrogressive and progressive textures. Unfortunately, transposition of high-grade schistosities has apparently been interpreted (Neathery and Reynolds, 1975) to represent secondary and tertiary thermal metamorphic phases. As a result, some retrogressive textural changes appear to have been confused with progressive changes, leading to the interpretation of additional phases of high-grade metamorphism. Neathery and Reynolds (1973) described a "type A Wedowee" lithology which corresponds to the metamorphic lithologies produced during the first thermal event of Neathery and Reynolds (1975). Petrographic studies by this worker of samples collected from this sequence along a traverse 2 km south of the town of Mellow Valley suggest that these lithologies are commonly phyllonites which contain a transposed high-grade schistosity (see fig. 4). Where this early schistosity is not transposed, Neathery and Reynolds (1975) have interpreted it as evidence of a later thermal phase.

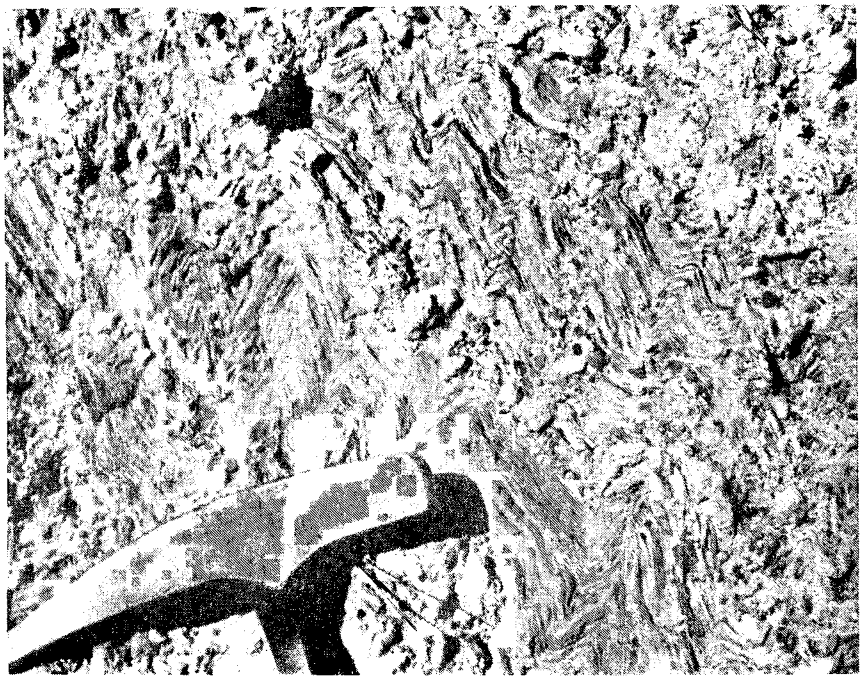
The S_1 foliation formed parallel to the axial surfaces of mesoscopic flow folds (F_1) (pl. 1-A) found throughout the region in each lithotectonic unit, thus indicating the contemporaneity of the foliation and the folding. The F_1 folds are invariably tight to isoclinal, ranging in interlimb angle from about 20° to 0°, and exhibit a "similar" or "flow" fold geometry. They are commonly asymmetric, with short limbs usually 80 to 90 percent shorter than the long limbs.

Throughout most of the metasedimentary rocks of the region, F_1 folds are defined by compositional layering (S_0) which ranges from fine laminations to lithologic units several hundred meters thick. In most cases this layering is believed to be sedimentary bedding largely transposed during D_1, so that it nearly always approximately parallels S_1 except in the hinge areas of F_1 folds. The primary compositional layering represents the only observed pre-S_1 planar structure in the region. Where marker horizons are largely absent in the more homogeneous country

PLATE 1



A. F_1-phase flow folds in biotite gneiss, muscovite biotite schist, and pegmatite of the Mad Indian Group in NW¼ sec 2, T. 19 S., R. 10 E.



B. F_3-phase crenulation folds in Talladega Group phyllite, 3 km west of Pyriton.

rocks, as in much of the Wedowee Group or many of the orthogneisses in the Tallapoosa block, F_1 folds are not visible, and the D_1 event is represented only by the D_1 tectonite fabric. Deformed dikes, pegmatites, and schlieren in some orthogneisses locally define F_1 folds. The foliation in these granitic gneisses parallels the axial surfaces of the F_1 folds, and the same foliation continues unabated across discordant contacts into the surrounding metasediments, where it can be recognized as S_1.

In many of the rocks, especially those of the Coosa and Tallapoosa blocks, the plane of the S_1 foliation contains a mineral lineation (L_{1m}) defined by biotite, muscovite, hornblende, quartz, crystalline graphite, or other minerals. The mineral lineation appears to have formed synchronously with the S_1 foliation, as many of the same minerals define both the planar and linear structural elements. At localities where F_1 folds have been identified in lineated rocks, the mineral lineations are parallel or subparallel to the F_1 fold axes. Because of the axial plane nature of the S_1 foliation, intersections of S_1 and S_0 commonly produce an intersection lineation (L_{1i}) which parallels F_1 and the mineral lineation. These three coaxial linear structures (F_1, L_{1m}, L_{1i}) are referred to as L_1 lineations in figure 3.

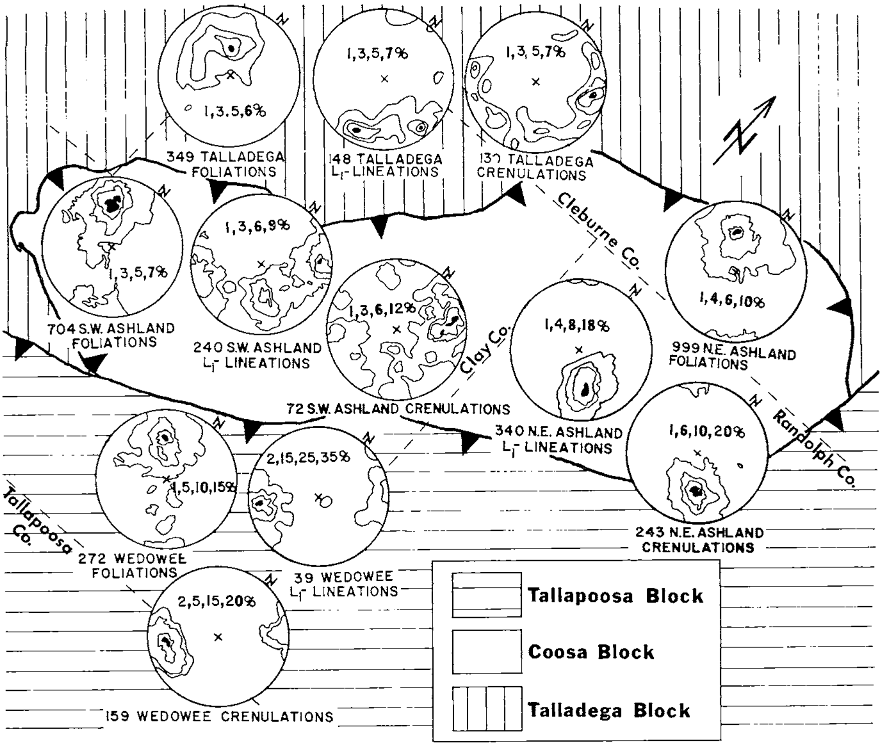


Fig. 3. Lower hemisphere equal area projections of mesoscopic structural data from portions of the major lithotectonic units in the Northern Alabama Piedmont.

D_1 phase linear structures (L_1) in the Tallapoosa block plunge gently with a constant orientation to the southwest. This trend is maintained to some degree in the southwestern portion of the northeast salient of the Coosa block (due to refolding by a later phase) but shifts approximately 90° to a strong down-dip lineation plunging moderately to the southeast in the central and northeastern part of this salient, resulting in reclined F_1 folds. D_1 phase linear structures in the Talladega block plunge gently to the south-southeast and do not trend exactly parallel to similar structures across the Hollins Line to the southeast (fig. 3).

The D_1–M_1 dynamothermal event appears to have been very intense and penetrative throughout the Northen Alabama Piedmont, yet megascopic structures relating to it have only rarely been identified. Mesoscopic folds with opposite vergences have been mapped in many areas throughout the region. These opposite vergences could result from a slight divergence between S_1 and S_0 in opposite senses. It is also possible that the opposite vergences formed when large-scale F_1 folds were generated during this phase, but their existence has rarely been documented for the following reasons: (A) detailed stratigraphic knowledge necessary to prove large-scale repetition of strata is lacking in most parts of the region; (B) several phases of folding follow F_1, resulting in complicated polydeformed geometries which obscure large F_1 folds; (C) large-scale faulting which occurred along the boundaries of the major blocks may have dissected any first-order nappe structures near hinge areas, so that only partial remnants remain. It is hoped that as additional detailed field mapping is conducted, the problem of the existence of these structures can be resolved.

D_1-phase structures can be observed at a number of localities throughout the Northern Alabama Piedmont. Several excellent exposures are described in detail in Neathery and Tull (1975). A mesoscopic folding phase that is earlier than F_1 has been recognized at a few localities in the Talladega and Coosa blocks. This phase is pre-M_1 and thus has no associated fabric, since most of the rocks were totally recrystallized during M_1. The observed folds may have occurred during soft-sediment deformation or during a pre-D_1 phase of tectonism. The phase has been recognized by the interference patterns produced during F_1 folding of compositional layering. These folds are extremely rare, and their importance is unknown.

Deformation phase two (D_2).—Large sections of the Tallapoosa block and parts of the Coosa block exhibit a second phase of deformation, which modified the D_1 fabrics to various degrees and retrograded M_1 mineral assemblages. This phase, termed D_2–M_2, has not yet been identified in the Talladega block but appears to be responsible for the major retrogression experienced by the two lithotectonic blocks to the southeast. This retrogression is evidenced by garnet, hornblende, and biotite alteration to chlorite and by possible secondary growth of sericite. The net effect of this intensive dynamic phase is a retrogressive textural and occasional mineralogic change that has produced variably developed phyllonitic textures, ranging from slightly deformed coarse-grained mica schists to fine-grained phyllonites or phyllitic mylonites. These changes are most apparent in pelitic rocks and are developed to the greatest degree in rocks of the Wedowee Group. Several workers (Jonas, 1932; Griffin, 1951; Neathery and Reynolds, 1975) have recognized the phyllonitic and retrogressive nature of many of the rocks in this region, but the dynamic events resulting in retrogression are poorly understood and have received little attention.

The D_2–M_2 phase resulted in a decrease in grain size in the D_1–M_1 mica schists, commonly producing phyllitic rocks that can rarely be distinguished from normal metamorphic phyllites in hand specimen. Studies of these rocks in thin section indicate, however, that the S_1 foliation has been severely transposed into a phyllonitic S_2 foliation by intensive tight microscopic crenulation folding (F_2) and shearing (fig. 4). S_2 is dominantly a cataclastic foliation resulting from anastomosing fluxion structures which bound the limbs of the F_2 microfolds and tend to obliterate them. The phyllosilicates are kinked, broken, and sheared, but the more mechanically competent porphyroblasts such as garnet remain essentially undeformed, although locally they are retrograded to chlorite.

Mesoscopic folds related to this phase of deformation have not been recognized and may not exist. Very thick zones of differential ductile shear essentially parallel to S_1 may have been responsible for these textures, but these zones apparently did not develop mesoscopic folds, nor did they develop into zones recognizable as faults. Good exposures of rocks exhibiting D_2 textural changes can be found along Alabama High-

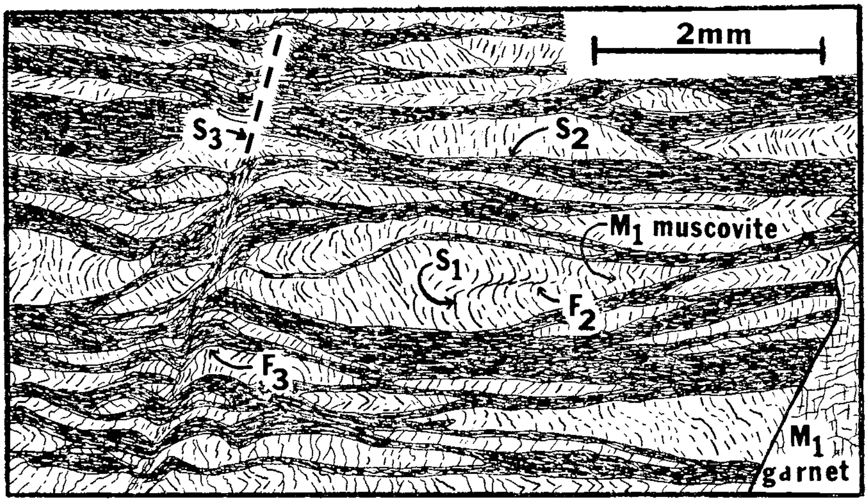


Fig. 4. Line drawing from photomicrograph of Wedowee D_2-phyllonite, 2.5 km (1.5 miles) south of Mellow Valley, Clay Co., Ala. Intensively kinked (F_2) and sheared S_1 schistosity (light lenses) becomes transposed into a fine-grained mylonitic matrix, S_2, (dark zones). Crenulation folding (F_3) of S_2 fluxion structure produces crenulation cleavage (S_3).

way 77, between Mellow Valley and Wadley in southeastern Clay and southwestern Randolph Counties, and along county roads leading east of Newell in northwestern Randolph County.

Deformation phase three (D_3).—The D_1 and D_2 fabrics and structures were deformed by another intensive dynamic event termed D_3, which produced folds of various sizes ranging from fine hair-like crenulations to tight megascopic folds more than 1 km in wavelength. These structures are termed F_3 mesoscopic and megascopic folds and are generated by flexural slip within the S_1/S_2 planes (pl. 1-B).

The axes of these folds plunge gently to the southwest in the Tallapoosa block, resulting in some northwestward dips of S_0, S_1, and S_2. In southern Clay County, the northeast-southwest trend of the F_3 folds in the Coosa Block is maintained, but dominant plunges are shallow to the northeast rather than to the southwest. In northeastern Clay County these folds shift, plunging moderately to the southeast down the dip of the foliation. In the Talladega block northeast-southwest trending F_3 folds are doubly plunging to the northeast and southwest because of later northwest-southeast cross-folding (F_4) (figs. 2 and 3). F_3 axial planes generally dip steeply to moderately to the southeast, although northwest-dipping axial planes occur as well.

The typical northeast-southwest Appalachian fold trend is thus maintained by the D_3 phase structures in most of the region and results in tight flexural-slip folds commonly overturned to the northwest. It is interesting to note that D_1 and D_3 phase structures are coaxial across both the Tallapoosa and Coosa blocks but differ by as much as 90° from one another in the Talladega block.

Commonly, crenulation folds generated during D_3 have developed a crenulation cleavage (S_3) parallel to their axial planes (fig. 4). This cleavage is non-penetrative and appears to have little or no associated recrystallization. It appears to be best developed along isolated zones, dying out rapidly across its strike in both directions. When this cleavage is developed to an extreme, S_1 and S_2 schistosities may become transposed, but this does not appear to be common. In some cases differentiated layering may be produced on a small scale. Crenulations related to this phase post-date D_2, since they fold S_2 and D_2-microfolds. Good exposures of D_3 phase folds that deform D_1 and D_2 phase structures occur along Alabama Highway 77 between Mellow Valley and Wadley in southeastern Clay and southwestern Randolph Counties and along U.S. Highway 431 northwest and southeast of Wedowee.

Deformation phase four (D_4).—D_3 phase structures have been disrupted along the Hollins Line Fault system (fig. 2). Earlier workers (Adams, 1926; Griffin, 1951) suggested that this line was an extension of the Whitestone Fault of Georgia. Throughout most of its length, the Hollins Line represents a contact between high-grade (upper amphibolite facies) and low-grade (lower greenschist facies) metamorphic rocks.

An important feature of the Hollins Line is the regional discordance of lithologic units and early formed structures produced in both the upper and lower plates. The lithologic discordance is most marked in the upper plate within the Poe Bridge Mountain and Higgins Ferry Groups, where large portions of the section are truncated against the fault (fig. 2). Because of the arcuate trace of the fault system, many lithologic units within the Poe Bridge Mountain Group are truncated against it in both directions along their strike. Perhaps the most spectacular evidence of these relationships can be observed west of Millerville, in south-central Clay County, where sharp ridges of graphite quartz schist and quartzite in the Poe Bridge Mountain Group are abruptly terminated against the fault. Similar discordance can be seen in south-central Cleburne County, where distinctive amphibolite sequences strike obliquely into the fault.

The geometric relationships between the trace of the fault and the trend of the units in the upper plate (Coosa block) suggest that the upper plate lithologies exerted little or no control over the position of the fault and that in fact the fault cut obliquely through the units.

Discordant relationships are not as common in the lower plate. The fault occurs at approximately the same level within the Hillabee Chlorite Schist for distances of greater than 10 km along strike before changing to a higher or lower level (fig. 2). In general, the Hillabee Chlorite Schist is no more than a few hundred meters thick below the fault. This suggests that the position of the fault was at least in part controlled by the lower-plate rocks. In several places, however, the fault has cut more deeply into the Talladega sequence and juxtaposes units that occur a few hundred meters below the Hillabee with the upper plate, eliminating the Hillabee altogether. At other localities, the fault has ridden somewhat higher into the Talladega sequence, preserving a section of the Hillabee some 2.7 km thick. As with the lithologic units, discordance across the fault is also characteristic of small-scale structures, particularly early formed (D_1 and D_3) linear structures.

In spite of the regional lithologic and topographic discordance observed along the Hollins Line, discordance along the fault is seen more rarely on the outcrop scale. Foliations in the Hillabee in the fault zone are approximately parallel to those in the rocks of the Poe Bridge Mountain and Higgins Ferry Groups, giving the appearance of concordant stratigraphic relationships. The contact zone is characterized by cataclastic schists (button schists) and phyllonites in the rocks of the upper plate and phyllites and phyllonites in those of the lower plate. The contact between the Talladega and Coosa blocks generally is knife-sharp, with no obvious interlayering of lithologies. The dip of the fault surface is variable up to 70° in some places, but shallow dips less than 20° have been found by deep drilling through the upper plate 12 km (7 miles) west of Millerville.

The southwestern part of the Hollins Line Fault system in east Chilton and western Coosa Counties is characterized by an imbricate zone in which the upper part of the Talladega block, including the Hillabee, is repeated in a series of slices. The faults bounding these slices anastomose in such a way that the Hillabee is repeated twice in some sections and is completely absent along others. Rocks in the upper plate do not appear to be imbricated along the fault zone.

Deformation phase five (D_5).—The Hollins Line Fault system has been deformed by a phase of folding referred to as F_4. These structures are open flexural slip folds and are represented locally by crenulations which crosscut earlier formed structures, including F_3 folds, and plunge gently to the southeast. At many localities two phases of crenulations are thus present. Several megascopic F_4 folds occur within the Talladega and Coosa blocks. Two such major structures are responsible for the reentrants in the Millerville and Hightower regions which isolate the northern salient of the Coosa block (fig. 1).

The presence and location of these reentrants or half windows suggests that the horizontal component of displacement along the Hollins Line, measured normal to the general fault trend, was a minimum of 18 km (12 miles). The metamorphic grade change suggests that the vertical component of movement may have been fairly large as well. These F_4 folds deform the Hollins Line Fault system but do not affect the Goodwater-Enitachopco Fault system to the southeast, which implies that the Goodwater-Enitachopco Fault is younger than the F_4 folding episode. The two major reentrants are reflected somewhat by reentrants along the Talladega Fault system and similar structures in the Valley and Ridge to the northwest.

Deformation phase six (D_6).—The Goodwater-Enitachopco Fault system apparently cuts the Hollins Line east of Millerville and north of Hightower (figs. 1 and 2). This system thus postdates the Hollins Line Fault but is undeformed by the F_4 cross-folds. The fault system has been observed at a number of localities, but its existence in other areas connecting known faults is speculative at present because of limited mapping. The northeasternmost extent of this fault system in Alabama, in southeastern Cleburne County, was mapped by McCalley and described by Adams (1926). From north of the village of Hightower to at least the Georgia line, this fault system juxtaposes rocks of the Tallapoosa block (Wedowee Group) with the Talladega block and eliminates the entire Coosa block and the Hollins Line Fault by overthrusting (fig. 1). Hightower is located at the triple-point junction of the three lithotectonic units. West and southwest from Hightower to Millerville is the northeastern salient of the Coosa block (fig. 2). The Poe Bridge Mountain Group lithologies and other rocks within the Coosa block apparently terminate against the fault south of Hightower and do not appear again northeastward in Alabama (fig. 2). In northern Randolph County the presence of this fault structure is speculative because of insufficient mapping, but along strike to the southwest in western Randolph County, Neathery and Reynolds (1975) recognized a line of structural discontinuity which they termed the Enitachopco Line. This line was recognized as an important fault zone in localities to the southwest in central Clay County by Prouty (1923).

In the area just east of Millerville is a second triple-point junction between the three major tectonic units, where the northeastern Coosa block salient terminates again against the Goodwater-Enitachopco Fault system (fig. 1). Again, the Wedowee rock units are in contact with those of the Talladega block, but only for a short distance before the Coosa block and Hollins Line Fault system reappear to the southwest and form the southwestern Coosa block salient, which continues to the Coastal Plain.

Along strike farther to the southwest, in northeastern Coosa County, Reynolds (ms) described the Goodwater Fault as an important zone of probable thrusting along which the Wedowee rocks have moved against rocks of the Hatchet Creek Group. The nature of the contact between the Wedowee and Hatchet Creek Groups southwest of the Goodwater Fault is unknown because of the lack of detailed mapping, but it is likely that the fault system continues to the overlap of the Coastal Plain in Chilton County. If the above described faults are indeed continuous, then the Tallapoosa and Coosa blocks are separated by a significant fault system stretching for a minimum length of 146 km (91 miles).

The style of the Goodwater-Enitachopco Fault system is somewhat different than that of the Hollins Line System. For example, rather than being represented by a sharp contact, the Goodwater-Enitachopco Fault system is a complex zone of brecciation from 4 to greater than 50 m thick. Similarly oriented breccia slices of a number of different lithologies occur within this zone in a matrix of phyllonites, mylonites, and tectonic schists, completely surrounded and isolated by tectonic contacts. Anastomosing cataclastic foliations separate the slices from each other. Earlier foliations within the breccia slices are commonly discordant to one another in adjacent slices and to the cataclastic foliation. The fault system appears to truncate lithologic units in the lower plates (Talladega and Coosa blocks) but generally parallels those in the upper plate (Tallapoosa block). Secondary planar structures are discordant across this line in many localities, and there is a marked change in the orientation of early formed linear structures as well.

The magnitude of movement along the Goodwater-Enitachopco Fault system is difficult to estimate, because it juxtaposes units of similar lithologic affinities and metamorphic grade throughout most of its length, and because no windows are known to exist in the Tallapoosa block. However, the relations north of Hightower where the Wedowee Group is faulted against the Talladega Group suggest major reverse faulting. The dip on the fault is steep in most places, ranging between 65° and 75° where measured at the surface.

CHRONOLOGY OF EVENTS

The events described above should be placed in an absolute geologic time framework in order to understand more fully the tectonic history of the Northern Alabama Piedmont. Unfortunately, the present knowledge of the ages of these events allows only broad generalizations. The

Jemison Chert fossils in Chilton County have been used to suggest relative ages for the units in the Talladega block as well as a maximum age for the metamorphism of this lithotectonic unit (Shaw, 1970).

Orthogneisses most likely intrusive into sediments of the Tallapoosa block have yielded Rb-Sr and U-Pb ages between 500 and 530 m.y. (Russell, 1975). Because these orthogneisses became highly deformed and metamorphosed during the D_1–M_1 events described above, the Middle to Late Cambrian isotopic ages suggest a minimum age for the Tallapoosa block metasediments and a maximum age for the D_1–M_1 events. Conventional K-Ar mica ages from the Tallapoosa block, Brevard Zone, and Inner Piedmont of 300 to 324 m.y. (Wampler, Neathery, and Bentley, 1970) provide a minimum absolute age for D_1–M_1 and probably represent ages of the uplift and emplacement of the D_4 and D_6 thrust nappes. This would suggest an Alleghenian deformational origin for such events. Because of the higher blocking temperature of hornblende, a single K-Ar hornblende age of 348 m.y. (Wampler, Neathery, and Bentley, 1970) from the Coosa block may more realistically imply a Devonian age for D_1–M_1 and would be in general agreement with the ages of the Jemison Chert fossils. If such ages should prove to be applicable to the D_1–M_1 events, then there appears to be little structural evidence for pre-Devonian tectonism in the Northern Alabama Piedmont. With the limited geochronologic data presently at hand, however, the possibility of earlier absolute ages for D_1–M_1 certainly should not be ignored.

DISCUSSION OF STRATIGRAPHIC-TECTONIC RELATIONSHIPS

The above discussion of the region's structural development shows that the Northern Alabama Piedmont is a highly strained belt that experienced intense plastic deformation during several early phases and was deformed into thrust nappes that were translated northwestward during later phases of development. The development of the large reverse fault systems apparently coincides roughly with the development of similar structures in the adjacent Valley and Ridge. Structural relationships in the Cartersville region (Hurst, 1973; Geologic Map of Georgia, 1976) and similar relationships described above in the Northern Alabama Piedmont suggest that the major reverse faults in the crystalline rocks of this region become progressively younger to the southeast. A similar situation has been reported for the southern Valley and Ridge province and has been used to support a gravity model of breakback thrusting as an emplacement mechanism (Milici, 1975). It is difficult to envision a similar mechanism for the emplacement of the crystalline lithotectonic units described above because: (A) in many cases the Piedmont faults dip rather steeply southeastward, requiring large-scale post-emplacement rotations, (B) the faults in general are not localized in any "glide zones" but commonly cut obliquely and randomly through thick highly deformed sequences of crystalline rock. A compressional mechanism for the generation of these structures is thus preferred.

If one assumes an approximate contemporaneity of Valley and Ridge thrusting with Northern Alabama Piedmont reverse faulting, two different faulting mechanisms appear to be necessary for the two provinces, if the major Valley and Ridge faults are indeed the result of gravity emplacement. Dennison (1976) suggested that gravity tectonics caused the emplacement of the thrust plates in the Valley and Ridge during an early Allegheny phase. He felt, however, that overthrusting of the Blue Ridge occurred during a later Allegheny phase, possibly as a result of some degree of compressional tectonics.

A number of authors have suggested correlations between the various lithotectonic units described above based on different interpretations of the boundary relationships. For example, Shaw (1970) proposed that the Talladega Slate Belt was bounded below and to the west by a pre-middle Ordovician unconformity in the Sylacauga region. This, of course, implies the absence of the effects of Taconic deformation throughout the Talladega belt. The Talladega Fault hypothesis, on the other hand, suggests the possibility of different stratigraphic and tectonic relationships within the Talladega block than might be implied by the unconformity hypothesis, especially when it is realized that the correct facing of most of the belt is unknown and that the exact structural relationships of the Jemison Chert sequence are still unresolved. The presence of polydeformed phyllonites along the contact between the Valley and Ridge and the Talladega block, discordance of units both above and below this contact, and the presence of deformational phases and structural styles in the rocks above the contact which are not known to occur in the sediments below strongly suggest major faulting along the northwestern Talladega boundary. Such faulting tends to obscure possible unconformable relationships (Bearce, 1973).

Although early workers (Adams, 1926; Griffin, 1951) interpreted the Hollins Line as a continuation of the Whitestone Fault along which the Hillabee Chlorite Schist had been intruded as a syn-kinematic mafic sill, more recent workers have interpreted this line as a zone of steep metamorphic gradients along a normal stratigraphic contact with only local faulting (Reynolds, 1972; Neathery, 1972; Neathery and Reynolds, 1973). According to the latter hypothesis the sequences to the southeast of this line, which appear to occur stratigraphically above the Jemison Chert, represent the youngest metasedimentary rocks in the Northern Alabama Piedmont (Neathery and Reynolds, 1973). The fault hypothesis for this line, which is outlined above, assumes no relative ages for the high- and low-grade belts but places them in completely separate lithotectonic units. The presence of the Goodwater-Enitachopco Fault system and its probable extension into Randolph and Cleburne Counties between the Wedowee and Poe Bridge Mountain Groups (fig. 2) suggests that these two groups are not physically continuous and possibly not correlative as was suggested by Neathery and Reynolds (1973).

The continuity and correlation of the Northern Alabama Piedmont rock sequences with those farther to the northeast in the Blue Ridge have also been subjects of some debate (Hurst, 1973). The Talladega and Tallapoosa blocks continue into the northwest Georgia Piedmont, but the Coosa block is not known definitely to continue north of Hightower, Ala. The Talladega rocks appear to terminate in the Cartersville region of Georgia (Geologic Map of Georgia, 1976). The Emuckfaw Formation, which forms the southeastern belt of the Tallapoosa block, was originally mapped as part of the Ashland Mica Schist (Adams, 1926). Although this sequence does have certain similarities to the Ashland Supergroup in the Coosa block (such as an abundance of amphibolites in certain zones), a direct continuity between the two units has never been shown. Rocks of the Emuckfaw Formation apparently continue through Georgia into North Carolina where they have been correlated with the Ashe Formation (Hurst, 1973). Thus the two northwestern lithotectonic units in the Northern Alabama Piedmont become overthrust along strike to the northeast by the Tallapoosa block. The latter belt may continue into the eastern Blue Ridge of North Carolina. The loss of the Talladega and Coosa blocks to the northeast may be important for regional prethrusting reconstructions of the Georgia and North Carolina Blue Ridge. Thick crystalline sequences, some of which may contain Lower Devonian strata, possibly root beneath the Allatoona Fault in the Georgia Blue Ridge.

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