GEORGIA

STATE DIVISION OF CONSERVATION

DEPARTMENT OF MINES, MINING AND GEOLOGY

GARLAND PEYTON, Director

THE GEOLOGICAL SURVEY

Bulletin Number 57

GEOLOGY AND MINERAL RESOURCES OF THE DALTON QUADRANGLE, GEORGIA-TENNESSEE

By

Arthur C. Munyan

ATLANTA

1951

Looking east toward the Cohutta Mountain front.

LETTER OF TRANSMITTAL

Department of Mines, Mining and Geology

Atlanta, July 16, 1951

To His Excellency, Herman Talmadge, Governor

Commissioner Ex-Officio, State Division of Conservation

Sir:

I have the honor to submit herewith Georgia Geological Survey Bulletin No. 57, "Geology and Mineral Resources of the Dalton, Quadrangle, Georgia-Tennessee." This investigation was undertaken by Arthur C. Munyan as a dissertation problem for the degree of Doctor of Philosophy at the University of Cincinnati. It is desired to point out that this report represents one example among many of cooperation between the Georgia Geological Survey and the universities. The productivity of our small permanent staff is appreciably expanded by sponsoring geologic research projects of this type, conducted by outstanding graduate students.

This bulletin, prepared at little expense to the State, is a detailed report upon a part of the Paleozoic area of Northwest Georgia, and reviews the stratigraphic, structural and economic geology of that part of the State. Particular reference is made to the mineral resources of the area which include barite, clay, limestones and dolomites, manganese and iron, and tripoli.

It is believed that this report will have transfer value to the solution of economic problems of adjacent areas.

Respectfully,
GARLAND PEYTON
Director

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GEOLOGY AND MINERAL RESOURCES OF THE DALTON QUADRANGLE, GEORGIA-TENNESSEE

By

Arthur C. Munyan

ABSTRACT

The Dalton quadrangle (Ga.-Tenn.), located in northwest Georgia within the Ridge and Valley province, is a fifteen-minute quadrangle with topographic base by the U. S. Geological Survey. Because of the excellence of the base map and the location of the quadrangle in an area of lower Paleozoic rocks, it was selected as a beginning point for a re-investigation of the geology of northwest Georgia.

Study of the quadrangle, primarily concerned with the stratigraphy and structure of exposed Cambrian and Ordovician strata in it, has resulted in a map showing the areal geology in considerably greater detail than has been done formerly. Some modifications and revisions of previous work have been established and suggested.

Outcropping formations of the Cambrian system consist, at least in part, of the following, described in ascending order: Weisner (?) quartzites and conglomerates, Rome sandstones and siltstones, Conasauga shales and limestones, and the lower part of the Knox dolomite.

The upper part of the Knox and the overlying Newala formation, previously assigned to the Lower Ordovician, may more properly belong with the Cambrian, because of the absence of a detectable interruption between the lower and upper Knox. On the other hand, a probable unconformity, which is thought to truncate the Newala as well as part of the Knox, seems to be a more natural and logical surface of separation between the two systems. This tends to confirm similar observations in east Tennessee and Virginia. The relative uniformity and persistence of Cambrian strata seem

to be in sharp contrast to the apparently inconstant character of some of the Ordovician formations in the area.

Exposed formations of the Ordovician present varying aspects on the eastern and western sides of the quadrangle because of facies differences. Some of the formations could be mapped separately in some areas, but general poorness of outcrop combined with lack of fossils and absence of determined strike continuity required that judgment of their exact equivalencies be reserved until adjacent areas are studied. Nevertheless, certain suggestions are presented and provisional names assigned to some units, but all are presently grouped as "post-Knox Ordovician."

Primary structural features of the quadrangle were simultaneously investigated with the stratigraphy, and are described and interpreted. Faulting and folding are demonstrated to be the chief cause of outcrop lineation. Several types of faults are discussed.

The mineral resources of the quadrangle are described and evaluated insofar as possible. Some recommendations for their future development are also made.

Tentative suggestions are offered to explain the geologic history of the area, in an attempt to stimulate future investigations in the Paleozoic area in Georgia.

INTRODUCTION

Purpose of Investigation

Geologists have been engaged for many years with problems of the Paleozoic rocks of the southeastern United States, but the Georgia region has, perhaps, not received the same amount of attention as adjacent states. This is particularly true in recent years, because only two reports of regional significance have been issued since 1947 dealing with Paleozoic rocks in the State. These are a report by Charles Butts, published in 1948 but written in 1937, and a comprehensive discussion of the Cartersville district by Thomas Kesler, in 1950. Considerable opportunity exists, therefore, for additional investigations of Paleozoic rocks in Georgia.

Controversies have inevitably arisen over certain critical phases of Paleozoic geology in Georgia; some of the arguments have been resolved satisfactorily but others continue unabated. Largely, the differences in opinion have arisen because of various interpretations which lead to dissimilar conclusions. But, on the whole, relationships and philosophies established in other regions have not, in the past, been applied in Georgia. Recent advances in knowledge demand, consequently, a re-examination of a large part of the Paleozoic section of Georgia.

One of the better known but still controversial areas within the Paleozoic region of the State is the Cartersville District which borders the Piedmont province on the west. Because obvious faults separate the Ridge and Valley from the Blue Ridge farther north, many investigators have been led to assume that a master fault—the "Cartersville" fault—separates the Paleozoic rocks of the Cartersville district from the crystalline rocks of the Piedmont. Kesler (1950), however, believes there is no demonstrable fault at that location in the Cartersville area. In addition, Kesler has raised many other questions about the stratigraphy of the Paleozoic sediments which cannot be answered satisfactorily within the district because of its isolation.

The present investigation was undertaken to help clarify many of the problems existing in the Georgia Paleozoic section. It is hoped that this initial study will be a nucleus from which, by expansion, the entire Paleozoic area, including the Cartersville district, could be re-mapped. Selection of the area which was to serve this purpose therefore had to be made carefully and with consideration for several factors.

First, the area selected should have an accurate topographic base map. Second, it should be located geographically as close as possible to Tennessee, in order to relate the Georgia section to the better known Tennessee section. Third, the area should be large enough to warrant careful investigation, but not too large to necessitate reconnaissance methods. And fourth, it was felt that the rocks of the area should represent the lower part of the Paleozoic column, so that an orderly progression of successively younger strata would be established as regional mapping continued beyond the limits of the chosen area.

The Dalton quadrangle met all of these requirements as far as could be determined from a preliminary survey. It was selected, as a result, to be the first step of the larger regional study. Few regrets have been made over its choice.

Field Work

Preliminary investigation of the Dalton quadrangle was begun in 1941, but the intervention of World War II, with travel restriction, prevented immediate completion of the project. Work was resumed in 1946 but no concerted effort was possible until the 1948-1950 interval. Field work was completed in September, 1950.

The press of university teaching duties prevented completion of field work as promptly as could have been desired, but the delay made available many opportunities for consultation and advice that otherwise could not have been obtained. The actual field work, done chiefly on weekends during the two year interval, probably would represent, chronologically, from six to seven months' work.

Acknowledgments

Many individuals have contributed time and advice to the investigation, but it was through the great interest and generosity of Garland Peyton, Director, Georgia Division of Mines and Geology, that the project was made possible initially, then carried to completion. Special thanks for inspiration and guidance must be paid to Dr. John L. Rich and Dr. Gordon Rittenhouse of the Department of Geology and Geography, University of Cincinnati, as well as to Dr. Kenneth E. Caster of the same institution.

Particular gratitude is due the members of the field conference held in the area in mid-July, 1950. These are: John Rodgers, Yale University; Robert A. Laurence, Philip King, Robert Neumann, George Swingle, United States Geological Survey; and A. S. Furcron and Brandon Nuttall, Georgia Division of Mines and Geology. Emory University made facilities available for research.

Many residents of the Dalton quadrangle also contributed much to the success of the investigation. Among them were: Mr. Keith, Eton, Ga., Mr. and Mrs. Lester Quarles, Chatsworth; Mr. M. W. Glenn and Mr. Francis Glenn, of the Georgia Talc Company, Chatsworth; and others too numerous to mention. All property owners were most cooperative and facilitated the investigation by pointing out rock exposures which otherwise could not have been located.

Methods of Map Preparation

The preparation of the geologic map (Plate VIII) has been done in the ordinary manner but with several inovations that warrant some explanation. Originally it was hoped that an outcrop map could be prepared to accompany the areal geologic map, but this soon proved impracticable because of the poorness of the exposures. It was decided, therefore, to employ a system by means of which some degrees of certainty of formational boundaries and faults could be expressed. This has been done in the following manner:

Formational boundaries:

> Solid lines are positive contacts; dashed lines are approximate contacts; and dotted lines are less certain contacts.

Fault traces:

> Solid lines are well-defined faults; dashed lines represent approximate, covered faults; and dashed lines with question marks are less certain faults or faults within a single formation. The overthrust side of the fault is shown by a—"T", while normal faults have the upthrown side designated by—"U", and the downthrown side by—"D".

Station numbers are shown on the areal geologic map (Plate VIII) to aid in the written descriptions found in the text of the report. Dips and strikes are also indicated on the map.

The cross-sections accompanying the map are somewhat diagrammatic in that precise reproduction of topographic profiles has not been attempted. Furthermore, the vertical scale is five times the horizontal scale, although the dips of the fault planes are approximately true in relation to the strata.

Location

The Dalton quadrangle occupies an area in northwestern Georgia bounded by the parallels 34° 45′ and 35° 00′ N., and the meridians 84° 45′ and 85° 00′ W. (Fig. 1.). It is the northwestern quarter of the 30 minute, Dalton quadrangle of 1895 published with scale of 1/125000 and a contour interval of 100 feet. Increases in population with attendant construction of new roads and highways, as well as new railroad right-of-ways after 1895, necessitated a re-survey of a portion of the area covered by the older map. Three of the four 15 minute quadrangles in the 30 minute Dalton quadrangle of 1895 have now been issued. The present 15 minute Dalton quadrangle map edition was published in 1943 on a scale of 1/62500 and a 20 foot contour interval. It was prepared largely from aerial photographs and is remarkably accurate in most details. No major deviations from topography were noted, but some very minor modifications, inevitable with the passage of time, were noted in culture, such as new roads constructed since 1936 and relocation of some roads which were in existence before that time.

Hereafter in this report the words "Dalton quadrangle" will refer exclusively, unless otherwise specified, to the 15-minute quadrangle which now bears that title.

The Dalton quadrangle includes, in Georgia, the northwestern part of Murray County, the northern half of Whitfield County, and a very small strip of the northeastern corner of Catoosa County. The quadrangle extends into Tennessee for a distance of approximately 0.85 miles north of the Georgia line, and includes in Tennessee, west to east, a small part of southeastern Hamilton County, a narrow strip of southern Bradley County, as well as a very small part of the southwestern corner of Polk County.

Main lines of two major railroads traverse the area from north to south, and a third railroad of equal rank passes

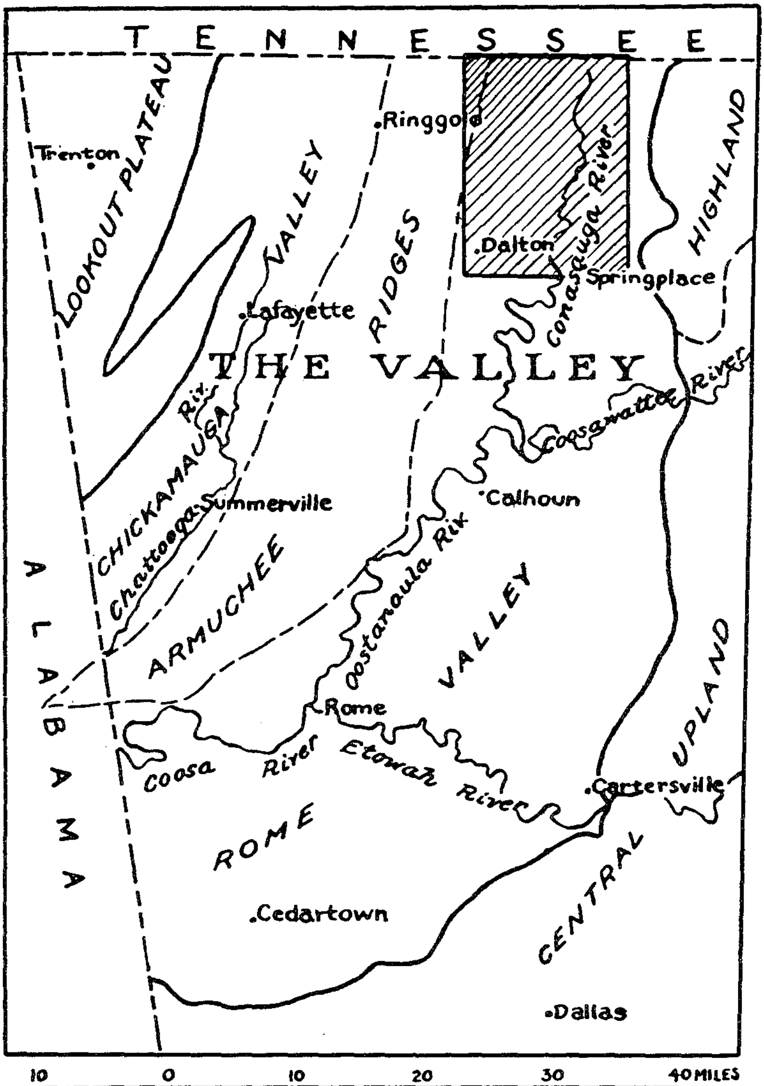


Fig. 1. Topographic divisions of northwest Georgia, showing location of Dalton Quadrangle.

across the southwestern corner of the area. The Louisville and Nashville right of way from Atlanta to Knoxville crosses the southeastern portion of the quadrangle in Murray County. The Southern Railway is located from three to four miles east of the western boundary of the quadrangle and essentially parallels it across the area from north to south. On the other hand, the N. C. and St. L. tracks enter the area about one half mile south of Dalton, then turn abruptly westward about a mile north of that city to leave the area.

Most of the important communities are located along the railroad right-of-ways and at least one of them, Chatsworth. has grown up as a result of the railroad's location. The city of Chatsworth, now the county seat of Murray County, lies astride the tracks of the Louisville and Nashville Railway. Formerly, when the 1895 Dalton map was published, the county seat was Spring Place, about 2½ miles west of Chatsworth; the railroad had not then been constructed. Similarly, the village of Eton, now some three miles north of Chatsworth, does not appear on the older map, and has, therefore, developed as a result of the railroad line. To the west, lies Dalton the largest city of the area and county seat of Whitfield County. It is situated in the southwestern corner of the quadrangle and is served by both the Southern and N. C. and St. L. railroads. North of Dalton, along the Southern route, are Varnell and Cohutta, both of which, though small, are thriving communities. Other, still smaller communities too numerous to list are located along the various major highways serving the area.

Chatsworth is the crossroads for U. S. 411, which is the main Atlanta to Knoxville highway, and U. S. 76, a scenic road from Wilmington, N. C. to Chattanooga, Tenn. U. S. 76 also passes through Dalton where it joins U. S. 41 connecting Atlanta to Chattanooga. State Route 71, north from Dalton, is a major link in a chain of state roads north in Tennessee. Numerous secondary roads within the limits of the quadrangle are paved or improved so that they provide access in all weather to the various communities.

Dalton is widely noted for its chenille industry. This manufacturing process, which only a few years ago was in the handcraft stage, has now become a highly mechanized industry employing large numbers of workers drawn from the vicinity. Chenille plants are located also in many other towns and villages of the area and provide a stable income and employment. Much of the growth of the industry is attributable to low-cost electric power, as well as to the initiative of the owners and employees.

A large proportion of the inhabitants of the Dalton quadrangle are farmers and land owners who have in the past and at present provided the human foundations necessary for the growth of the towns and cities serving the section. Crops are diversified but are now tending towards greater livestock production than formerly. This increases the acreage of grassland which in turn improves the soil. Other soil conservation practices such as contour plowing, terracing, reforestation and so forth, are increasing tremendously the value of farmlands within the quadrangle.

Mineral production in the Dalton quadrangle is now confined to limestone for agricultural and aggregate purposes, chert for road metal, along with sporadic manganese, iron, and some barite mining. Two companies in Chatsworth process talc and shale mined in the nearby Cohutta Mountains to the east and at one time considerable quantities of shale were mined for brick making.

PHYSIOGRAPHY

The Dalton quadrangle lies wholly within what has been termed (Butts and Gildersleeve, 1948, p. 3) the Paleozoic area of northwest Georgia which occupies portions of two physiographic provinces—the Appalachian Plateaus on the west and the Ridge and Valley on the east, but the Dalton quadrangle lies entirely within the latter (Fenneman, 1938, Pl. III.). These natural subdivisions, while not so named by Hayes (1899) were described by him in some detail. Later M. R. Campbell (1925) restudied and described the area carefully, but still retained the term "The Valley" for the section called the Ridge and Valley by Fenneman. Campbell's Lookout Plateau, however, was recognized by him to be a part of the larger Appalachian Plateaus province. At the

Tennessee line, The Valley is approximately 35 miles wide, but swinging southward then westward toward Alabama in a broad arc, it widens to a maximum of 53 miles along a line from Cartersville northwestward to the base of Lookout Plateau (Fig. 1).

The Valley, in general, has much the same characteristics in Georgia as it has elsewhere, but its relief in the southern sector is considerably less than that farther north. Elevations within The Valley range, on the average from 600 to 800 feet above sea level, although some ridges are considerably higher. However, the mountains of the Blue Ridge to the east and the escarpment of the Plateau to the west are from 1000 to 2000 feet higher than the average elevation in The Valley. The difference in elevation results both from the type of rock underlying the several provinces and from the structural attitude of these rocks. The rocks of the Blue Ridge province are hard crystalline materials which resist erosion and weathering, whereas those of The Valley are mostly limestones and shales that are relatively less resistant and thus stand at lower elevations. On the west, The Valley is bounded by the prominent, east-facing escarpments of Lookout Mountain marking the eastern edge of the Appalachian Plateaus province. The nearly horizontal strata of the Plateaus, largely capped by resistant Pennsylvanian sandstones, stand out in bold relief from the crumpled beds of The Valley.

A detailed examination of The Valley shows that it has, in reality, a greatly diversified floor which consists of broad plains, and low rounded, as well as sharply serrate, linear ridges which have developed because of differential erosion on beds of varying resistance and structure. Campbell (1925, pp. 138-139) subdivided The Valley into three parts (Fig. 1). The division farthest to the northwest he called Chickamauga Valley after the river of the same name that drains its northern part. The surface of this valley is lower than either the Lookout Plateau on the west or the ridges which bound it on the east. Its floor is fairly level and smooth, with occasional, low, rounded hills and ridges.

The next division east of Chickamauga Valley, which Campbell called the Armuchee Ridges, is characterized by a series of prominent ridges, trending more or less parallel to the general strike of The Valley, with relief varying from a few hundred feet up to as much as 1000 feet above the valley floors. The eastern boundary of the Armuchee Ridges was designated as a line following the base of these ridges that extend almost continuously from Tennessee on the north to Alabama on the west. Near the Tennessee line the ridges are not conspicuous, but, in a general way, the boundary follows the Southern Railway southward from Red Clay for a distance of about ten miles. From that point, it continues southward along the east base of Chattoogata Mountain about 2 miles west of Dalton, thence south and southwestward toward the Alabama state line.

The Rome Valley, the third subdivision named by Campbell (1925), for the city of Rome, Ga., is the largest of the three divisions of The Valley. Along the Tennessee line it is about 13 miles across, widening at Cartersville to about 25 miles, then narrowing to approximately 21 miles along the Alabama line. It is drained principally by the Coosa River and its tributaries of which the Etowah and the Oostanaula are the largest. The Etowah enters Rome Valley from the east near Cartersville, then flows in a westerly direction toward Rome where it joins the Oostanaula to form the Coosa. The Oostanaula River is a longitudinal stream draining the northern portion of the Rome Valley and is formed by the confluence of the Coosawattee and the Conasauga. Conasauga River, in the Dalton quadrangle is a fairly large stream which rises to the east in the Cohutta Mountains of Murray and Fannin Counties. From its source it flows north into Tennessee as if to join Ocoee River but then turns south into Georgia again and flows southward to Calhoun where it joins the Coosawattee. The Conasauga is one of the principal streams of the Dalton Quadrangle.

The Rome Valley is characteristically a plain modified by a few isolated ridges, hills and even mountains. Among others, Camp Ground Mountain and Cedar Ridge are prominent in the northern part of the section within the boundaries of the Dalton quadrangle. Hayes (1899) recognized the existence of two widespread and distinct levels within what is now called the Rome Valley, naming the lower of these, closely associated with the master drainage pattern, the Coosa peneplain. The upper level, he called the Highland Rim, which Fenneman (1938) doubtfully correlates with the Harrisburg peneplain of Pennsylvania. Both levels are present within the Dalton quadrangle, the lower ranging from about 700 to 750 feet in elevation, while the higher level seems to vary from about 940 to 1000 feet above sea level. The Coosa level apparently is marked by Recent alluvium which outlines to a large extent the present stream systems of the quadrangle. (See Plate VIII.)

Locally within the Dalton quadrangle, details of relief are directly related to the areal geology. The numerous, subparallel ridges and valleys result from strata with differential resistance to erosion and with structural attitudes of such a nature as to expose them in alternating belts. The higher, more prominent ridges, without exception, are supported by beds with a high silica content either in the form of chert or sandstone. The chert, usually derived from the Knox, occurs as a weathering residuum and in the form of massive ledges; it is responsible for White Cut, Cohutta, Red Clay and Cedar Ridges in the western and central areas of the Dalton quadrangle, as well as a ridge immediately west of the Rome fault (Fig. 4), and another just west of the city of Dalton. East of Conasauga River, another ridge, underlain by Knox cherts, but with a relief less than the ridges west of the river, trends slightly east of north across the quadrangle. Its southern end is about 1 mile west of Spring Place; its northern end is just west of Colvard School.

Prominent ridges underlain and supported by sandstones of three different formations are: Camp Ground Mountain, held up by Weisner(?) quartzite; Sumac Ridge, resulting from the Athens sandstones and siltstones; and Hamilton Mountain, north of Dalton, underlain by the "Bays" sandstones. Ferruginous Rome sandstones are responsible for areas of low, rounded, "comby" hills and short ridges in the section just east of Dalton and northward along Coahulla Creek, as well as in several areas adjacent on the west to Conasauga River. Such areas, having a relief much less than that of the chert and standstone ridges, seem to be, in general, characteristic of the Rome. An exception must be noted, however, in Gap Spring Ridge, in the northeastern corner of the quadrangle, which is also underlain by the Rome, but which has a relief nearly equal to that of most of the Knox ridges.

Recent alluvium, associated with the major stream valleys, masks the geology of the Paleozoic rocks locally, but serves to emphasize the asymmetry of the ridge profiles. Scarp slopes of many ridges face west and northwest while dip slopes are east and southeast. This is well illustrated on the ridges immediately west of Coahulla Creek, and also in the hills west of Conasauga River.

Stream patterns within the quadrangle are largely controlled by the position of carbonate rocks, such as Conasauga limestones, which offer less resistance to weathering and erosion than the sandstones and chert-bearing formations. Because of the areal geology pattern, trellis drainage has developed in which the master streams are longitudinal subsequents with tributaries joining the trunk streams by means of transverse valleys. As a result, numerous water gaps have formed such as the one near the eastern boundary where Sumac Creek cuts through Sumac Ridge, and another, south of there, near Eton, where a tributary to Mill Creek has cut through Camp Ground Mountain. Just north of Dalton, the Mill Creek which is tributary to Coahulla Creek, has created a series of gaps through several ridges lying nearly at right angles to its course toward the southeast.

STRATIGRAPHY

CAMBRIAN SYSTEM

Rocks of Cambrian age occupy extensive areas within the Dalton quadrangle and comprise the larger part of the exposed geologic column. All of them are sedimentary materials which were deposited in the Appalachian geosyncline largely as a result of mechanical processes. Differences in lithology exist, however, making it possible to separate several formations which, in the commonly accepted ascending order of age (Howell, B. F., 1944, Chart 1) are as follows: Weisner, Shady (not identified in Dalton quadrangle), Rome, Conasauga and Knox (in part).

The Weisner formation, which crops out intermittently throughout the Southern Appalachians, is chiefly a massive quartzite with alternating beds of shales. Commonly it is a good ridge-maker when the resistant beds are structurally situated to expose them.

The Shady formation, where identified, as in the Cartersville, Ga., district, is usually a dolomite (Kesler, 1950), and, apparently, is likewise only locally developed. The formation may be but a basal member of the Rome.

Strata of the Rome formation are primarily thinly-bedded, sandy and, in places, more highly colored than adjacent formations. Furthermore, the quantity of sand as well as its grain size seem to decrease toward the younger part of the formation, making it difficult, as a result, to draw a precise boundary between the Rome and the overlying Conasauga shales. Other criteria are generally required to make a satisfactory differentiation between the two formations.

The Conasauga formation, in northwest Georgia, is ordinarily termed a shale but other rock types are known to exist within its limits. Much difficulty was experienced during mapping of the Dalton quadrangle because of an unsuccessful attempt to separate members of the formation, and it was finally decided to map the group as a unit. Nevertheless, in the text below, distinctions are made between members insofar as possible. On the whole, the Conasauga consists, in the Dalton quadrangle, of yellowish shales, in part calcareous, and of thin to massively bedded limestones which ordinarily underlie major valleys. No unconformities seem to exist between the Conasauga and the Rome, below, or the Knox above.

The Knox "formation" as shown on the geologic map (Plate VIII) is, in reality, a group of formations which, because of poorness of critical outcrops, could not be mapped individually. However, it is quite probable that beds of the Copper Ridge, Chepultepec and Longview formations are represented in places within the Knox in the Dalton quadrangle. Butts and Gildersleeve (1948, geologic map), following the recommendations of the Cambrian Subcommittee (Howell, 1944), indicate that only the Copper Ridge properly belongs in the Cambrian, while the Chepultepec and Longview are shown as Lower Ordovician. Furthermore, Butts and Gildersleeve also place the Newala formation, overlying the Longview, in the Lower Ordovician.

There seems to be little reason, at least in the Dalton quadrangle, to postulate a systemic boundary at the top of the Copper Ridge. No discoverable evidence of any interruption to sedimentation at that horizon was brought to light during the present investigation. It is suggested, therefore, that the Cambrian time interval of the Dalton quadrangle actually embraces strata as young as Newala, but considerably more evidence over a greater area will be needed to demonstrate this conclusively.

The descriptions and relationships of individual formations up through the Newala in this report have been treated as component parts of the geologic column as outlined by Butts and Gildersleeve (1948). This has been done primarily because of a lack of sufficient evidence to the contrary, and secondarily because of the fact that it makes possible greater ease of cross reference to previous reports. This, however, should not obviate the strong probability that many fundamental changes in nomenclature will eventually be made in the Cambrian of the Southern Appalachians.

WEISNER FORMATION

The Weisner formation, originally described by Smith (1890), was named from exposures occurring on Weisner Mountain located in eastern Alabama.

Distribution—Strata of lithology similar to that of the Alabama locality have long been known in the Valley region of Georgia, but are restricted in occurrence to rather widely separated localities where they constitute but a small portion of the Paleozoic rocks of the region. Exposures, isolated because of tectonic disturbances or original sedimentation, ordinarily are correlated primarily by means of lithology and stratigraphic position, and secondarily by paleontologic methods.

A mass of quartzites and quartzite conglomerates produces, in Murray County, a prominent ridge named Camp Ground Mountain. This ridge begins near Oran crossroads, about 1½ miles north of Chatsworth, and extends northeastward beyond the east boundary of the quadrangle at a point about ½ mile east of Eton. No deposits of a similar kind are known in the area.

Lithology—Exposures on Camp Ground Mountain are chiefly massively-bedded quartzites and intercalated quartzite conglomerates, together with some thinner, shaly zones which are poorly exposed. A section transverse to the strike of the mountain may be seen in a water gap along the road leading eastward from Eton (Station 1). There, over a distance of about 225 feet, thick bedded, hard, tough, quartzitic conglomerates at the west end of the gap, are succeeded, to the east, by a series of somewhat less massively bedded quartzites and nonpersistent layers of greenish, platy siltstones up to about 6 inches thick. Much brecciation of the eastern end of the section has occurred so that it is virtually impossible to trace any bed more than a few feet. Flood plain alluvial deposits effectively conceal the western extent of the conglomerates.

The brecciated zone along the east base of Camp Ground Mountain was traced several hundred yards south from the gap by means of exposures along an old logging road and borrow pits located along its strike. A series of springs, situated approximately along the same strike as far as the south end of the mountain, probably mark the trace of a fault zone. Considerable quantities of massive, honeycombed blocks of limonite and jasperoid also occur along this zone at the east base of the mountain. In a few places, small, moderately well formed hexahedrons of yellow pyrite occur in cavities within the limonite. One small pinnacle of a medium-gray, shaly limestone also was found cropping out in the brecciated zone. It is thought, therefore, that the mineralization is genetically related to a fault zone and that the limestone pinnacle perhaps represents a fragment in the brecciated drag zone.

Thin sections made of the quartzite from beds near the southern end of the mountain (Station 2) show that it is a feldspathic orthoquartzite which approaches the composition of a sub-graywacke (Pettijohn, 1949, p. 255). It is a poorly sorted, quartzose rock in which the grains between the diameters of 0.1 to 0.4 mm. are predominantly (90%) angular to sub-angular, but those between the dimensions of 1 to 2 mm. are sub-angular to sub-rounded. Many of the larger grains of quartz show overgrowths which are anhedral in outline, with dust rings that indicate a former rounded to sub-rounded shape. Some micro-stylolitic development (Plate I, A) also is present, but in many cases grains which evidently were once a unit have since been sheared and a quartz "meal" produced along the fracture. This is evidenced by parallel extinction in the adjacent but now separate grain fragments.

A small percentage of accessory minerals is also present, such as some sericite which is usually smeared out along the grain boundaries. Also, a little interstitial biotite as well as a small amount of limonite occurs along the fractures.

There seems to be little doubt that the quartz grains, both large and small, are now at least in a second, and perhaps a third cycle. Also it is probable that this rock was subjected to great pressure, perhaps before folding, which, along with solution, produced the now fractured stylolitic structures. Furthermore, the presence of the sericite could indicate that the rock has undergone partial metamorphism, probably in late Paleozoic time.

The conglomerate, near the western end of the section exposed in the water gap, contains angular to sub-angular quartz pebbles, but in some beds near the center of the section, the pebbles are rounded and flattened. The pebbles range up to an inch or more in longer dimension, although their average size more closely approaches ¼ inch. Thin sections reveal that the conglomerates are much like the quartzites in that the quartz pebbles are cemented in a quartz matrix which is essentially the same as the pebble-free material. The pebbles, however, contain dust-like zones of magnetite inclusions which are clues to the vein origin of the quartz composing them. And, although no feldspar was noted in the sections, kaolinized fragments in hand specimens show that it is present. Considerably more sericite is present in the conglomerates examined than in the quartzites; it is estimated that 10% to 15% of the total rock is sericite most of which occurs as thin, wavy laminations in fractures which cross grain boundaries indiscriminately. This fact is attributed to the development of the sericite during or after orogenic movement.

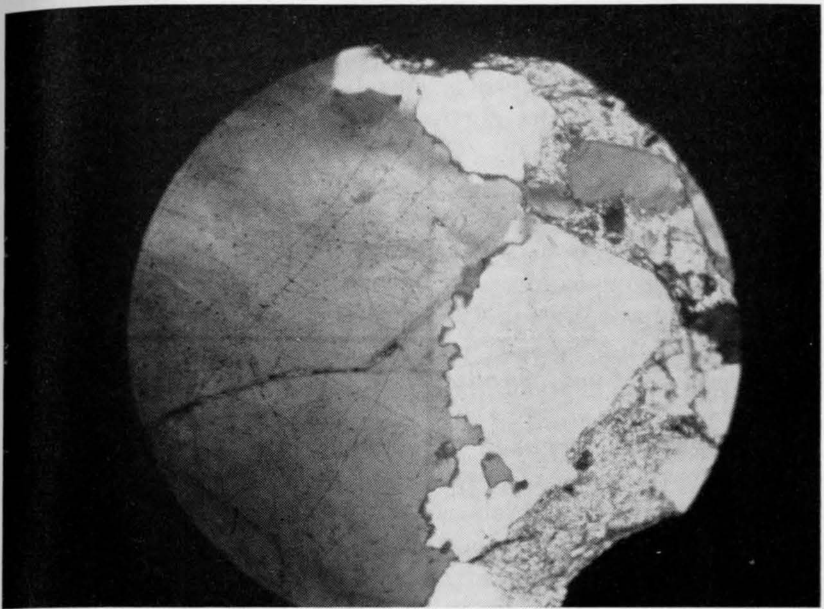
No evidence of fossil organisms or organic structure was noted.

Correlation and Stratigraphy—The quartzose rocks of Camp Ground Mountain are isolated both structurally and geographically, so that any correlation at present with rocks elsewhere in the Appalachian region must be made with extreme caution. Butts and Gildersleeve (1948, p. 12) assigned the Camp Ground Mountain outcrops to the Rome, but noted that it was an exceptional occurrence if that correlation were correct. However, they did not recognize the faults bounding the mountain and thought, therefore, that it was merely an extension of the Rome siltstones cropping out immediately southeast of the mountain. P. B. King (1950, Field conference, 15 July) observed that the quartzites and conglomerates, in his opinion, belong to the Chilhowee group, and to the Cochran formation in particular. This may very well be true, but the writer believes that these rocks are more closely related to the quartzites and conglomerates which have been described by Kesler (1950, p. 8-9) as Weisner. Any correlation is, however, strictly provisional and might be termed "Weisner-type" at present.

ROME FORMATION

The Rome formation was so named in 1891 by C. W. Hayes from Rome, Floyd County, Georgia (Hayes, 1891). The name "Rome", however, was antedated by the names Montevallo or Choccolocco which were simultaneously introduced for beds of equivalent age by the Alabama Geological Survey in 1890 (Woodward, 1929). The Alabama names never attained widespread usage and now have been discarded in favor of the more popular term "Rome" for beds occurring in Alabama, Georgia, Tennessee and southwestern Virginia (Howell, and others, 1944).

Plate I



A.—Sutured boundaries between quartz grains of the Weisner(?) conglomerate at Station 1. (50X, crossed nicols).

B.—Crenulated Rome sandstone at Station 4.

Distribution—The Rome formation crops out in three major belts as well as in several smaller areas crossing the Dalton quadrangle from north to south. The outcrop area of the southeasternmost of these is closely associated with a fault which bounds it on the northwest and which is probably responsible for its position. The other two major belts occupy a central position in the quadrangle and although not connected by surface exposures, are thought to be related as the east and west limbs of a shallow synclinorium. Of two other areas of exposed Rome, one occurs in the northeastern section of the quadrangle between Sugar Creek and Conasauga River, while the second may be seen in the northwestern corner as a very narrow outcrop band.

Lithology—The rocks of Rome age within the Dalton quadrangle have been so closely folded and faulted that no section was found in which reliable measurements of either thickness or stratigraphic sequence could be made. Notwithstanding this difficulty certain characteristics of the formation make possible its separation from the Conasauga overlying it.

Predominantly the Rome is sandy or silty in varying degrees both areally and stratigraphically. It is, however, as noted by Butts (1926, p. 66) . . . "a rather heterogeneous formation, being composed of red shale, green shale, reddish or chocolate sandstone, light-gray, rusty-weathering calcareous sandstone, and local beds of fairly pure limestone and dolomite. The red shale and the rusty-weathering calcareous sandstone are the most characteristic features and are unmistakable markers of the formation." At Rome, Georgia, the type locality, the rocks of the formation were described by Hayes (1902, p. 2) as being thin-bedded, fine-grained sandstones and sandy shales which are brilliantly colored with various shades of yellow, green, red, purple and white producing a noticeable banding in the formation. He further states that the lower portion of the Rome consists of thin-bedded red sandstones, while the upper portion is chiefly variegated shale. Butts and Gildersleeve (1948, p. 11-12) noted the variegated colors of the shales and mudrocks stating that these, along with the red sandstones, are distinctive characteristics of the Rome. On the other hand, a different type of Rome has been recognized north of Resaca, Georgia. At that point, which is some twenty miles south of the Dalton quadrangle, the Rome shales assume a yellowship color while the sandstones become greenish. This observation seems to be correct, at least in part, because a great deal of the Rome in the Dalton area possesses such relatively drab coloration. However, certain exposures (Stations 3, 4) show the bright banding of reds, purples, and yellows both in the shales and in the standstones. It is likely that these represent, in the Dalton area, only the lower part of the Rome, for in each instance the exposures are so situated structurally that the lower stratigraphic horizons could have been brought near the surface at those points. The yellowish and greenish beds, therefore, probably belong to the upper portion of the formation, and this seems to be borne out in the areal relationships.

The Rome exposure situated in the northeastern part of the quadrangle between Sugar Creek and Conasauga River, probably represents the lower portion of the formation. No good continuous outcrops of the formation were seen within the quadrangle, but an excellent series of road cuts occur along the Spring Place—Cleveland, Tenn., road about one-half mile north of the quadrangle boundary. At that locality, the Rome consists of heavy, brownish-red beds of rather massively-bedded sandstones and thinner beds of siltstones. Cross-bedding is common and one zone in the sandstones shows good ripple markings. Small scale folding and faulting throughout the quarter mile length of the road cuts make it impossible to trace a given horizon with certainty. No fossils were found. Thus, no stratigraphic sequence could be established at that point. But the presence of the Conasauga immediately to the southeast is suggestive, at least, that a large part of the Rome is present and that the described beds are likely to be its older parts. Topographically, the more resistant sandstones of the Rome have resulted in the creation of a prominent ridge extending southward into Georgia for several miles. The northwestern foot of this ridge is marked by a fault which brings the lower portion of the Rome in contact with upper Conasauga.

Vertically dipping, dark-brownish sandstones, probably of the same general stratigraphic zone of the Rome, are found along a small eastward-flowing tributary to Conasauga River, south-southeasterly of Beaverdale, at a road crossing about 1½ miles southeast of Holiness Church and 1 mile southwest of Hampton Island (Station 4). Ledges of sandstone, striking approximately N 32° E, lie transversely across the stream valley at intervals of 20 or 30 feet over a distance of about 100 yards down stream from the road crossing. These beds, which are more resistant than the intervening ones, are highly crenulated and irregularly folded layers ranging from ½ inch to 2 inches in thickness. Most of the layers are composed of medium-grained quartz sand cemented by a mixture of carbonates and limonite. Fresh rock fragments are dark gray.

Approximately 1 mile southwest of this sandstone exposure may be found a zone of thin limestones which are probably of Rome age. The limestone beds occur along the road ditches at a point 1½ miles east of Deep Spring and about a mile west of Conasauga River (Station 5). The rock crops out in beds about 1 foot thick and is finely crystalline, dense and medium-gray with slight purplish and greenish casts. Immediately below it, stratigraphically, to the east, and in contact with the limestone, is a 1½ inch thick bed of thinly laminated, fine-grained, dark brown sandstone. Apparently there has been a slight overturning of the strata at this location for although the strike is N 22° E, the dip is 80° SE, thus placing the sandstone at a lower horizon. Westward from this point for about ½ mile, occur intermittent outcrops of thinly bedded, silty, yellowish and brownish shales and thin sandstone layers which are thought to represent the upper zone of the Rome.

Carbonate rocks of Rome age are, in general, either poorly developed or seldom exposed within the Dalton quadrangle. The more common rock types are the thin sandstones, siltstones and shales which, on weathered surfaces usually show drab, reddish-browns and yellows. Less often seen are the banded colors that seem to be more characteristic of the Rome in the type locality. Many exposures of relatively unweathered Rome, particularly within the city limits of Chatsworth, are greenish-yellow, closely approaching the colors of the overlying Conasauga shales. The close resemblance of the Rome to the Conasauga in the Chatsworth area was noted by Smith (1931, p. 193) during the course of investigation of the shales of northwestern Georgia. He points out that the "hard, greenish-drab clay is not typical of the Rome formation elsewhere", and concluded that the exposures should be assigned to the Conasauga. Similar outcrops may be seen occasionally in the other areas of the Rome within the quadrangle.

Correlation and Stratigraphy—No fossils were found in the rocks mapped as Rome in the Dalton quadrangle during the present investigation, although diligent search was made for specimens with which to confirm the observations of previous investigators in the area. As a result, the stratigraphic position of the Rome in this quadrangle is established entirely upon the basis of its lateral continuity and lithologic similarities with fossiliferous beds at other localities. Butts and Gildersleeve (1948, p. 13) also noted the paucity of organic remains within the Rome in Georgia, and state that only at one locality was a form found which could demonstrate the Lower Cambrian age of the formation. On the other hand, Resser (1938, p. 9) states that examples of the Rome fauna are not difficult to find near Rome, Georgia, and that, therefore, the stratigraphic position of the formation there can be readily established. The occurence of an *Olenellus* fauna from a number of different localities throughout the Southern Appalachians establishes, in his opinion, the Lower Cambrian age of the Rome. Because the faunal collections from the Rome are widely separated geographically, the organic sequence within the formation cannot be stated with assurance. Nevertheless, Resser believes that the upper contact of the Rome is marked, in east Tennessee, by the presence of the overlying Rutledge limestone which, in Georgia, may be equivalent to the lower portion of the Conasauga.

Rodgers and Kent (1948, p. 2) in contrast, have separated, in northeastern Tennessee, 360 feet of shale formerly assigned to the Rome, lying immediately below the Rutledge limestone, into a new formation called the Pumpkin Valley Shale. This unit, they state, is more closely related both faunally and lithologically to the Conasauga than to the Rome. Rodgers has also examined several of the upper Rome exposures in the Dalton quadrangle, and concludes (Personal communication, 1950) that the Pumpkin Valley Shale is represented there. However, poor exposures combined with intense local folding and faulting within the formation in Georgia, probably precludes the identification of this zone as a mappable unit. Consequently, on the geologic map (Plate VIII), it is not differentiated, but is considered to be the upper part of the Rome.

The contact between the Rome and the Conasauga has, in general, been established by several criteria. These are, in order of importance, first, the occurrence of a few thin lenticular limestones and dolomites interbedded with a much thicker section of non-silty, yellowish shale near the base of the Conasauga; second, thin-bedded, brownish sandstones interbedded with brownish and reddish-yellow siltstones in the upper part of the Rome; third, the geomorphic expression of the two formations: Rome underlying, usually, an area in which the hills and valleys are "comby", and with a more prominent relief than the areas underlain by the Conasauga, which in contrast, usually occupies broad, gently undulating valleys; and fourth, the very occasional occurrence of extremely poorly preserved fossil fragments in shales associated with the thin limestones of the lower Conasauga beds.

Use was made of the distinguishing features described above wherever possible, but in a majority of the localities visited not all could be employed. In such cases, the contact has been indicated on the geologic map as slightly doubtful, or when still less evidence was available, as highly doubtful.

It seems quite likely, but undemonstrable at present, that the Rome-Conasauga boundary is conformable and perhaps is a lithologic line which represents merely a slight, but normal change in depositional conditions. (See Geologic History.)

Thickness—No reliable measurements of thickness could be made of the Rome formation in the Dalton quadrangle. Various estimations of thickness have been made in the past, but the limits of variation are so great that little or no importance may be attached to them in this vicinity. It is possible that there may be a great variation in thickness of the Rome due to the mode of deposition of the predominantly clastic materials.

CONASAUGA FORMATION

The Conasauga formation was named by Hayes (1891, p. 143) from exposures in the Dalton quadrangle along Conasauga River. Previously, the terms "Coosa" and "Flatwoods" shales had been applied to beds of equivalent position in western Georgia and eastern Alabama (Butts, 1926, p. 67-69. But, as in the case of the Rome formation, general acceptance and wider usage of the term "Conasauga" has established it firmly, while the other, prior names have been discarded (Wilmarth, 1938, p. 515).

Distribution—The Conasauga formation occupies several extensive areas within the Dalton quadrangle; it is particularly well developed along Conasauga River from which it takes its name. As in the case of the other Paleozoic formations exposed within the quadrangle, the Conasauga crops out in a series of roughly parallel, relatively narrow bands trending slightly east of north. The width of the bands varies widely in response both to structure and to topography. There is no regular repetition nor alternation of the Conasauga with the Rome below and the Knox above; neither is there regular persistence along the strike. Faulted plunging folds have, in most cases, been responsible for this discontinuity.

One area of the Conasauga occurs on the east side of Holly Creek immediately east of Chatsworth. This exposure extends eastward beyond the limits of the quadrangle to the foot of Fort Mountain marking the western front of the Cohutta Mountains, and also may be found in the deep reentrant made by Holly Creek in the mountain front east of Eton.

A second narrow belt of Conasauga trends in a general northerly direction across the Dalton-Chatsworth road approximately 1 mile west of the intersection of that road with U. S. Highway 411 in Chatsworth. The northern limit of this exposure is marked by a thrust fault which cuts it out at a point about three tenths of a mile due west of Oran, and about the same distance southeast of the southern end of Camp Ground Mountain. Nearly in line with the strike of this band but offset slightly to the west is another Conasauga exposure underlying the immediate vicinity of the village of Eton. Alluvial deposits in that section effectively conceal all but a part of the probable extent of the formation.

A very narrow slice of the Conasauga appears about ½ mile northeast of Dunn's Store, north of Sumac Creek and east of Conasauga River. It continues in a north-northeasterly direction beyond Gregory's Mill to the south side of Perry Creek where it disappears beneath younger alluvial deposits. It is likely that in the area between Gregory's Mill and Perry Creek, now concealed by the alluvium of Conasauga River, this slice of the Conasauga is faulted against another part of the Conasauga, thus joining it with the main mass of the formation occupying the Conasauga River valley.

The river valley exposures are not continuous for the reasons set forth above, but nevertheless extend with only minor interruptions across the quadrangle area from north to south in a band which averages about three and one half miles wide. This figure is strictly applicable only at those points where structural saddles exist between the ends of plunging anticlines exposing the Rome along their crests.

Near Dawnville the western part of the Conasauga River outcrops join with the Coahulla Creek exposures. The outcrops lying along the eastern banks of Coahulla Creek also mark the western slope of Cedar Ridge which is capped by the Knox formation, and which delimits this band on its eastern boundary. The western boundary of the band is, in general, marked either by Coahulla Creek or its alluvium. Near the Georgia and Tennessee boundary, a fault brings these Conasauga outcrops in contact with other Conasauga beds thus merging the east and west Coahulla exposure belts. The western Coahulla Creek section extends southward across the quadrangle, passing through the eastern limits of Dalton. It maintains a strike varying from a few degrees west of north at the south end, to as much as 25 degrees east of north near the Tennessee line. The eastern Coahulla Creek section, on the other hand, after paralleling the western belt as far south as an east-west line through Pleasant Grove, diverges rather sharply toward the southeast continuing in that direction to the southern boundary of the quadrangle.

A fault of considerable magnitude bounds the western Coahulla Creek Conasauga exposures along the western side across the entire length of the quadrangle. North of Dalton, on the north side of Mill Creek, this overthrusting brings the western Coahulla Creek outcrops in contact with another and parallel exposure of the Conasauga which may be designated as the Varnell-Cohutta area. The tracks of the Southern Railroad follow this area which is a narrow, trench-like valley extending from Dalton northward a good many miles beyond the limits of the quadrangle. Except for the southern 2½ miles, Knox dolomites here bound the Conasauga on both sides, but the western boundary is probably another overthrust of considerable magnitude.

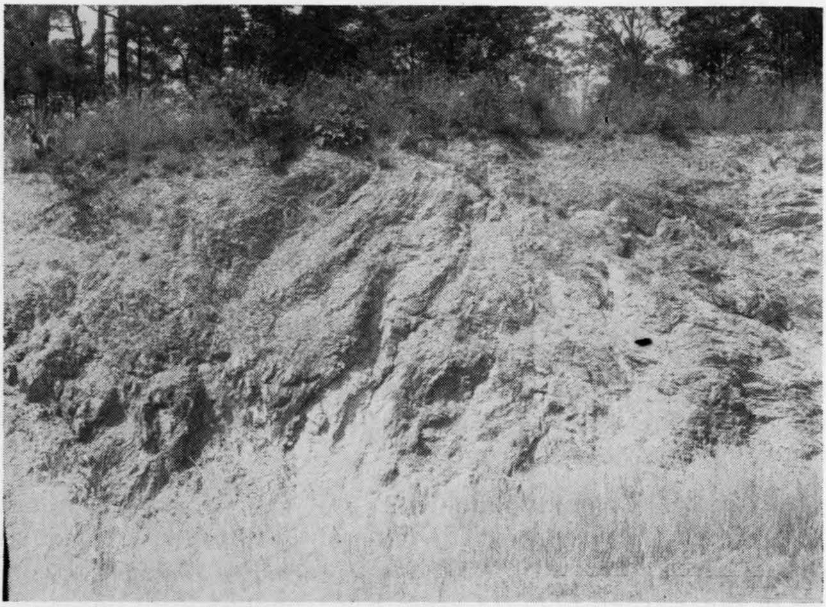
A somewhat similar narrow crop of the Conasauga, about 1 mile northwesterly from the town of Cohutta, may be found occupying the northern 3 miles of the valley of Tiger Creek. As in the Varnell-Cohutta area, Knox bounds the Conasauga on both its east and west sides, but the western border is another fault.

The northwestern corner of the quadrangle is occupied by a rather wide area of Conasauga, again flanked by Knox on both sides but apparently not faulted as are the adjacent exposures to the east. West of Dalton, in Hungry Valley and Crow Valley, Conasauga may be found occupying their lower levels.

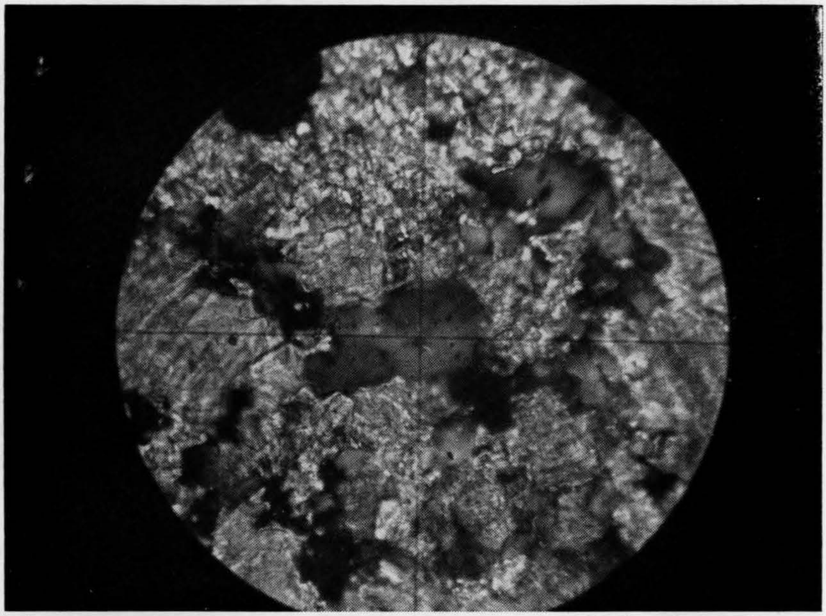
Lithology—The Conasauga rocks of the Dalton quadrangle have, as in the case of the Rome formation, been so intricately folded and faulted that no reliable sequence can be established. There seem to be at least three and perhaps four zones within the formation which can be used for mapping purposes although none can be mapped as a unit. Each will be discussed separately, and for the sake of clarity may be designated as follows:

	Zone	
Top	D	Limestone and dolomite
	C	Shale
	B	Thin limestones and shale

Plate II



A.—Contorted Conasauga shales just east of Chatsworth.



B.—Authigenic andesine in Conasauga shale near Dawnville. (200 X, crossed nicols)

Base A Shale (doubtful)

The uppermost limestone and dolomite (Zone D) is best developed and exposed along the west side of Cedar Ridge which lies adjacent to and on the east side of Coahulla Creek. The following section was measured along the road leading eastward from Coahulla Creek toward the County Farm. The locality is about 1¼ miles northwest of Dawnville, and about 2¼ miles east-northeast of Pleasant Grove Church (Station 6). The general strike is approximately N 30° W, while the dip is about 15° northeast.

Top. Elevation at gap along road is about 880 feet.

Unit #	Thickness	Description
KNOX (Copper Ridge)		
32.	11.0 ft.	Covered zone
31.	2.0	Limestone, mottled, dark blue-gray with some lighter gray, laminated
30.	4.5	Covered . . . shale?
29.	4.0	Shale, calcareous, moderately hard, beds less than ¼ inch thick
28.	0.5	Limestone, shaly, laminated, light gray
27.	0.6	Siltstone, laminated, dirty brown
26.	1.0	Limestone, shaly, laminated, light gray, with some weathered, irregular chert layers about 1 inch thick
25.	6.0	Limestone, massively bedded (individual beds up to 1 foot thick), finely crystalline, hard, mottled light and dark gray
24.	4.0	Covered
23.	2.2	Limestone, very finely crystalline, massively bedded, breaks with conchoidal fracture, dark gray on fresh surfaces, light gray when weathered; thin, brownish and tan irregular chert layers and nodules in upper 10 inches
22.	3.5	Limestone, very dense, massive layers up to 1 foot in thickness but intercalated with ¼ to ⅛ inch harder layers; dark gray to black
21.	10.0	Poorly exposed zone containing blocky fragments of moderately massive, brownish-tan, siliceous, tripoli-like material, and some yellowish shale
20.	0.3	Limestone, very finely crystalline, irregularly bedded, medium-dark-gray

Unit #	Thickness	Description
19.	0.2	Finely siliceous, brownish, fairly hard tripoli-like material
18.	21.4	Shale, tan to brown, deeply weathered
17.	0.3	Siliceous, laminated, fine-grained, irregular induration, tripoli-like material
16.	0.3	Chert, with whitish and black siliceous oolites of varying shapes, massive, blocky fracture
15.	0.2	Siliceous, tan, laminated, fine-grained, tripoli-like material

CONASAUGA (Maynardville) (Zone D)

Unit #	Thickness	Description
14.	15.5	Covered
13.	1.0	Limestone, shaly, platy, light gray
12.	11.0	Limestone, massive, coarsely crystalline, blue-gray
11.	2.0	Limestone, medium crystalline texture, medium-gray, weathers to a "shelly" surface
10.	1.0	Covered
9.	2.5	Limestone, mottled dark and light gray by irregular patches of color
8.	3.5	Limestone, medium crystalline texture, prominent color banding—light gray bands 1/16 to ⅛ inch wide; dark gray bands ¼ to 2 inches wide
7.	3.0	Limestone, medium crystalline, massive, dark gray, this is a single layer
6.	3.0	Covered
5.	2.0	Limestone, dark gray to black, massive, finely crystalline, with small dark, calcareous oolites
4.	3.5	Limestone, massive, beds 10 to 12 inches thick; weathered surfaces show alternating light and dark banding, dark bands more coarsely crystalline than light gray bands. Fragment of unidentified trilobite cephalon about 8 inches above base in light gray band
3.	3.0	Limestone, dark gray, thin-bedded and shaly; forms slight bench.
2.	6.0	Limestone, massive, dark gray, contains dark colored calcareous oolites; ledge former
1.	5.0	Covered. Section begins at road intersection at quarry. Elevation approximately 745 feet.

Units 15 through 21 in the above section, it will be noted, consist of tan, poorly laminated, loosely coherent, siliceous material interbedded with layers of oolitic chert. The siliceous material is a substance which may be best described as tripoli. It is a light, porous, siliceous rock locally known as "rottenstone" that has been extensively mined in Murray and Whitfield Counties. (See section on Economic Geology.) The siliceous material is chalcedonic quartz, whose tan color is derived from the presence of iron oxides. The intercalated, thin beds of oolitic chert consist of spherical, ovate and elongated, ovate, black oolites in a light tan matrix of dense chert which breaks into blocky fragments. Some banded, agate-like chert beds are also present in places, but seem not to be persistent.

The tripoli zone may be traced northward and southward along the strike from Station 40 varying in elevation with minor structural undulations of the formation. It is particularly well developed in a road cut on the east side of Coahulla Creek, due east of Horseshoe Bend, on the north-facing slope of a small westward-flowing tributary (Station 7). Outcrops of the zone occur in rather widely scattered areas throughout the quadrangle; its peculiar characteristics and constancy make it a useful horizon for correlation purposes. In Murray County, the tripoli and the oolitic chert may be found in a road cut due east of Gudger Ford on Conasauga River at a point about ¾ mile north of the Fashion-Kings Bridge road (Station 85). Identical material may be seen in a cut of the Louisville and Nashville Railroad, north of Chatsworth, at a point situated due west of Oran cross-roads (Station 8). It may also be observed in a road cut 0.2 miles northwest of Colvard School crossroads on the road to Gregory's Mill. In Whitfield County, the same zone crops out at many places where there is a normal contact between the Conasauga and the Knox.

The extensiveness of the zone combined with its more or less constant characteristics—in particular, the silicified oolites, strongly suggests that it and they resulted from alteration of carbonate rocks. Furthermore, thin sections reveal that many of the individual ooliths contain a few thin carbonate shells which alternate with thicker chalcedonic shells. This relation together with the fact that the interstices between the individual ooliths commonly show well developed chalcedonic comb structures seems to point strongly to replacement of carbonate material by silica.

The limestones of the measured section of the west flank of Cedar Ridge which lie stratigraphically below the tripoli zone (Units 1-13) constitute at least the larger part of the uppermost calcareous member of the Conasauga (Maynardville) (Zone D). As far as could be determined from the areal relations, the oolitic limestones may, in general, be used to determine position within the Conasauga. This is in contrast to the lower shaly limestones which apparently do not contain oolites.

A thin section cut from a sample of the bed in Unit 5, but from a location approximately ½ mile southwest of the measured section (Station 9) shows the following:

> Oolithic structures composed of calcite; some having concentric banding with several shells, but others with a single shell forming their exteriors. Many ooliths merely a mass of small, interlocked, calcite crystals with random orientation. Under crossed nicols, many ooliths seem to lose their identities, merging with the calcite matrix in which they are imbedded; this is particularly true of those ooliths with but a single band. Some show poorly developed radial structure.
>
> The interstitial calcite is, in general, in crystals of comparable size to those of the ooliths. Some randomly scattered plates of calcite of much larger size are present.
>
> No quartz was noted.

Oolitic limestone occurs at numerous other localities within the quadrangle and has been useful in determination of the structural relations in many cases.

Two and one half miles south of the locality for the above measured section, a small ridge crosses the Dalton-Chatsworth road on the east side of Coahulla Creek. This ridge is also designated as Cedar Ridge, but is separated from the main body of the ridge farther north. Along its western flank are exposures of the upper limestone zone in a series of quarries situated north of the road. Maynard (1912) gives several sections measured on various properties in this vicinity, and notes that some of the quarries were opened for the purpose of quarrying "black marble". The dark bluish-gray to black colors exhibited by some of the Conasauga strata led to these developments.

Typical Conasauga shales (Zone C) occupy the interval just below the upper limestone (Zone D), but their precise relationship to it is not known with certainty in the Dalton quadrangle. The shale is soft, laminated, olive-green to yellowish when relatively fresh, but brownish and somewhat reddish when weathered. It contains no appreciable amount of silt and this characteristic can be used in most places to distinguish the Conasauga from the Rome where exposures of both formations consist of shales alone. The character of the shale suggests that it may have been derived to some extent from the weathering of thin-bedded limestone, but chemical analyses reported by Smith (1931) show very small percentages of lime or magnesia. On the other hand Resser (1938, p. 13) thinks that much of the shale was derived from limestone which has been leached of its soluble constituents, because the fossils he found are not so flattened as they would be if they had been buried originally in shale. Butts (1928, p. 69-70) has observed in Alabama that the limestone—"through leaching of its content of lime, . . . weathers to clay which preserves the original bedding and apparently nearly the original thickness of the limestone". Observations during the current investigation tend to confirm Butts' and Resser's opinion because, in some instances, shaly, weathered exteriors of outcrops pass into rock with a high carbonate content in a matter of a few inches of depth below the surface. Furthermore, many property owners with dug and drilled wells report that the water is "hard", even though only shales can be observed at the surface, and are in such a structural attitude that the wells must penetrate the same beds at depth that appear on the surface.

The lower limestone and shale (Zone B) apparently lies below the shale (Zone C) just described, but there is no definite line of demarcation between the two. Again the exact relations are obscure because of the intensity of the folding and faulting within the formation; it is entirely possible that this lower zone represents structural repetition of the heavier carbonate phases and that weathering is responsible for the difference in appearance. On the other hand, some characteristics are persistent and are worthy of description.

The predominant aspect of this zone is the occurrence of relatively thin-bedded limestones interbedded with the typical olive-green to yellow Conasauga shale. The thickness of the zone, insofar as can be determined, seems to be less than that of the uppermost limestone zone. No oolitic beds have been found in these limestones, nor is the tripoli zone associated with them. Much of the rock shows, on weathered exposures, rather prominent dolomitization along bedding planes, and joint planes which creates an anastomosing network of brownish dolomite enclosing irregular areas of less altered limestone. Such features may be seen excellently developed just east of the Louisville and Nashville tracks, in the southern part of Eton on the north bank of Mill Creek (Station 10).

The thin, shaly limestones seem to occur only at places well within the areas of Conasauga exposure, thus suggesting that they lie at a lower stratigraphic horizon than the heavier bedded oolitic limestone. A location at which these relations may exist is about 1¼ miles west of Norton and about 1½ miles southeast of Clines Crossroads (Station 11). Similar material can be seen about ¾ mile north of Beaverdale on the road to Mt. Pleasant School (Station 12).

Shales and limestones probably representing the lower part of the Conasauga (Zone B) are exposed in cuts along the Dalton-Chatsworth road immediately east of Cedar Ridge (Station 13). A section was measured beginning at a point 286 feet east of the T-road intersection with the highway. Ditches on the side road, to the north, expose the tripoli zone with the siliceous oolites which mark the base of the Knox. Dips on those beds at that point are west at a slight angle. At the point where the following section begins, however, dips in the shale are nearly vertical. Thus it is likely that an unmapped, intra-formational fault may intervene between the two outcrops. There is also some folding and faulting within the section.

The section was measured along the road from west to east:

(Units 1, 7, and 13 are not stratigraphic thickness, but linear feet.)

1. West end of section, 286 feet concealed, beginning at road intersection.
2. 41.6 ft., Shale, tan and brown, laminated, fractured into short pencil-shaped laths; a little interbedded tan siltstone; contorted.
3. 1.0 ft., Limestone, shaly, blue-gray, nodular, coarsely crystalline, not persistent, strike about E-W, dip vertical.
4. 33.8 ft., Shale, brown to tan, with a 5 foot zone of darker gray, "pencil" shale; strike and dip same as bed 3.
5. 3.0 ft., Limestone, gray, finely crystalline, nodular; consists of two 1 ft. thick beds of limestone with interbedded gray shale; the limestone occurs as rounded masses with exterior shells of shale which wrap around the 3 inch to 6 inch sub-spherical limestone cores.
6. 208 ft., Shale, tan to olive-green, laminated, with thin, tan siltstone layers; all somewhat folded and contorted.
7. 390 ft., Concealed, probably an intraformational fault of unknown displacement.
8. 63.2 ft., Shale, tan to olive-green, thinly laminated, slightly calcareous; strike, N 22° E, dip, 36° SE, no evidence of overturning.
9. 9.0 ft., Shale and thin, interbedded limestone; shales are olive-green to tan; limestones are grayish, finely crystalline, shaly, non-persistent, and vary in thickness from ½ inch to 2 inches. Two zones carry poorly preserved fossils which are principally unidentifiable trilobite fragments. The ¾ inch limestone marking the base of this unit carries a few fossils as does another ¾ inch limestone 72 inches above it, stratigraphically. Dip and strike as in Unit 8.
10. 90 ft., Shale, olive-green to tan, laminated, dip and strike as in Unit 8.
11. 75.4 ft., Concealed, probably shale as in Unit 10.

12. 90 ft., Shale, tan to olive-green, contorted, no dip and strike measurable.

13. ½ mile covered to Conasauga River.

Units 2 through 9, inclusive, may represent Zone B. The olive-green shales, beginning with Unit 10, possibly are a portion of Zone A shales, but may be merely a zone of more thorough carbonate leaching.

The lowermost shale (Zone A), which is doubtful, may consist of typical olive-green to yellow shales lying below the thin, shaly limestones above and the Rome formation below. The great structural complexity of the Conasauga makes it impossible to determine with any assurance whether this zone actually exists or whether it represents repetition of the shales already described.

Limestones and dolomites of the Conasauga occur in many parts of the quadrangle, but usually lack definitive characteristics by means of which they may be assigned a particular stratigraphic position within the formation. Such carbonate rocks often possess a distinctive pattern of anastomosing, white, crystalline calcite veins which contrast strongly with the dark gray rock matrix. It is likely that the degree of veining is a direct result of tectonic stresses and subsequent filling of the open joints thus produced.

Correlation and Stratigraphy—The original description of the Conasauga by Hayes (1891) stated that it consists of alternating beds of limestone and calcareous shale. Later, Hayes (1902) said that the Conasauga consists of great thickness of fine clay shale with occasional beds of pure blue limestone from a few inches to several hundred feet thick. At the same time he noted that the formation presented different aspects at various localities so that there is variation in the percent of shale (or limestone) from place to place. Previously, Hayes (1894) had described the Conasauga from the Ringgold area, west of the Dalton quadrangle, where he says the formation shows the following section:

Top	Blue seamy limestone or calcareous shale
	Yellow or greenish clay shale
Base	Thin limestone, partly oolitic, interbedded with shale

No specific locality is stated for this section, so it must be assumed that it represents a synthesis of several exposures. It is very likely that there were tectonic relations not mapped in sufficient detail by Hayes, which led him to this conclusion. His section does not seem to agree with those of subsequent workers in adjacent areas, nor with that of the Dalton quadrangle.

Resser (1939, p. 12) indicated that the Conasauga of Georgia is composed of the equivalent of four formations in Tennessee. These are, in ascending order, Rutledge limestone, Rogersville shale, Maryville limestone and Nolichucky shale at the top. Thus, he assigns the lower part of the Conasauga to the Middle Cambrian, and the upper or Nolichucky equivalent, to the Upper Cambrian. In this stratigraphic order he follows Campbell (1894) who made the original designations of these four formations as components of the Conasauga.

Oder (1934, p. 469-497) restudied the Knox formations, describing at their base, the Maynardville limestone, which he considered older than the Copper Ridge and younger than the Nolichucky (Fig. 2). Rodgers and Kent (1949, p. 11-12), on the other hand, have reassigned the Maynardville to a pre-Knox position, calling it a member of the Nolichucky. They believe, with reason, that the affinities of fauna and lithology of the Maynardville are closer to the Nolichucky than to the Knox.

Within the area of the Dalton quadrangle, the Maynardville is present and has been identified (Rodgers, personal communication 1950) as the uppermost, heavy limestone (Zone D) of the Conasauga. Units 1 to 14 of the measured section on west side of Cedar Ridge (Station 6) belong in this category. Rodgers believes that the upper limit of the Maynardville may lie above the tripoli zone, but for the purpose of mapping in the Dalton area, the tripoli zone is considered to be the base of the overlying Knox because of the development of large quantities of chert above that horizon. There is no apparent interruption of deposition between the Conasauga and the Knox. Identifiable fossils are scarce or lacking in most exposures of the contact zone and other parts of the formation examined, so that it is impossible to determine exact equivalency by that means. Some localities show extensive development of *Cryptozoon* sp. at the level of the oolitic cherts within the tripoli zone. The same fossil was noted by Rodgers and Kent, and by Oder in the east Tennessee sections. Lack of adequate exposures in the Dalton area has prevented the delineation of the Maynardville as a map unit.

At present, no attempt was made to separate the members of the Conasauga in the Dalton quadrangle beyond the correlation of the Maynardville. Additional work may make possible the recognition of the Rutledge, Rogersville, Maryville, and Nolichucky equivalents. It may be suggested, however, that the lower shale (Zone A) might be Pumpkin Valley, Rutledge, or Rogersville. There has been no opportunity in the Dalton area to determine whether there is a limestone at the Rutledge position immediately overlying the Rome because of the extreme poorness of exposures. The whole question of detailed correlation demands much more stratigraphic work in the region, with a goal of establishing reliable markers which can be used both in the Tennessee section as well as in the Georgia area to the southeast. Fossils, if they can be found, may serve this purpose, but other correlative criteria need close examination, too.

Thickness—No reliable measurement of thickness of the Conasauga is possible within the Dalton quadrangle. Local folding and faulting within the formation precludes accurate determination of the total thickness of the formation. There have been estimates by various investigators, but the variation in limiting values gives little meaning to the quoted figures. For example, Hayes (1894) states that the Conasauga could be from 1500 to 4000 feet thick.

CAMBRO-ORDOVICIAN

Knox

The Knox "group" was first named by Safford (1869, p. 204) for the rocks typically developed in Knox County, Tennessee. Safford included in his Knox three subdivisions which he called, beginning at the base, "2c′, Knox sandstone",

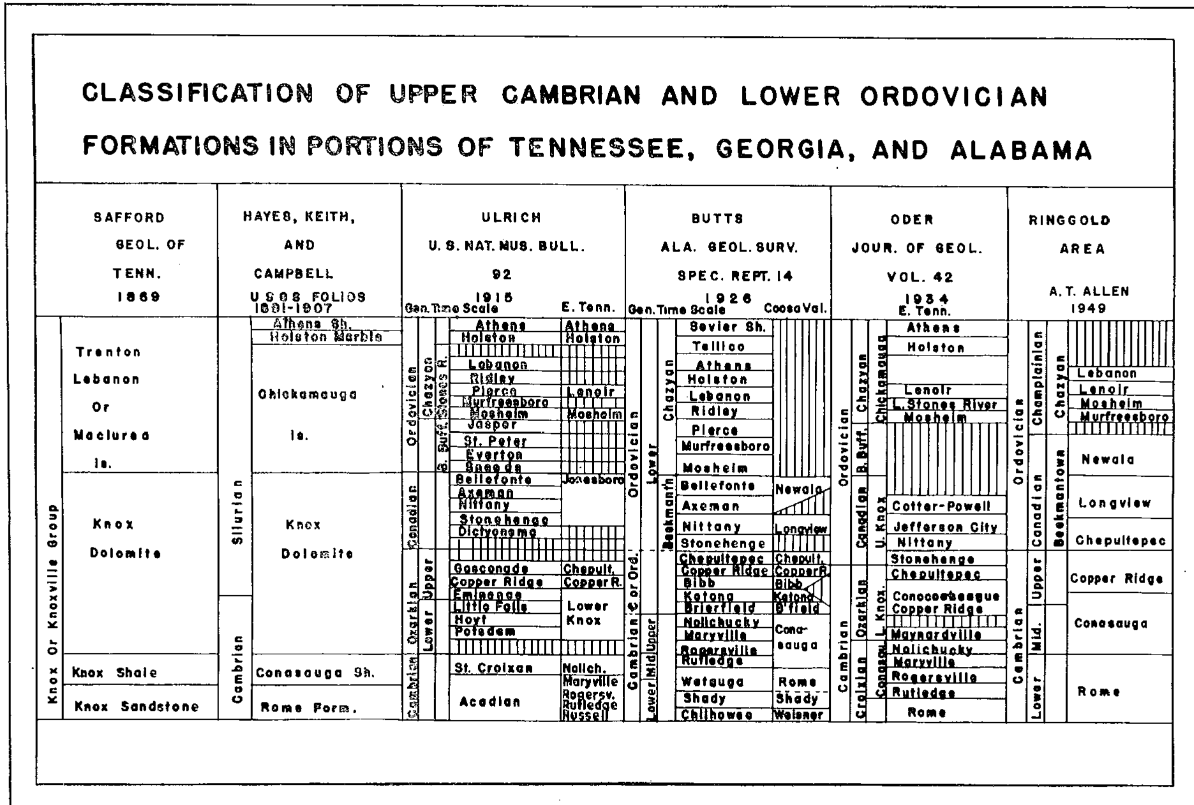


Fig. 2. Former Paleozoic classification—now obsolete in part.

"2c″, Knox shale". and "2c‴, Knox dolomite." The lower two beds were renamed by Hayes, in ascending order, "Rome sandstone and Weisner quartzite" for 2c′ and "Conasauga shale" for 2c″. The present day Knox includes the dolomites of Safford's upper 2c‴.

Ulrich (1911) proposed to split the Knox into several formations and introduced the name Copper Ridge for certain beds in the vicinity of the original type locality for the Knox. Subsequently, Ulrich (1924, p. 24) redefined the stratigraphic limits of the Copper Ridge—"so as to include all the pre-Chepultepec part of the Knox dolomite in the Knoxville trough and the western part of the Valley in Tennessee." (Wilmarth, 1938).

The name Chepultepec was also proposed by Ulrich (1911) for a division of the Knox overlying the Copper Ridge. The type locality for this formation is in Murphrees Valley, Alabama, just west of the old town of Chepultepec. After Ulrich's original description, the limits of the formation were variously interpreted until Butts (1926) defined the Chepultepec as resting conformably upon the Copper Ridge, and being overlain unconformably by the Longview. The U. S. Geological Survey in 1936 officially adopted the age designation of Lower Ordovician (Beekmantown) for the Chepultepec (see Fig. 2).

Ulrich (1924, p. 16) also proposed the name Longview for beds overlying the Chepultepec which he found developed around the town of Longview in Shelby County, Alabama.

Representatives of all three of the Knox formations are known to occur in Georgia, but their separation within the Dalton quadrangle was unsuccessful in so far as formational boundary mapping is concerned.

Distribution—The Knox, as mapped in the Dalton quadrangle, occurs in a series of sub-parallel, north-south trending belts, some of which are further split into smaller slices by faults which parallel their general strike. This is the case of the large area of Knox around Spring Place, which, when traced northward, becomes divided by a thin slice of Conasauga north of Sumac Creek. The same Knox area is further subdivided on its east by a fault that begins just south of

Mill Creek, about 1 mile west of Eton, producing a Knox belt trending northeastward toward Crandall. Butts and Gildersleeve (1948, geologic map) mapped a wide area around Spring Place as Newala, but this section is underlain by Knox cherts and there is no evidence of the presence of the Newala.

West of Conasauga River and immediately east of Coahulla Creek lies Cedar Ridge which is separated into a larger northern portion and a smaller, isolated southern portion; both parts of the Ridge are capped by Knox strata.

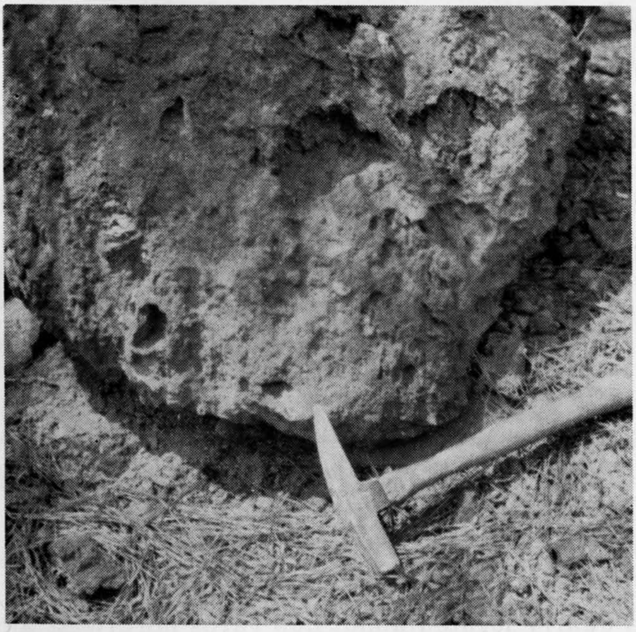
Knox beds may also be found in two belts in the Dalton vicinity; one, a very narrow slice, occupies a prominent ridge on the east side of the city, while the other lies in the western environs and is exposed over a much wider area. The eastern Dalton belt extends northward across Mill Creek where it begins to widen considerably due to repetition through faulting, and at a point about 5 miles due north of town is split into two belts by the intervention of younger beds. The western Dalton belt maintains approximately the same width for a distance about 5 miles north of town where it, too, widens through folding and faulting. About 1 mile west of Cohutta, another fault brings up the Conasauga producing a further split in Knox exposures north of that point.

Lithology—The Knox within the Dalton quadrangle characteristically consists of chert residuum and clay soils derived from the weathering of the carbonate rocks comprising it. Seldom is it possible to observe fresh rock exposures so that mapping has, perforce, been based almost entirely on the distribution of the chert ledges and boulders which are so characteristic of the Knox here and elsewhere. No continuous exposures of fresh rock were found exceeding about twenty feet stratigraphically, thus it has been impossible to establish the relative position of those outcrops within the Knox except in a most generalized fashion. It has been necessary, therefore, to relate the outcrops described below to more complete sections established elsewhere.

The basal portion of the Knox (Copper Ridge) is exposed on the east side of the southern part of Cedar Ridge at an old road quarry located about 300 yards northwest along the road from Harmony Church, which, in turn, is approximately

Plate III

A.—Partially dolomitized Conasauga limestone at Station 10 in Eton.



B.—Boulder of massive Knox chert (Copper Ridge).

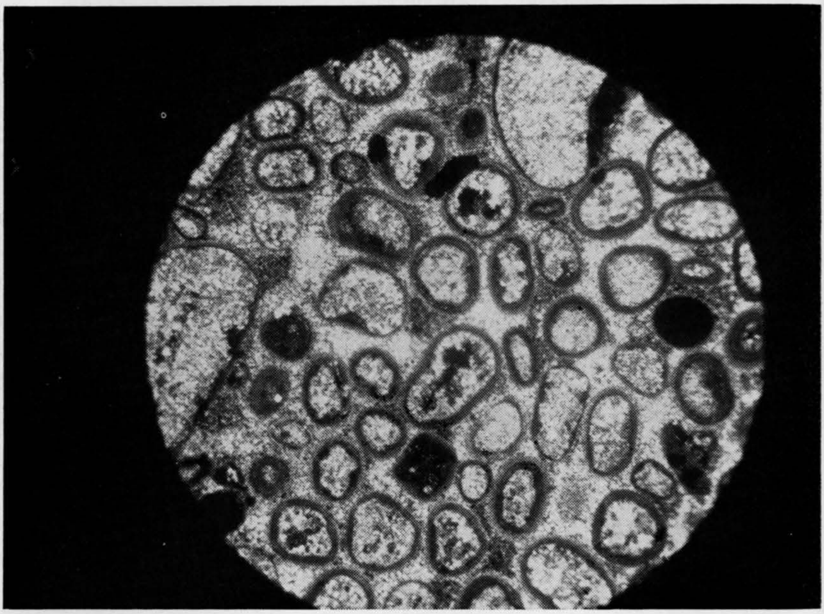
½ mile north of the Dalton-Chatsworth road (Station 14). Beginning at the highway the tripoli zone with the thin beds of oolitic chert (see preceding measured section given for the Conasauga at Station 6) is also intermittently exposed along the east base of Cedar Ridge. Minor undulations along the strike direction of as much as 20 or 30 feet combined with soil mantles are responsible for its precise position and exposure at any given point. At the quarry locality, therefore, although the tripoli zone is not observable, it is quite likely that it lies but a few feet below the base of the following section because it crops out about 200 feet north of the quarry floor at a slightly higher elevation:

Top—Elevation approximately 775 feet (Station 14)

Bed	Thkns. Ft.	
7	......	Rather extensive, wide, nearly flat bench; no rocks in place, but blocky fragments, about 3 inches thick, of dark gray chert with dark gray to black oolites, scattered about on surface
6	16.0	Partly covered; some exposed ledges of dolomite, thin bedded, dark gray
5	3.0	Dolomite, thin bedded, scaly, laminated, dark gray, much like Bed 6
4	5.5	Dolomite, massively bedded, a medium gray matrix in which are imbedded platy, sub-rounded, irregular pebbles of a lighter gray, dolomite. Pebbles seem to have rough orientation parallel to bedding. Range up to 1½ inches thick, but average about ½ inch in thickness. Stand out in slight relief on weathered surface, but are invisible on fresh fractures
3	3.5	Dolomite, thick bedded, but weathers to a finely laminated surface, gray, crystalline
2	11.0	Dolomite, massive, gray, finely granular, dip, 10° SW, strike, N 65° W
1	6.0	Covered, elevation at road approximately 730 feet

Plate IV

A.—Oolitic chert layers at base of Knox on Cedar Ridge.



B.—Siliceous oolites from above bed. (25 X)

Outcrops occur at levels higher than that of Bed 7 in the preceding section, but are so poor and so widely separated vertically that they are of little practical stratigraphic value.

Exposures of the Knox dolomites are rare in the Dalton quadrangle, but may be seen in a few localities. One of these is at Deep Spring (Station 15), on the east side of the northern portion of Cedar Ridge about 4 miles north of Dawnville. Brownish-gray dolomite crops out at the entrance to the spring in the form of well-rounded, bouldery masses imbedded in a heavy mantle of blocky, dense, dark-gray, banded chert. Not more than about 6 feet of dolomite is exposed. About ¼ mile southwest, at Deep Spring Church (Station 16) near the base of the knoll on which the church is built, are thin beds of tan and gray, oolitic chert lying a few feet above olive-green and gray Conasauga shale, and stratigraphically below the dolomite at the spring.

Another outcrop of dolomite may be seen in a large spring near Colvard School crossroads on the east side of the Cleveland-Spring Place road in the northeastern section of the quadrangle. Coarsely-crystalline, brownish-gray dolomite layers interbedded with finely-crystalline, dark-gray dolomite crop out in the depression occupied by the spring as well as in road cuts about 100 feet north of the spring (Station 17). The beds strike N 25° E and dip 36° SE there. About ¼ mile northwest of the spring, on the road to Gregory's Mill, exposures of southeastward-dipping, blocky, angular, tan, oolitic chert interbedded in tan, tripoli-like siltstone lies immediately above similarly dipping, yellowish to olive, laminated, clay shales of the Conasauga. It is more than likely that the dolomites and cherts of the Colvard School as well as the Deep Spring locality represent beds of the lower part of the Copper Ridge formation.

One half mile southeast of the Colvard School locality is an exposure of dolomite probably lying considerably higher in the section (Station 18). The beds at that point, with a strike N 32° E and dip 42° SE, consist of light-gray to bluish, dense, finely-crystalline dolomite containing layers and nodules of black, blocky chert. No fossils were noted in the crop which exposes about thirty feet of the formation in the bed of a small branch. This exposure was mapped as Newala by Butts and Gildersleeve (1948, geologic map) but there seems to be no justification for such identification.

Also along the Cleveland-Spring Place road at a point about ¾ mile south of Sumac Creek at Sumac Crossroads (Station 19), are poor exposures of a coarse-grained, sugary, light-tan, quartz sandstone which is thinly-bedded but massive in appearance. The quartz grains are sub-rounded and partially frosted. The outcrop, lying on both sides of the highway, shows an appreciable contortion in the form of sharp, small folds with considerable divergence in strike and dip from place to place. The structural attitudes vary from a north-south strike and 67° E dip, to a strike of N 50° W and vertical dip in a matter of twenty yards. Blocky, tan, dense, chert fragments seem to occur in the road cuts and fields in all directions from the sandstone crops so that it was impossible to trace the zone farther than the area of immediate exposure.

About five miles northeastward from this point, on the road leading eastward from Gregory's Mill across the Cleveland-Spring Place road, and about ½ mile east of that crossroad, a similar sandstone was noted. At that point (Station 20) nearly horizontal, thin-bedded, medium-grained, tan sandstones crop out in a section about two feet thick. It is not known whether this sandstone and the other farther south are of equivalent age.

Rodgers and Kent (1948, p. 19) and Rodgers (personal communication, 1950) point out that a thin, but widespread sandstone marks the base of the Chepultepec. Therefore, although there may have been repetition through local intraformational faulting or folding, it is possible that these sandstones mark the base of the Chepultepec in this area. But, although it is likely that the Chepultepec is represented east of the sandstones because of dip, the appearance of the cherts did not seem sufficiently diagnostic to warrant a definite identification.

Positive recognition of the Chepultepec in the northern part of the city of Dalton was made by Butts and Gildersleeve (1948, p. 18) and was re-confirmed during the present investigation. Yellow, cavernous, fossiliferous chert occurs in a cut at the intersection of U. S. Highway 41 with Tyler Street. However, attempts to trace this zone with any degree of accuracy met so little success that it was not believed justified to record them.

An exposure of Knox occurs along the road about 1¼ mile west of Cohutta and about ¼ mile west of Tiger Creek on the east slope of a prominent ridge just west of a crossroads (Station 21). Porous, massive, dense, yellow chert in massive ledges, which break into small, flaky fragments, carries a number of silicified gastropods (*Lecanospira?*). The strike is N 45° E, dip 43° SE. This probably represents the Chepultepec formation. Similar beds could probably be found adjacent to and underlying the post-Knox beds in the area north of Dalton, as well as in the belt beginning just south of Varnell and continuing northward about a mile east of Cohutta, and thence into Tennessee.

Correlation and Stratigraphy—The Knox has been subdivided in Alabama by Butts (1926, p. 10) into six formations which are in ascending order: Brierfield, Ketona, Bibb, Copper Ridge, Chepultepec, and Longview. In Georgia, the Knox, according to Butts and Gildersleeve (1948, p. 18), consists of the Copper Ridge, Chepultepec, and Longview. Northeastward, in Tennessee, the Knox group is comprised of the Copper Ridge, Chepultepec, Longview, Kingsport and Mascot formations. Identification of these units is based both on the contained fossils and stratigraphic position within the group, as well as upon more or less constant lithologic characteristics. Present practice is to place the Cambro-Ordovician boundary at the top of the Copper Ridge. The Chepultepec, Longview, Kingsport and Mascot formations, therefore, comprise the Lower Ordovician (Beekmantown).

Rodgers and Kent (1948, p. 14-32) have described a new type section for the Copper Ridge and have also described the strata of the Chepultepec, Longview, Kingsport, and Mascot formations lying above it at Lee Valley, Tennessee. The details of those sections are not generally applicable to specific exposures in the Dalton quadrangle, but some features seem to have sufficient areal persistence to be useful in most of the area underlain by Knox in east Tennessee and Georgia. One criterion of major importance is the predominance of dolomite and chert. A second is the occurrence of a thin sandstone member at the base of the Chepultepec, and a third is the presence of certain fossils at the Kingsport-Mascot level which may be useful in establishing general equivalence of those formations with certain strata lying above the Chepultepec in the Dalton area.

Butts (1926, p. 84-87) describing the various members of the Knox in Alabama, states that the Copper Ridge—"as a whole is a genuine dolomite." He notes further that it is siliceous, light-gray, finely to coarsely crystalline and ordinarily thick-bedded. Characteristically, it produces great quantities of chert upon weathering and loss of carbonate content. Butts also reports that the chert is distinctive in being dense and hard, yellowish or grayish, as well as in forming blocky fragments. These chert characteristics are, according to Butts, quite different from those of the chert from the overlying Chepultepec formation which is cavernous, mealy and relatively soft so that it forms more rounded masses; it is also fossiliferous. He notes, however, that similar chert occurs here and there in the Copper Ridge. On the other hand, he reports that the Longview chert, while compact, is brittle and flaky, weathering into small fragments.

Oder (1934, p. 489) cautions that close comparison of the cherts is necessary if they are to be used as aids to mapping, and indicates, therefore, that this criterion alone is not very definitive. During the present investigation, it was observed that the Knox in the Dalton quadrangle could be mapped only on the basis of the presence or absence of large quantities of tough, yellow, chert fragments and ledges which ordinarily produce prominent ridges. All attempts to subdivide the Knox met with little success, although it was recognized that both the Copper Ridge and the Chepultepec are present. Lateral tracing of the contact between the two formations proved to be so uncertain that their separation did not seem justified and, as a result, the Knox has been mapped as a single unit.

The relation of the Knox to the Conasauga was believed by Butts (1926, p. 71) to be disconformable in Alabama, at least in Cahaba Valley where the lower Knox beds rest upon Rome. This condition, however, seems to be exceptional insofar as the general relations between the Knox and Conasauga are concerned elsewhere. Correlation charts prepared by various writers show an hiatus existing between the basal Knox and the Conasauga. The reasons for this are obscure.

The relation between the Knox and the Conasauga in the Dalton quadrangle does not seem to warrant the assumption either of angular or erosional unconformity. On the contrary, there seems to be a conformable relationship between the two formations to the extent that only a time hiatus might exist at the plane of contact. Such a condition could be true if the lower carbonate rocks of the Knox group in Alabama, i.e., Brierfield, Ketona, and Bibb formations, are actually offshore facies of the shale which is farther east and is now called the Conasauga. During post-Bibb time, transgression might have occurred toward the east and northeast, bringing the carbonate environment into a position above the Conasauga in the Dalton area. Furthermore, the occurrence of the still younger Kingsport-Mascot beds only in the vicinity of Knoxville might thus be explained if they are the representatives of the easternmost limit of the Knox transgression. In other words, the Knox is a "terrane" (Caster, K. E., personal communication, 1950) cutting across time lines, but preserving lithologic similarities. It might better be termed a "magna-facies" (Caster, 1934).

The "Knox" contact with the overlying Newala seems quite normal, and, as far as could be determined, conformable.

LOWER ORDOVICIAN

Newala Formation

The Newala formation was named by Butts (Butts, 1926, p. 95) from Newala post office, Shelby County, Alabama. It is extensively developed in Alabama and in Georgia, but the name is not used in the Tennessee area. Butts and Gildersleeve (1948, p. 19) included the Newala as the basal member of the "Chickamauga" limestone, but mapped it separately. It has also been mapped as a unit in this investigation of the Dalton area.

Distribution—The Newala formation occurs in the eastern part of the Dalton quadrangle cropping out along a narrow belt at the west base of Sumac Ridge. Exposures begin at a point just north of Mill Creek in Murray County and continue northward and northeasterly for seven or eight miles to a point about 1½ miles east of Colvard School crossroads. Outcrops are not continuous over that distance because they are covered in places by later alluvial deposits so that many structurally critical areas cannot be observed. This is particularly true in the flood plain of Sumac Creek, where there is considerable offset to the east of the Newala exposures on the north side from those on the south side of the stream. Stream deposits from Mill Creek also veil, and limit the Newala at the southern limit of its exposure belt, because the formation was not found on the south side of that valley. It is probable that a fault cuts it out in that area beneath the alluvium.

Lithology—The Newala consists principally of moderately fossiliferous, dark, blue-gray limestones and pearl-gray dolomites in heavy, massive beds which may assume a pinkish cast in places. Exposures in the Dalton quadrangle do not reveal the entire section, so that detailed measurements on individual beds were not obtained, but the formation crops out in several places so that its general characteristics may be observed.

Outcrops about 1.6 miles southwest of Eton on Mt. Carmel road (Station 22) show a series of eastward-dipping, light-gray, massive limestone and dolomite beds cropping out in rounded, bouldery form on the west slope of a low ridge. The exposures occur in a horizontal distance of approximately 500 feet, but their dip is variable. To the west, the lower part of the formation dips as low as 4 degrees southeast, but at the east, near the base of the Athens, dips reach as much as 20 degrees southeast. Using the Busk method of geometrical construction of folds, the section exposed at that locality can be computed to be about 110 feet thick. The upper ten feet of the section consists of a thick-bedded, massive dolomite that is finely and evenly crystalline, and is light-gray with a slight pinkish cast. About 30 feet below the top of the formation, cross-sections of fossils (*Ceratopea* sp. cf. *keithi* Ulrich) appear in light-gray, but more coarsely crystalline dolomite. Similar material together with a little intercalated, darker gray limestone, occurs lower in the section.

The structure in this vicinity probably is a broad, open anticline, flanked to the west by a somewhat more steeply dipping, asymmetrical syncline. If such is the case, the extraordinary width of the Newala outcrop in the area just north of Mill Creek can be explained. Furthermore, such a structural condition might conceivably repeat the upper portion of the formation so that the total thickness of the formation is unexposed. The computed thickness of 110 feet is only about one half the thickness found for the Newala a few miles to the north.

One mile to the north of Station 22, on the Eton-Franklin School road about 1 mile east of the school near T. B. M. 778 where a small stream crosses the road, the Newala is again partially exposed (Station 23). No reliable thickness could be obtained for the formation there on the bouldery pinnacles and ledges bordering the small stream along the west side of Sumac Ridge. The formation consists of light-gray, banded, somewhat mottled limestone and dolomite with a few poorly preserved fossils.

Good exposures of the Newala occur east of Fashion about ¾ mile along the bottom of a tributary to Pinhook Creek, at a point about 200 yards north the road (Station 24). The limestone is light-gray, with anastomosing, thin, brown, dolomitic layers so distributed that they give the appearance of a small scale pinch and swell structure. The dolomitic bands have a very slight relief above the larger limestone "eyes". Some cross sections of fossils were noted, among them: *Ceratopea* sp. cf. *keithi*, *Hormotoma* (?), *Maclurites* sp., an unidentified bryozoan and a small orthoceroid cephalopod.

Immediately north of Sumac Creek, about 1 mile west of the east boundary of the quadrangle, the Newala crops out in the vicinity of the crossroads at T. B. M. 794 (Station 25). The strike at this point is N 3° E, and the dip is 40° SE. The bed is partially exposed in fields northwest of the crossroads, as well as in ditches along the two roads. Measurements of the stratigraphic thickness there, beginning at the lowest point of exposure, give the figure of 201 feet, which is likely to be more reliable than others obtained for the Newala in the area. The overlying breccia zone was not observed at this locality.

Two and one half miles north of Station 25, at the Cookerly property, which is about a mile and a half east of the Colvard School crossroads, the poorly exposed Newala again crops out in a narrow zone 250 yards wide, lying between Athens shales to the east and Knox to the west (Station 26). Since the dip is 22° SE, the thickness at this point becomes approximately 235 feet. The Newala here is overlain by a thin limestone breccia, which is probably Blackford.

Correlation and Stratigraphy—The Newala contains a few fossils which are sparingly present at several localities in the quadrangle. One exposure is located about 1¼ miles east-northeast of Zion Hill Church (Station 27). In the light-gray limestone at that point are numerous specimens in cross-section of *Ceratopea* sp. cf. *keithi* Ulrich, and *Maclurites* sp. cf., *affinis* Billings. Some two miles south of this locality, at Station 24, numerous, poorly preserved fossils occur in cross-section. Butts and Gildersleeve (1948, p. 21-22) referred to some of these exposures (Stations 23 and 24) and have identified the formation as Newala principally on the occurrence of *Ceratopea keithi* and stratigraphic position.

The Newala immediately overlies the Longview according to Butts (1926, geologic column opp. p. 80) but this relationship was not observed in the Dalton area because of a lack of suitable exposures. The Newala is not recognized in the east Tennessee section, but equivalent beds exist there as pointed out by Oder (1934, p. 488-489) who has, on the basis of fossil evidence, demonstrated the co-existence of several species of the upper part of the Newala with those of the "Cotter-Powell" division of the Knox. Later, Oder and Miller (1945) proposed the name Mascot for the "Cotter-Powell" and the name Kingsport for those beds underlying it which were formerly called "Jefferson City". Both the Kingsport and the Mascot correspond in part to the Newala, therefore the Newala probably represents the upper portion of the Knox sequence in Georgia, and should be included in the Knox group.

The top of the Newala is marked by one of the great unconformities of the Southern Appalachians. As yet, in Georgia, the extent and exact evaluation of the amount of erosion that occurred in the post-Newala, pre-Middle Ordovician interval have not been made. Nevertheless, on the basis of the small amount of information available, it seems safe to say that in places all of the Newala, Longview and perhaps part of the Chepultepec were eroded during that time. This is illustrated along Haig Creek, on the western side of the quadrangle, where post-Knox Ordovician beds rest (probably) on the Chepultepec.

MIDDLE ORDOVICIAN

Post-Knox Ordovician

The Knox sequence, including the Newala, is overlain in the Dalton quadrangle, by several formations which, in this investigation, have been mapped as a unit representing Middle Ordovician deposits. The absence of adequate outcrops has largely prevented the lateral tracing of individuals beds, while the occurrence of the exposures in isolated fault blocks and widely separated areas has increased the uncertainty of correlations within the group. Therefore it is felt that considerably more evidence is necessary than is now available to warrant positive conclusions not only about their local, but also about their regional relations.

Three general areas within the quadrangle are underlain by rocks of this age: An eastern belt of exposures in Murray

County along Sumac Ridge, extending from just north of Mill Creek, north-northeast to a point about 1½ miles east of Colvard School crossroads where the beds are concealed by later alluvium, thence northeastward beyond the eastern limit of the quadrangle. On the western side of the quadrangle in Whitfield County, are two larger fault block areas and a third, smaller one in which these formations occur. The westernmost one, called the Hamilton Mountain block, strikes slightly west of north through the city of Dalton and extends to about 1½ miles south of Varnell. The southern end of the other main fault block begins about a mile east of the northern end of Hamilton Mountain, and trends northeasterly beyond the northern limit of the quadrangle. It is herein named the Mt. Olive Church fault block. Georgia State Highway 71 enters this belt just south of an eastward flowing stream fed by Copeland Springs and tributary to Coahulla Creek. The highway continues north on the belt for about three miles nearly to Mills Creek and the road to Red Clay, but north of that point the highway lies approximately upon the contact between the upper Knox and the post-Knox Ordovician. The eastern most of the three western fault blocks involving these younger beds has little extent within the quadrangle; about three fourths of its area within the quadrangle lies north of the Tennesee line. The best exposures occur along a side road to the east of its junction with Tennessee Highway 60 (Georgia 71) at T. B. M. 890. The outcrops start near T. B. M. 828, about 1 mile east of T. B. M. 890, and may be seen along the road to the east for a distance of about 0.3 miles.

Butts and Gildersleeve (1948, p. 24-29) reported the presence of the following formations in the areas herein mapped as post-Knox Ordovician; in ascending order, they are: "Mosheim", "Lenoir", "Holston", "Athens", Ottosee" (Sevier), and "Lowville-Moccasin". There are no known exposures in the quadrangle area of the "Mosheim", although it is possible that the bed is present, but concealed, in the interval existing between the lowermost "Lenoir" and the uppermost Knox. Although beds of the other post-Knox Ordovician formations crop out in the several belts, not all of them are exposed in a single locality.

Blackford—In addition to these, another formation heretofore unrecognized in Georgia, marks the base of the post-Knox Ordovician sequence. This is the Blackford mentioned previously in connection with the top of the Newala.

The term Blackford was originally proposed by Butts (1941, p. 126) as "The Blackford facies of the Murphreesboro formation." He included in it the basal clastics such as red beds, chert conglomerates, and gray shales that commonly occur just above the unconformity at the top of the Knox group in Virginia, but did not recognize the horizon in Georgia.

Later, Cooper and Prouty (1943, p. 862) assigned the Blackford to the base of their now abandoned "Cliffield" formation, as a member. Since then, Cooper (1950, p. 29) has assigned formational rank to the Blackford.

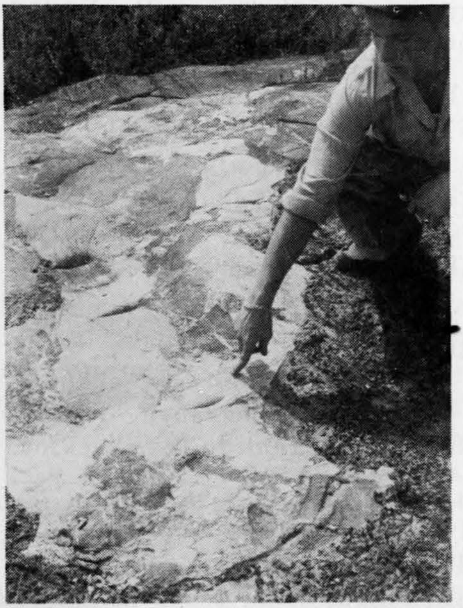
Distribution—Outcrops of the Blackford formation are, in general, poorly exposed and widely separated in the Dalton quadrangle. The formation may be noted in the Sumac Ridge belt of post-Knox Ordovician rocks in association with the interval between the top of the Newala and the base of the Athens, always occurring, where observed, immediately above the Newala. It has also been noted in the two western fault blocks, cropping out just above the Knox cherts but stratigraphically below the "Mosheim"-"Lenoir" zone.

The most southerly exposure (Station 28) of the Blackford observed in the eastern belt occurs about 500 yards southwest of Station 22, described under the Newala, in a broad, open field. The exposures there are essentially horizontal, and flat, tabular surfaces from which the thin soils have been stripped.

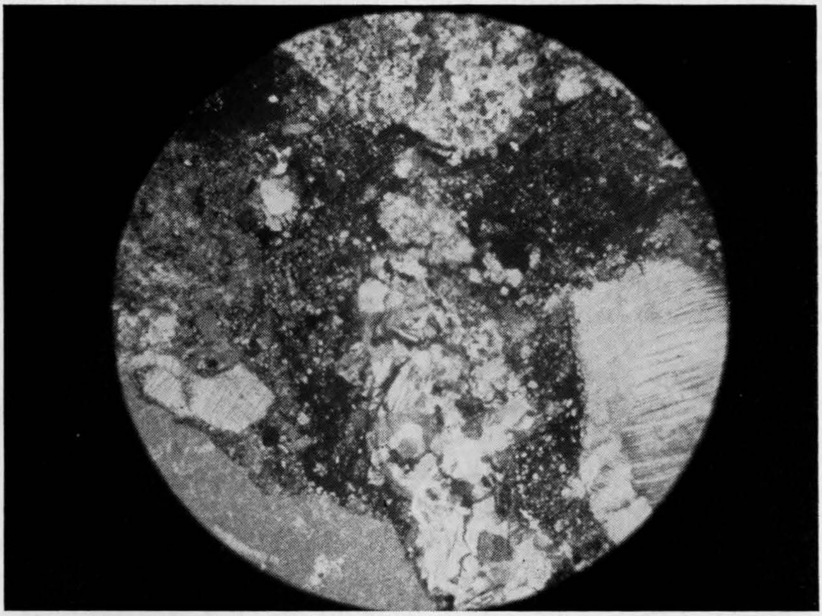
A particularly good exposure of the Blackford also occurs at Station 23, previously described under the Newala. The bed crops out in the small stream bed just north of the road from Franklin School, at the point where the stream emerges from a culvert beneath the road. An irregular surface about thirty feet square exposes nearly fresh rock.

A third exposure of the Blackford in the eastern area may be found at Station 26, which is about 7¾ miles north-northeast of the last described one. Again, the breccia zone im-

Plate V



A.—Blackford limestone breccia at Station 28.



B.—Blackford breccia at Station 26. Dark cementing material is limonite. (25 X, crossed nicols) mediately overlies the Newala at this locality as in the preceding ones. Diligent search along the strike belt of the Newala would undoubtedly reveal several other localities where the Blackford could be observed.

In the two westernmost fault blocks, the Blackford has been noted at several localities. It has been traced along the base of the ridge, underlain by the Knox, extending from a point just north of Mill Creek on the north of Dalton, and on the west side of Haig Creek, northward for a distance of about 2½ miles beyond Poplar Spring Church. Beds referred to the Blackford, have also been noted in the Mt. Olive Church block, along the east base of the first Knox ridge east of Varnell and Cohutta (Red Clay Ridge). Exposures in this belt are not as numerous as those in the western belt, but in road cuts several hundred yards south of the east-west road connecting Varnell with Georgia Highway 71, the Blackford horizon probably crops out paralleling the road on its west side and nearly at road level (Station 29).

Lithology—The Blackford formation presents a varying lithology from place to place, but, characteristically, it seems to be primarily a zone of re-worked coarse clastics. Apparently it possesses two types of lithology in the Dalton quadrangle, but the difference may be due to superficial alterations caused by weathering or it may also be due to underlying rock types. The two kinds of Blackford might be termed the eastern type and the western type in accordance with its occurrence in those general areas of the quadrangle.

The eastern type is a limestone-dolomite breccia in which highly angular blocks of several kinds are cemented in random orientation in a bed of variable thickness. Some of the blocks, which may range up to as much as 2 feet in long dimension, are very light pearl-gray, thinly-bedded limestone, while others are light-gray dolomite, slightly more massively bedded. In places, particularly at Stations 23 and 28, the cementing material appears to be a medium-coarsely crystalline limestone containing a few poorly preserved fossils. At Station 26, the cementing material is a moderately hard, red, sandy hematite, and in addition to the usual limestone and dolomite fragments, smaller pieces of a light-gray, medium-grained, quartz sandstone were noted. Some of the blocks composing this breccia seem also to be fragments of a pre-existing conglomerate or breccia, because several were noted to contain slightly rounded, smaller, different colored and textured limestone particles. These particles, several inches in length, are imbedded within the larger fragments apparently with random positions.

The western type of the Blackford differs appreciably from the eastern, and approaches more closely the description applied to beds of similar stratigraphic position in Virginia (Cooper, 1950, p. 29). Where observed, the formation consists of a highly irregular zone of red clays, and chert fragments showing little evidence of regularity of bedding. Outcrops, for the most part, are poor and the zone may be recognized chiefly only by the reddish soils which it produces in contrast to the yellowish soils of the underlying Knox (Laurence, R., personal communication, July, 1950). A ditch at Station 30, located about 3 miles north of Waring on an east-west road shows these reddish clays occurring through a thickness of about 20 feet, but this may be only a part of the true thickness. Similar exposures may be found in the next eastern belt, but at no point could any but deeply weathered materials be seen.

The limestone-dolomite breccia of the eastern side of the quadrangle is perhaps not the result of sub-aerial erosion, but may represent sub-aqueous erosion by wave action upon both consolidated and unconsolidated carbonate rocks (J. L. Rich, 1949, personal communication). It seems likely that if broad, low warping occurred in post-Newala time, some fold crests could have been slightly emergent from the waters of the geosyncline, while other fold crests remained submerged.

Weathering and erosion of the rocks of the emergent portions of the folds perhaps produced in the resulting residuum a lithology differing considerably from the unweathered, but eroded rocks of the submerged sections. Thus, although differing greatly in lithology, the oxidized western-type clastics probably are essentially time equivalents of the blocky, angular carbonate clastics on the east side of the quadrangle.

Correlation and Stratigraphy—Cooper (1950, p. 29-30), who has studied the relations of the post-Knox Ordovician beds extensively and thoroughly in Virginia and Tennessee, has concluded that the Blackford—"represents the material washed off an old land surface developed on the Knox dolomite"—but, at the same time, however, he believes these clastics were re-worked and re-deposited upon that erosional surface immediately after its resubmergence. Cooper (1950) has reasoned its age from interfingerings of the Tumbez limestone which are found near near Hansonville, Russell County, Virginia, where the Tumbez limestone contains a fauna corresponding to that of the Lenoir limestone as it occurs in the Lenoir City-Philadelphia belt in Tennessee. Laurence (1944, Table 1) considered a zone of shaly dolomite and altered volcanics, occurring between "Post-Nittany" dolomites and Mosheim vaughanites, to be representatives of the distinct hiatus developed in post-Knox--pre-Lenoir time. Later, Laurence (1950, personal communication, 26 October) indicated that he is not so certain that his "33" beds belong in the post-Knox--pre-Chickamauga interval, because he believes that—"some of the earthy Blackford beds may contain reworked volcanic ash", and the "33" beds, then, are probably Blackford. This zone is called the Attala conglomerate in Alabama (Butts, 1926).

If both the eastern and western types of these clastic materials actually represent the same stratigraphic horizon, then it is likely that they indicate an interval of warping and attendant sub-aerial and sub-aqueous erosion. Furthermore, a considerable truncation of Knox group formations is indicated, i. e., from the top of the Newala possibly down as far in the section as Chepultepec. The Blackford, therefore, represents the base of the Middle Ordovician.

"Mosheim" formation: No exposures of the Mosheim are known within the quadrangle, but it may occur in the covered intervals between the top of the Knox and the base of the Lenoir in the two westernmost fault blocks as well as in the interval between the Newala and the base of the Athens in the eastern area. Outcrops on the road from Gregory's Mill east toward Cisco (east of the quadrangle boundary) at a point about 0.3 miles east of the boundary of the quadrangle were examined by John Rodgers, Robert Laurence, P. B. King (Field conference, 15, July, 1950) and others and were tentatively identified as representing both "Mosheim" and "Lenoir". The interval at this point is about thirty feet between the Newala and the Athens of which the Mosheim occupies about one half the thickness.

The typical "Mosheim" is a very light-gray, extremely finely crystalline, nearly lithographic limestone. It has been described as a calcilutyte (Cooper and Prouty, 1944, p. 866-68), a characteristic which seems widely persistent, but, unfortunately, not confined to a single stratigraphic horizon.

"Lenoir" formation: The only outcrops definitely identified as "Lenoir" occur about 1 mile north of the Tennessee line just east of Tennessee Highway 60 near the base of the west-facing slope approximately ¼ mile north of T. B. M. 890 (Station 31). The formation there is a medium-coarsely crystalline, gray limestone of rather massive appearance in the few ledges exposed. The weathered surfaces appear whitish from a thin patina of chalky matter, and standing out in relief on many of them are numerous specimens of *Maclurites magnus* Lesueur preserved in the form of light-brown chert. Some individuals reach a maximum dimension of more than four inches. Stose and Schrader (1923, p. 21) note that the "Lenoir" ("Chickamauga") of the Cleveland (Tenn.) district thins to about 20 feet at the Georgia line.

"Holston" marble formation: Outcrops of the "Holston" formation are more numerous than those of the two preceding formations in the Dalton quadrangle, but are confined to the two westernmost fault blocks. The more extensive exposures may be seen in the Mt. Olive Church block, but even there the outcrops are so widely spaced that detailed mapping did not seem warranted. The largest exposure of the formation occurs in an old quarry located about 1/4 miles east of State Highway 71, on the south side of an east-flowing tributary to Coahulla Creek heading up in the vicinity of Pittner Hill just east of the town of Cohutta (Station 32). Folding or faulting, or both, in that locality have obscured the stratigraphic sequence to such a degree that only a small portion of the entire exposure could be interpreted. However, certain facts seem generally applicable. First, there are two easily distinguished types of limestone, both of which have a dark red color. Second, one of the limestones, usually the lower, has definite reef structure in places. Third, an obvious surface of discontinuity separates the two limestones; and fourth, the cross-bedded, thin-bedded, upper limestone thins across the top of the reef.

The lower limestone at Station 32 is massive, very coarsely crystalline and contains fossil fragments and specimens up to an inch or more in length, including a few brachiopods and many bryozoa. In general, the fossils are light cream color, on reddish, weathered surfaces. Fresh material, however, is light pinkish-gray, with some mottling caused by interstitial brown limonite, and various other red and yellow iron oxides. These oxides, at places, form a boxwork produced by leaching and carbonate rhombs around which the oxides had formed.

Some fossils could be tentatively identified. Among them were: *Rafinesquina* sp. cf. *minnesotensis*; *Rhinidictya* sp. cf. *nicholsoni*; and *Isochilina* (?). This material has assumed a mound-like form about 10 feet high which, in cross section on the quarry wall, may be certainly identified as a small reef. The upper surface of the reef is slightly irregular.

The upper limestone zone at this locality is thinly and unevenly bedded, more finely crystalline and contains fossil fragments of much smaller size than the reef zone. With bedding planes showing cross-bedding and tending to converge toward the crest of the reef mound, the rock apparently is a calcarenite derived in part, at least, from erosion and redeposition of material from the underlying reef.

Thin sections of the lower limestone show many types of bryozoa so intimately interlocked that it may be termed a bryozoan reef. Sections of the overlying calcarenite show small percentages of small quartz grains, which further substantiate the idea of its clastic character.

The angular relationship between the two limestone zones has been previously noted and well illustrated (Stose and Schrader, 1923, Pl. XIII, Figs. A and B) in manganese mines in Tennessee a few miles north of the quadrangle limits. A lower limestone there was identified as bryozoan reef material, but it was thought that the overlying calcarenite represented the Tellico, because the disconformity was believed to have been formed through sub-aerial erosion.

Economic concentrations of various manganese and iron oxides commonly occur at the contact between the two limestones and in channels cut into the underlying reef rock. A zone of ferruginous pebbles has also been observed near the top of the reef zone (Stose and Schrader, 1923, Pl. XV, Fig. B).

"Ottosee" formation: Soft, yellow and red, laminated shales and siltstones overlie the "Holston" limestone in both western fault blocks (Stations 33 and 36), and occur also in the small fault slice at the Tennessee line (Station 34).

Structural conditions in the Mt. Olive Church block are obscure so that the following section measured at Station 35, located about ⅓ of a mile north of Copeland Springs road, on Highway 71; thence 300 yards east to second ridge from highway, probably represents only a part of the whole:

Copeland Springs Section

Top: ridge crest.

Unit	Thickness	Description
6	322.5 ft.	Shale, silty, yellowish, thin-bedded; small loose blocks of brownish red sandstone and dense, yellow chert occur at ridge crest
5	17.2	Shale, yellowish, thin bedded
4	4.3	Sandstone, coarse-grained, brownish red, ledge-former
3	25.8	Shale, yellowish, thin bedded
2	30.1	Sandstone, coarse-grained, brownish red, in layers 6″ and 8″ thick
1	107.5	Clay (Shale?) red

Base—small creek near house.

The structural attitude is essentially constant with a strike of N 10° E and a dip of 40° SE.

A very few thin zones, usually not over ten inches thick, contain casts of unidentified fossils in beds in the western block on Hamilton Mountain tentatively assigned to the "Ottosee", but scattered specimens may be noted here and there throughout the total thickness of this bed in the other blocks. Yellow shales and siltstones weathering to a deep, brick red color probably mark the outcrop of the zone in both of the larger fault blocks. Excellent exposures of this phase may be seen in the western block on an east-west road between Haig Creek and Farrar Branch across Hamilton Mountain about 2½ miles north of Dalton (Station 36). The following section begins on the west side of the valley of Haig Creek and continues eastward to the intersection of the ridge crest of Hamilton Mountain with the road about ¼ mile west of Farrar Branch.

Hamilton Mountain Section (Station 36)

Top: ridge crest, elevation about 840 feet at road level.

Unit #	Thickness in feet	Description
Zone G		
63	14.1	Sandstone, massive, fine grained, hard, brick red to purple, some lamination
62	92.0	Covered, but probably thin-bedded red sandstone from appearance of soil rubble.
61	0.6	Sandstone, massive, fine-grained, red and purple.
60	105.0	Siltstone, shaly, laminated, dark red, somewhat coarser grained at top.
59	4.0	Sandstone, massive, coarse-grained, hard, yellowish.
58	1.5	Sandstone conglomerate containing rounded quartz pebbles from ⅛ inch to ¼ inch in size.
57	26.0	Siltstone, sandy, laminated with darker and lighter red zones.
56	1.5	Bentonite, whitish gray, flaky, pearly luster, laminated, soft. (B-3?)

Unit #	Thickness in feet	Description
55	40.0	Siltstone, sandy, laminated with darker and lighter red zones.
54	0.4	Fossil zone, with *Camarotoechia* sp., cf. *plena.*
53	164.6	Siltstone, sandy, laminated with darker and lighter red zones.
52	1.2	Sandstone, massive, coarse-grained, hard, yellow, grading into the conglomerate below.
51	0.4	Conglomeratic sandstone with subangular quartz pebbles up to ¼ inch size; yellow; much manganese staining.
50	30.2	Sandstone, fine-grained, soft, dark red, thinly bedded, with color banding of brown and yellow.
49	0.3	Sandstone, massive, hard, brown, medium-grained.
48	2.0	Siltstone, sandy, red, laminated.
47	0.4	Sandstone, massive, hard, reddish-brown, medium-grained.
46	43.0	Covered
45	25.0	Siltstone and fine-grained sandstone in thin layers, mottled red and gray.
44	3.0	Sandstone, thinly bedded, medium coarse-grained, yellowish.
43	1.7	Conglomeratic sandstone with rounded quartz pebbles up to ½ inch, also a few scattered subangular dark chert fragments, but no identifiable feldspar. Bed is quartzitic and breaks across cement and pebbles alike; a little iron staining.
Zone F		
42	2.0	Sandstone, massive, hard, medium coarse-grained yellowish.
41	208.0	Covered
40	5.0	Sandstone, massive, fine-to medium-grained, hard, red when weathered, but light cream to yellow on fresher surfaces.
39	71.0	Covered
38	1.0	Sandstone, massive, fine-to medium-grained, hard, weathers red, yellow when fresh.
37	10.7	Sandstone and siltstone in alternating beds, sands in beds up to 0.5 ft. thick, reddish.
36	10.7	Covered

Unit #	Thickness in feet	Description
35	6.4	Siltstone, reddish, laminated.
34	1.0	Sandstone, massive, fine-grained, red.
33	15.0	Sandstone intercalated in siltstone, both reddish-brown; sandstone in layers up to 0.5 feet thick.
32	17.0	Covered
31	17.0	Sandstone and intercalated siltstone, both reddish-brown.
30	21.5	Covered
29	5.7	Silstone, red, laminated.
28	0.4	Sandstone, massive, fine-grained, red.
27	17.0	Covered
26	0.3	Sandstone, massive, fine-grained, red.
25	3.0	Siltstone, laminated, red.
24	0.4	Sandstone, massive, fine-grained, red.
23	0.5	Siltstone, laminated, red.
22	0.4	Sandstone, massive, fine-grained, red.
21	4.3	Siltstone, sandy, thin bedded, reddish-brown.
20	1.8	Sandstone, massive, fine-grained, weathers red, light gray when fresh.
19	2.3	Siltstone, sandy, laminated, soft, red.
18	0.2	Sandstone, massive, fine-grained, red.
Zone E		
17	116.0	Siltstone, laminated, alternating layers of red and yellow in lower third, upper two thirds are uniform brick red.
16	71.0	Covered
15	12.8	Siltstone, laminated, yellow.
14	1.0	Siltstone, yellow, numerous fossil casts.
13	3.0	Siltstone, yellow, laminated.
12	29.0	Covered
11	8.6	Siltstone, somewhat harder than beds above and below, red.
10	29.0	Siltstone, brown to red, some yellow banding.
9	59.0	Covered
8	66.0	Siltstone, reddish-brown, some cream colored layers up to 2 feet thick.
7	16.0	Siltstone, red, mud rock, soft.
6	6.6	Siltstone, finely laminated, more resistant, red.

Unit #	Thickness in feet	Description
5	56.0	Siltstone, brownish-red, some thin cream-colored layers producing a banding effect.
4	44.0	Covered
3	15.0	Limestone, gray, crystalline, rounded pebbles of light-gray limestone.
Zone D		
2	10.0	Covered
1	2.0	Limestone, coarsely crystalline, red, highly fossiliferous ("Holston" formation), in creek bed.
Zones A, B, C		
0	163.6	Covered

Base—Knox

The rocks of the preceding section may be grouped, in a broad way, into three or four large zones each of which possesses its own characteristics.

The lowest exposures, represented by a few feet of reddish "Holston" marble, may be designated as Zone D, if it is assumed that the Blackford, at the base, is Zone A, the "Mosheim" is Zone B, and the "Lenoir" is Zone C.

Above is Zone E, a thick series of siltstones and shales which include at their base a 15 foot bed of pebbly, mottled, gray limestone (Units 3-17). Zone E is 533 feet thick, and includes, near its top, a thin, fossiliferous zone (Unit 14) from which the carbonates have been leached. This is probably "Ottosee".

Zone F, succeeding the siltstones of Zone E, has a thin sandstone (Unit 18) marking its base. The entire zone, consisting of alternating red siltstones and red sandstones (Units 18-42) has a thickness of 422.6 feet. This may be "Sevier".

Zone G, the upper portion of the Hamilton Mountain section, is marked at its base by a quartzite conglomerate (Unit 43), and consists of red and yellow siltstones, thin sandstones and a few thin quartz conglomerates. It also includes a thin bentonite layer (Unit 56). Forty feet below the bentonite is a thin layer containing poorly preserved fossil impressions with *Camarotoechia* cf. *plena* (Unit 54). This may be "Bays".

Athens formation: A series of grayish-yellow siltstones and sandstones about 3500 feet thick crop out in Sumac Ridge near the eastern border of the quadrangle. Predominantly, the rocks are thinly-bedded, yellow siltstones; roughly, 500 feet above the base, prominent, massive, medium-coarse-grained, quartz sandstones occur (Station 37). Succeeding this zone, are more thinly bedded siltstones which are sandier than the lower siltstones, but about the same color. No fossils were observed.*

East of the quadrangle, to the east of Cisco, Georgia, the Athens is overlain by massive beds of limestone conglomerate in which highly angular fragments of limestone and chert are cemented by a coarse, reddish quartz sand matrix. This formation has been called the Tellico (Butts and Gildersleeve, 1948, p. 29). About 700 feet of reddish sandstones and interbedded red siltstones, lying above the conglomerate, and truncated to the east by an overthrust sheet of crystalline rocks, were included in the Tellico by Butts and Gildersleeve.

Correlation and Stratigraphy—The names employed in the preceding section on lithology to designate various beds within the post-Knox Ordovician sequence have been inherited from previous classifications. It is uncertain at present that such formational names are validly applicable to the strata to which they have been assigned in the Dalton area. It remains for future investigation to determine their precise relations to the general regional Appalachian stratigraphy of the Middle Ordovician beds. Figure 2 shows the developments in correlation of these horizons according to the interpretations of previous investigators.

It is particularly noteworthy that the firmly entrenched column of Ulrich, which has been closely followed by Butts, has suffered a major attack. Recent work has demonstrated conclusively that extensive revision of the lower Middle Ordovician and also part of the Mohawkian is necessary before a coherent, comprehensive picture of that time emerges.

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*Since this report was written, a zone of graptolites *(Diplograptus ?)* was discovered near the base of the Athens, by members of a field trip sponsored by the Southeastern Geological Society in April, 1951.

Butts and Gildersleeve (1948), in their work on the Paleozoic rocks of northwest Georgia, adopted the stratigraphic column which had earlier been established by Ulrich (1929, p. 73) and which had been applied to much of the southern Appalachian region. Their specific identifications of the various formations of post-Knox Ordovician age, particularly within the Dalton quadrangle, seem questionable in the light of knowledge gained from study there and elsewhere in the Appalachians. This fact they have partially recognized in their tentative correlation of the "Ottosee" in the Mt. Olive Church belt, and also beds which were labeled "Lowville-Moccasin", in the Hamilton Mountain section. The present investigation has not solved these problems of correlation but work in progress may contribute a small part toward their eventual clarification.

Butts and Gildersleeve (1948, p. 30-31) made a distinction between the exposures of the Mt. Olive Church and the Hamilton Mountain exposures, because they believed the first to represent the "Stones River"-"Blount" sequence, while they assigned the latter to the Lowville-Moccasin. Using the correlation offered by Butts (following Ulrich) (1926, opp. p. 80), this meant, on Hamilton Mountain, as they state (1948, p. 31), that—"There is here a great hiatus between it (Lowville-Moccasin) and the Knox due to the absence of the Stones River and Blount groups and the Newala limestone." The discussion following is an attempt to clarify the stratigraphy of the Mt. Olive and Hamilton Mountain sections, and to demonstrate the possibilities and probabilities of inter-correlation between them and the Sumac Ridge belt on the east side of the quadrangle.

"Mosheim-Lenoir": At present, several significant facts about both the local and regional correlation of these beds are noteworthy. One is the apparent constancy of lithologic and stratigraphic succession of the beds constituting the lower part of the group in and nearby the quadrangle.

Both the eastern and western outcrop areas may have, in ascending order: Blackford, "Mosheim" and "Lenoir", although thicknesses of the beds vary. If, by means of tracing along the strike, the "Mosheim" and the "Lenoir" may be tied in with the east Tennessee section, then the designation of these beds in the Dalton area may be made with much more certainty than at present. However, in the eastern belt, only one locality, just east of the quadrangle boundary on the Gregory's Mill—Cisco road, shows a section in which rocks of both "Mosheim" and "Lenoir" lithology are recognizable. And, in the western blocks, while the "Lenoir" is exposed (Station 31), no identifiable outcrops of "Mosheim" were observed, although it may be present in covered areas between the Blackford and the "Lenoir". Furthermore, the "Lenoir" of the western exposures contains numerous specimens of *Maclurites magnus* Lesueur, but none were found in Sumac Ridge exposures.

Ulrich (1929) included the "Mosheim" and the "Lenoir" in his "Stones River" group, which, at that time, he maintained was entirely Chazyan. Later, he (Ulrich, 1939, p. 106) removed the "Lebanon" from the "Stones River", placing it at the base of the overlying Black River. Simultaneously, he placed the Ridley-Pierce, which was considered to be older than any part of his "Blount" group, above the Ottosee. This, in effect, destroyed the identities of both the "Stones River" and the "Blount" groups. (See Fig. 2) B. N. Cooper (1945) has given a particularly good analysis of this entire question of Middle Ordovician stratigraphy of the central Tennessee-Virginia region. He states that one of the chief means by which it was considered that the "Stones River" might be identified was the gastropod *Maclurites magnus* Lesueur, and argues correctly that "either this species has a long range or it has been loosely identified". Therefore, since Butts' "Lenoir" of the Mt. Olive Church fault block in the Dalton quadrangle has been identified by Butts and Gildersleeve (1948, p. 26) primarily on the basis of the occurrence of *Maclurites magnus* Lesueur, it seems best at present to reserve judgment concerning its regional correlation, although it is probably correctly identified.

Cooper and Prouty (1944, p. 852-853) had previously demonstrated that typical Mosheim lithology is repeated several times in the Virginia section. Therefore, according to Cooper (1945, p. 270), the stratigraphic position of the Mosheim is doubtful. Its correlation in the Dalton quadrangle must also remain uncertain until it may be traced laterally into the east Tennessee section.

"Holston"—In the Mt. Olive Church block of the Dalton quadrangle, the "Lenoir" is overlain by coarsely crystalline, red limestones called the "Holston marble". The Holston was originally described by Keith (1895) as—"lentils of variegated marbles of many colors in blue and gray limestone." Six years later, Keith (1901) described the lower part of the "Chickamauga" limestone as containing many beds of coarsely crystalline marble which he believed to be lentils in the "Chickamauga". Butts (1926, p. 105-107) stated that the Holston marble in the Knoxville, Tennessee, region succeeds the Lenoir—"and there are cogent reasons for believing that the Holston **underlies** the horizon of the Athens shale **which is not present in the belts where the Holston crops out."** (Bold type by present writer.) Butts did not state his "cogent reasons", but it is presumed that the statement is based upon Ulrich's (1911, p. 414) concept of the existence of an Athens trough to the east, and a Knoxville trough to the west, in both of which sedimentation was believed to have occurred more or less independently, but successively and alternately.

Ulrich (1911, p. 414) had interpreted Hayes' (1895) work in the Cleveland quadrangle to mean that an hiatus was present between Hayes' uppermost "Chickamauga" (or Ulrich's Lenoir) and the basal Athens shale. In the Knoxville area, he assumed that the Holston was the topmost member of the Chickamauga, thus underlying the Athens and Tellico horizons. The Holston and Athens-Tellico are not areally coextensive, so that his opinion might have been correct.

The yellowish, thin-bedded, shaly and sandy beds overlying the "Mosheim-Lenoir" zone of Sumac Ridge in the eastern Dalton area were assigned to the Athens by Butts and Gildersleeve (1948, p. 28-29). Their correlation seems valid, because if the rocks of the Dalton section are traced northeastward toward Benton, Tennessee, in the Cleveland quadrangle, they join with exposures which Hayes (1895) identified as Athens. Furthermore, both thickness and lithologic sequence are essentially similar between the Dalton and Cleveland quadrangle exposures. On the other hand, in the western Dalton area, the "Lenoir" is succeeded by the "Holston", no Athens shale being present. These two sections, then, one on the eastern side of the Dalton area, the other on the west, set forth, it is thought, nearly the same stratigraphic and areal situation that exists farther north in the Cleveland and Knoxville quadrangles.

Another explanation for the fact that the Athens-Tellico and the "Holston" have not been found together in the same area is possible, however, because it is more than likely that the "Holston" represents an offshore facies of the apparently more clastic Athens-Tellico. It may be suggested (Figure 3) that the "Holston" reefs, which, incidentally, probably correspond to the lenticular development of red limestones noted by Keith, gave rise to large quantities of lime sands. These "Holston" lime-sands, along with a few small, introduced, quartz and heavy mineral grains, eventually consolidated into a calcarenite, represent an offshore, clastic, lime-sand facies of the inshore clastic, quartzose siltstones and sands of the Athens-Tellico strata formed farther east at the same time. If this assumption is correct, then the "Holston" is equivalent to part of the Athens-Tellico, and should **not** be found in contact with it, and the deposits **could** not be areally coextensive.

Rodgers (1949, p. 131) states that within the limits of a single strike belt in Tennessee the Holston becomes a facies of the Tellico, while the Athens, lying below the Tellico, is a clastic facies of the Lenoir. Furthermore, he states that the whole group represents a clastic equivalent of limestone of Black River and Chazy age farther to the northwest. King (1950, Fig. 9) indicates the same relations between the limestone lithofacies of the "Chickamauga" and the clastic Athens-Tellico group and younger formations to the east. Such a correlation as the latter was suggested by Hayes (1895) who believed that part of—"the Chickamauga limestone is replaced by the Athens." Cooper (1941), also, has stated that the Athens formation in Virginia is much more extensive than previously believed, and that, northwest of Clinch Mountain, it is represented by a limestone facies.

"Ottosee": Overlying the "Holston" are a series of yellow and red shales, which, in the Mt. Olive Church block, were tentatively referred to the "Ottosee" by Butts and Gildersleeve (1948, p. 29).

Keith (1895, p. 4) named a thick series of calcareous, yellow shales, weathered from light-blue, shaly limestone, overlying the Tellico sandstone and underlying the Bays sandstone, the Sevier. The name had been used earlier by Campbell (1894 a, p. 176; and 1894 b) for beds which he described as underlying the Bays sandstone and overlying both the Chickamauga limestone north of Clinch River and the Moccasin limestone south of Clinch River. Ulrich (1911), however, split off the basal calcareous shales of the Sevier, and assigned the name "Ottosee" to them from exposures at Ottosee Lake in Knoxville, Tennessee. He described the formation as overlying (conformably ?) the Tellico sandstone to the southeast, but being unconformable upon the Holston to the northwest, in the vicinity of Knoxville. There seems to be little doubt that the Ottosee of Ulrich is a valid subdivision of the Sevier, but considerable doubt exists whether there is a demonstrable unconformity between it and the underlying Holston, if King's and Rodger's interpretation of the Athens-Lenoir and Tellico-Holston relations is correct.

It seems necessary, therefore, not only to eliminate entirely Ulrich's "Stones River" and "Blount" groups, but also to re-adopt Keith's original terminology for the Middle Ordovician of the Knoxville quadrangle with modifications such as the addition of the term "Ottosee" for the calcareous beds at the base of Keith's Sevier and the term Blackford for beds at the base of the post-Knox. Integrated with this, must be Hayes' section in the Cleveland quadrangle. Figure 3 diagrammatically illustrates the section as it is presently believed to exist in the Dalton quadrangle and elsewhere in the Southern Appalachians.

The yellow shales overlying the "Holston" in the Mt. Olive Church block in the Dalton quadrangle, identified by Butts and Gildersleeve (1948, p. 29) as "Ottosee", are probably correctly placed in the section. Consequently, if this is so, then the yellow shales and siltstones of Zone E in Hamilton Mountain are also likely to be "Ottosee", for they, too, overlie reddish limestones which probably are "Holston".

"Sevier": Above the "Ottosee" shales in both the Mt. Olive Church and the Hamilton Mountain sections are alternating layers of red siltstones and sandstones. The zone composed of units 2-6 of the Copeland Springs section, and Zone F in

Hamilton Mountain, both of which seem to possess the same stratigraphic position and lithology, are, therefore, thought to be correlative, and may be "Sevier" in age. There is no good reason for the assumption that a depositional interruption occurred between the shales of the "Ottosee" and the shales-siltstones-sandstones of the overlying "Sevier" in Hamilton Mountain. On the contrary, close similarities of lithology, bedding and color give predisposition to the assumption of their depositional continuity.

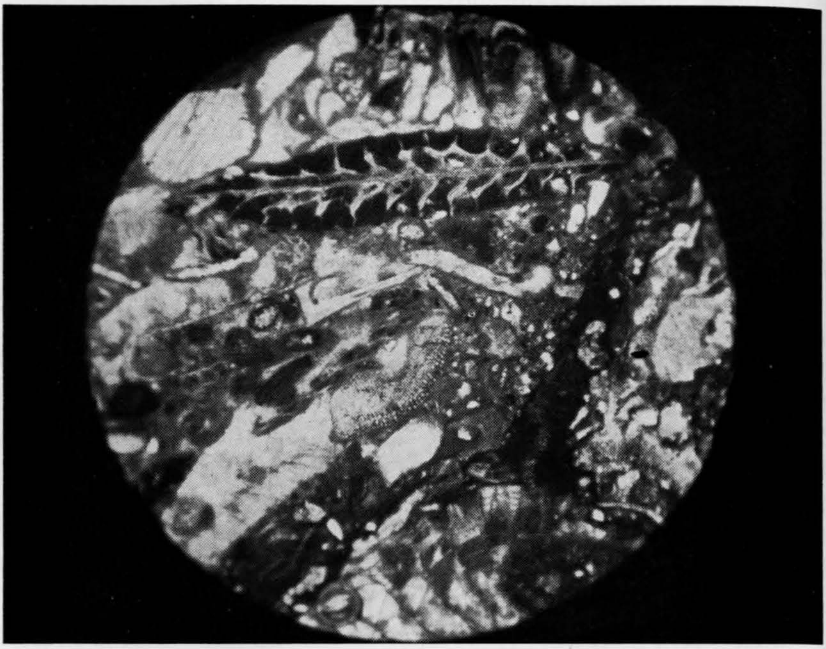
"Bays"—Zone G, in Hamilton Mountain, consists of quartzites, sandstones and shales, and includes a thin bentonite layer. If Zone F, below, represents the entire thickness of the "Sevier" in the Dalton quadrangle, then it is possible that Zone G represents the "Bays". This possibility was suggested by Rodgers, Laurence, King and others, recently, after examination of the Hamilton Mountain section (1950, Field Conference, 15, July). The occurrence of the thin bentonite may be significant because it might be equivalent to either the V-1 or V-2 bentonite layers noted by Rosenkrans (1936, pl. 10) in Virginia within the Bays.

The Bays was named by Keith (1895, p. 4) for exposures of red, calcareous and argillaceous sandstones in Bays Mountain, Tennessee. He noted that a red color is marked and persistent, but that great variations occur in its thickness, and considered it to be a near-shore formation.

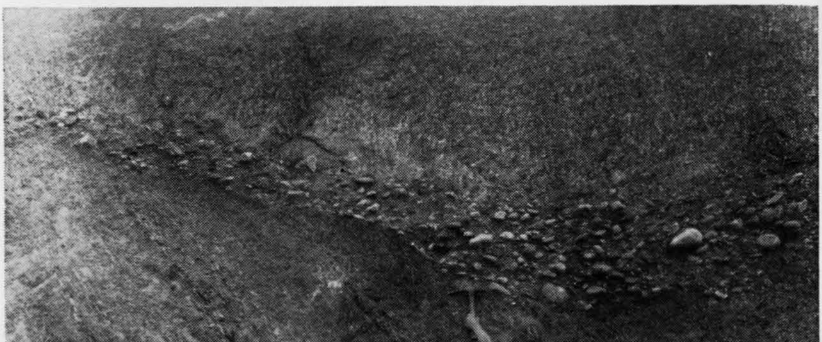
If the exposures along Hamilton Mountain are truly Bays, much future work will be required to prove the correlation. Consequently, they are herein provisionally referred to as the "Bays".

The writer agrees heartily with Cooper and Prouty (1943, p. 860-862) that—"the conventional classification of the Ordovician limestones—in the Appalachian Valley needs to be re-examined and evaluated—." Furthermore, as they point out, the use of names such as "Mosheim", "Lenoir", "Ottosee" and "Lowville-Moccasin" must be restricted and largely abandoned unless each is specifically qualified as to the investigator and the locality in which the exposures were identified. It is possible that by careful re-definition such names may be re-employed, but this should be done only in a manner commensurate with complete clarity of their positions in both a time and a rock classification.

Plate VI



A.—Bryozoa in Holston "marble" reef at Station 32. (25 X)



B.—Angular unconformity between Conasauga shales and Tertiary (?) alluvium along Perry Creek.

TERTIARY(?)ALLUVIUM

Covering a large portion of the Murray County area east of Conasauga River, is a superficial blanket of alluvium situated for the most part appreciably higher than the present flood plains of the streams. In places, however, this alluvium ranges down in elevation so that it is in direct contact with the Recent stream alluvium, but it also has been noted at elevations as high as 1000 feet on Sumac ridge. It lies indiscriminately upon the truncated edges of the older Paleozoic rocks below, but the lower surface varies considerably in elevation from place to place suggesting that the alluvium was deposited upon a pre-existing erosional surface of considerable relief. Some creep has undoubtedly occurred since its deposition so that any accurate estimate of the amount of pre-existing relief cannot be made at present. The deposit has been subjected to much erosion since its formation, and now remains largely in those areas which are more or less protected from direct erosional attack by streams.

Distribution—Two roughly parallel belts of the alluvium flank Sumac Ridge on either side for much of its extent within the quadrangle. These strips are segmented not only by transverse streams such as Perry, Sumac and Mill Creeks, but are also separated into many small outliers through dissection. The two belts, best developed north of Mill Creek, apparently merged south of that stream, and once formed a very extensive cover over Spring Place and vicinity where it now remains as remnants, principally in interstream areas. Another remnant occurs just above the present flood plain of Conasauga River on the east side of the river from Beaverdale where the river makes a big bend to the west. This area is separated fully by 1½ to 2 miles from the nearest other outliers of the western Sumac belt, and indicates that much of the intervening area has been stripped of its cover.

The present valley of Conasauga River apparently is the western boundary of the Tertiary (?) alluvium, because material of this sort was not recognized west of that line. Only one exception was noted in which the alluvium occurs on the west bank of the river. That is its occurrence on the lowlands between the confluence of the river and a small tributary in the northeastern corner of the area.

Lithology—The alluvium, as usually mapped, consists of a dark red, sandy, pebbly to cobbly, poorly stratified clay or soil-like material. The percentage of sand is moderately high and as has been pointed out (Rich, J. L., personal communication, July 1949) can ordinarily be used as a distinguishing criterion. The sand grains range in size from fine to coarse, and sorting, therefore, is poor. The pebbles and cobbles present, ranging in size from more than a foot in long dimension to about ¼ inch, are well rounded and attain, in general, larger and larger size toward the eastern boundary of the quadrangle. The pebbles and cobbles are chiefly quartz and quartzite, but, not far west of Camp Ground Mountain, angular fragments of conglomeratic quartzite are also present in the alluvium. Numerous rounded cobbles of porous, limonitic and hematitic material containing coarse, quartz sand grains occur on the surface and in the alluvium along the ridge extending northward through the western limits of Eton. Such iron-bearing pebbles and cobbles are present in many sections of the area covered by the alluvium, and probably represent fragments of formerly more extensive iron oxide concentrations within the alluvium that have since been partially destroyed by erosion. Haseltine (1924, p. 82-83) reports that a good grade of limonite ore, occurring in dark-red, residual soil, about ½ mile south of Eton, contains geodes with highly colored interiors. The geodes and smaller fragments make up the bulk of the ore at that locality.

Mr. Carl Pack, Chatsworth, Georgia, presented the writer with a specimen of dark, brownish-red, ferruginous, medium-grained sandstone containing an excellent leaf impression (*Aelaeagnus?*) which he reports finding about 8 miles north-northeast of Chatsworth in Hassler's Mill Valley. This locality is in the Cohutta Mountain quadrangle, in a large re-entrant due east of Eton. The alluvium is there well developed with its typical dark-red color, but contains many very large, angular, quartz boulders. Although the area was subsequently searched for other fossil specimens, none were found. Therefore it is uncertain that the specimen actually represents plant life during the time of alluvial deposition. Furthermore, the rather rounded appearance of the entire specimen suggests that it may be an artifact, which, then, could easily be explained by having belonged to the Indians who

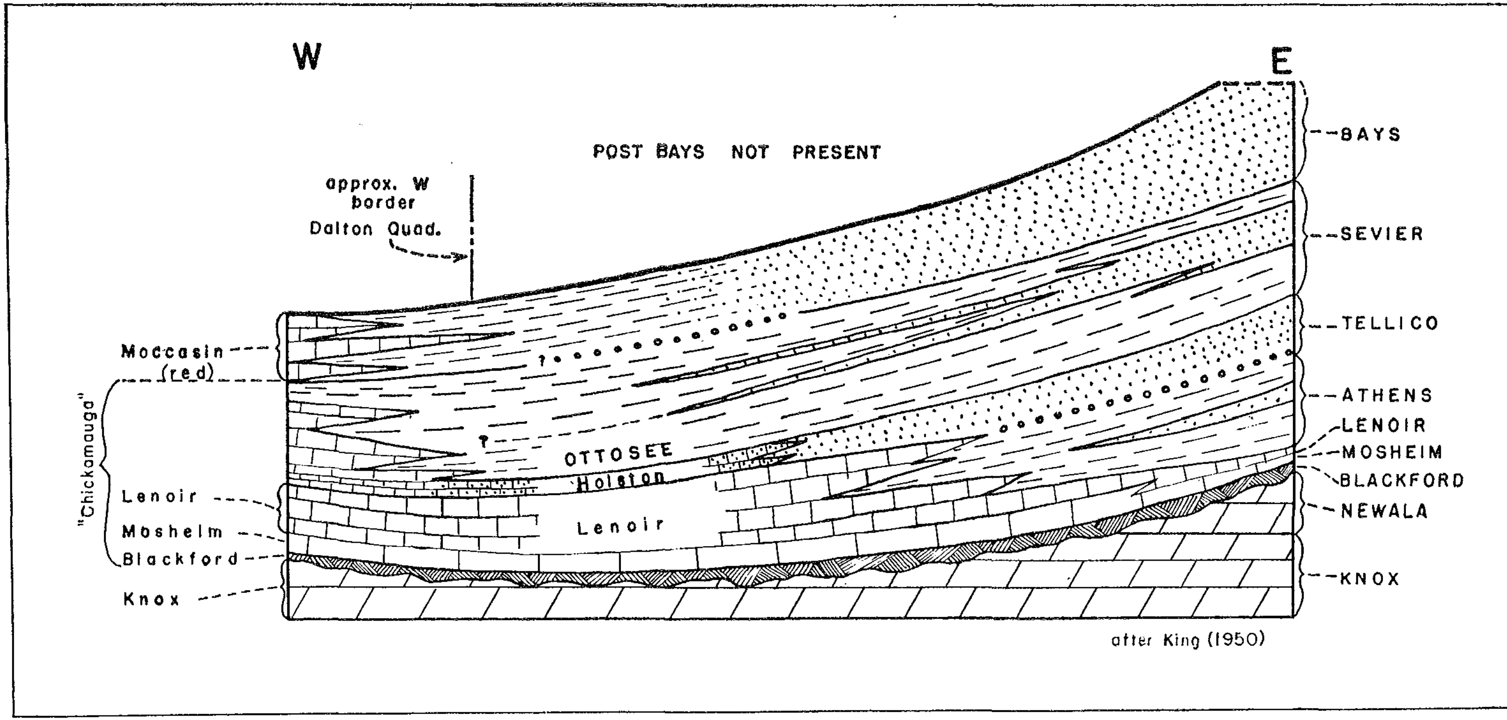


Fig. 3. Stratigraphic relations in Lower and Middle Ordovician.

once occupied the Hassler's Mill section. It is entirely possible that the specimen was brought to the area from some section of the Coastal Plain where ferruginous sandstones, containing leaf impressions, occur.

Correlation and Stratigraphy—Safford (1869, p. 438) noted the occurrence of what he termed—"The Eastern Gravel" which he described as bordering, in the Valley of East Tennessee, nearly all of the rivers, but, in particular, those issuing out of the Unaka Mountains. He states that the coarse gravels may be found two or three miles from these rivers, on ridges often at a height of 300 or 400 feet above the stream levels. The pebbles, or cobbles—"of all sizes below that of a man's head", he believed were largely derived from the Unakas as well as from the Chilhowee Mountains because some of them contain the characteristic Scolithus-rods. Although he does not specifically so describe them, it is evident that he wrote of quartz and quartzite "pebbles", because he mentions the "Chilhowee Sandstone". He did not attempt to date the gravels.

Any attempt to date such a localized deposit as the ferruginous alluvium of this area meets with many difficulties. Being wholly, it is believed, continental in origin and deposition, such beds commonly lack diagnostic organisms, or more often, any recognizable organic structures of any sort. Consequently it is necessary to use some other method of approach to date them. One of these which promises more than others, it seems, is a geomorphic analysis, but even then many uncertainties continue to exist.

Several observations may be pertinent to the discussion. First, the deposits are confined to the belt lying between Conasauga River and the foot of the Cohutta Mountains to the east. Second, the coarseness of the contained cobbles increases toward the mountains. Third, the cobbles have compositions that strongly suggest an origin in the crystallines of the Cohuttas. Fourth, the areal distribution of the alluvial deposit is in and west of the Hassler's Mill-Holly Creek reentrant into the Cohuttas. Fifth, there is a suggestion that the deposit thins toward Conasauga River; and sixth, the deposit has been formed on a pre-existing erosional surface which lies several thousands of feet below the present high levels within the Cohutta Mountains.

Some of the conclusions that may be drawn from these facts are: first, that the deposit has been derived from the erosion and re-deposition of materials, from the Cohutta Mountain re-entrant. Second, the form of the deposit was probably a large alluvial fan whose thickest part once lay about at the present position of the Hassler's Mill-Holly Creek locality, and whose outer edge probably was determined by Conasauga River. Third, subsequent erosion has deeply dissected the once more extensive deposit. Fourth, the old erosional surface upon which the fan was formed was not only adjacent to much higher land to the east, but also, probably had a somewhat different drainage pattern from the post-alluvium—Recent pattern.

Evidence of this latter statement may be found in the ridge previously mentioned just west of Eton (Station 38). The alluvium in that vicinity attains a possible thickness of more than 75 feet, because it forms not only the entire height of the ridge above the general level of the town of Eton, or a relief of 75 feet, but may also extend down as far as the level of Mill Creek, or perhaps still lower. If this is correct, then the present ridge represents at least a partial reverse of topography, because where there is now positive relief, there was once a plain and perhaps even a valley in the underlying Knox dolomite.

The superposition of Recent flood plain deposits upon the older, red alluvium indicates that it was formed in an earlier cycle, probably before the transverse valleys of Perry, Sumac and Mill Creeks were in existence. However, during the time of deposition of the red alluvium, there were distributaries flowing westward across the fan toward Conasauga River. The minimum level of the floor of such distributaries is indicated by the presence of quartz cobbles at elevations of approximately 1000 feet along Sumac Ridge just north of Sumac Creek. Therefore, since that time there has been a minimum of 240 feet of downcutting, because today, Sumac Creek lies, at the transection line to Sumac Ridge, at an elevation of about 760 feet.

Assuming that the 1000 foot elevation at the same point on Sumac Ridge represents the top surface of the old alluvial fan, and also assuming that an elevation of 720 feet at Beaverdale, 4½ miles west of the ridge, marks the top of the fan there, then there is a drop of 280 feet in that distance, which computes to less than 1 degree of slope. This figure, probably representing the slope only of the lowermost portion of the fan, if valid, further corroborates the inference that the fan distributaries were approaching grade at the level of the stream (Conasauga ?) marking the western limit of the fan.

It might also be inferred, it seems, that the distributary gradients, farther east in the Holly Creek re-entrant, were much steeper than that of Holly Creek at present. Also, formerly a much greater volume of water may have been available, because today, Holly Creek is not forming a fan. This, in turn, suggests that the climate was wetter—perhaps a pluvial period was in existence, and, therefore, finally, that perhaps such a period of abnormally high precipitation represents one of the pluvial periods of the Pleistocene.

It must be noted that the results of the present investigation differ materially from the interpretations placed on the deep red soils of the Spring Place vicinity by Butts and Gildersleeve (1948, p. 20). They interpreted the red soils, which are now known to be alluvium, as residuum from weathering of the Newala.

RECENT ALLUVIUM

Many of the streams of the Dalton quadrangle have developed rather prominent and extensive flood plains. This is particularly true of the two master streams, Conasauga River and Coahulla Creek, and their larger tributaries. The flood plains are underlain by a distinctive grayish, loamy material which, because of its evident active association with the streams, has been termed Recent alluvium.

The bottom lands are highly productive as farms and, as such, are greatly prized and valuable property. Some of the "bottoms" are used for grazing purposes just north of Dalton, but elsewhere, they are normally tilled and planted to produce cotton, corn, grains and other crops.

STRUCTURE

GENERAL STATEMENT

The Dalton quadrangle occupies a part of the tectonic zone called the Appalachian geosyncline, which was a locus of deposition throughout the Paleozoic and an area of intense deformation several times during that era. Although various parts of the geosyncline may have had somewhat different local depositional and orogenic histories in general, it may be considered a mega-tectonic unit that has undergone many of the same changes. Rodgers (1949, p. 1644-1645) has summarized some of the former and current ideas on Appalachian structure, pointing out that there are three distinct divisions of the geosyncline within the United States: (1) a northern segment, known to have been affected by three periods of orogeny, (2) a middle portion, and (3) a southern segment. The latter two, at least that part of them in the Ridge and Valley province, seems to have undergone but a single period of intense diastrophism which occurred near the end of the Paleozoic.

However, there seems to have been at least one preceding period in which some deformation took place, although its magnitude probably was not as great in the Southern Appalachians as it may have been elsewhere. King (1950, p. 661) has discussed this phase, relating it to the Taconian orogeny. He states that the evidence of the first orogenic movement indicated by the sediments of the geosyncline points toward a Middle Ordovician beginning in the Southern Appalachians, and a Late Ordovician culmination in New England. There is little doubt that a decided change in depositional conditions arose in post-Knox Ordovician time because truncation of Knox beds by the Blackford indicates some degree of warping, erosion and deposition in immediate post-Newala time. The replacement of the carbonate Knox-Newala environment by one in which considerably more siliceous clastics were being washed into the geosyncline, also supports the idea of possible orogenic movements in the source areas to the southeast at the beginning of Middle Ordovician time.

Post-Paleozoic movements are not well understood in the

Dalton area, nor elsewhere in the region, and must await further geologic and geomorphic work. However, some movements probably have occurred since the Appalachian revolution and are responsible for some of the "peneplain" levels present in the region. Perhaps it was due to some such late movement that the Tertiary (?) alluvium was deposited over much of the eastern Dalton quadrangle. Possibly a slight uplift has occurred in the interval since the Tertiary (?) alluvium was deposited, because streams have now cut their valleys an appreciable distance through it to form their existing flood plains. Alternatively, perhaps the regimen of the streams has been shifted by a change in the quantity of materials transported, thus producing, after removal of much of the sediment load, an excess capacity, of energy, for additional downcutting.

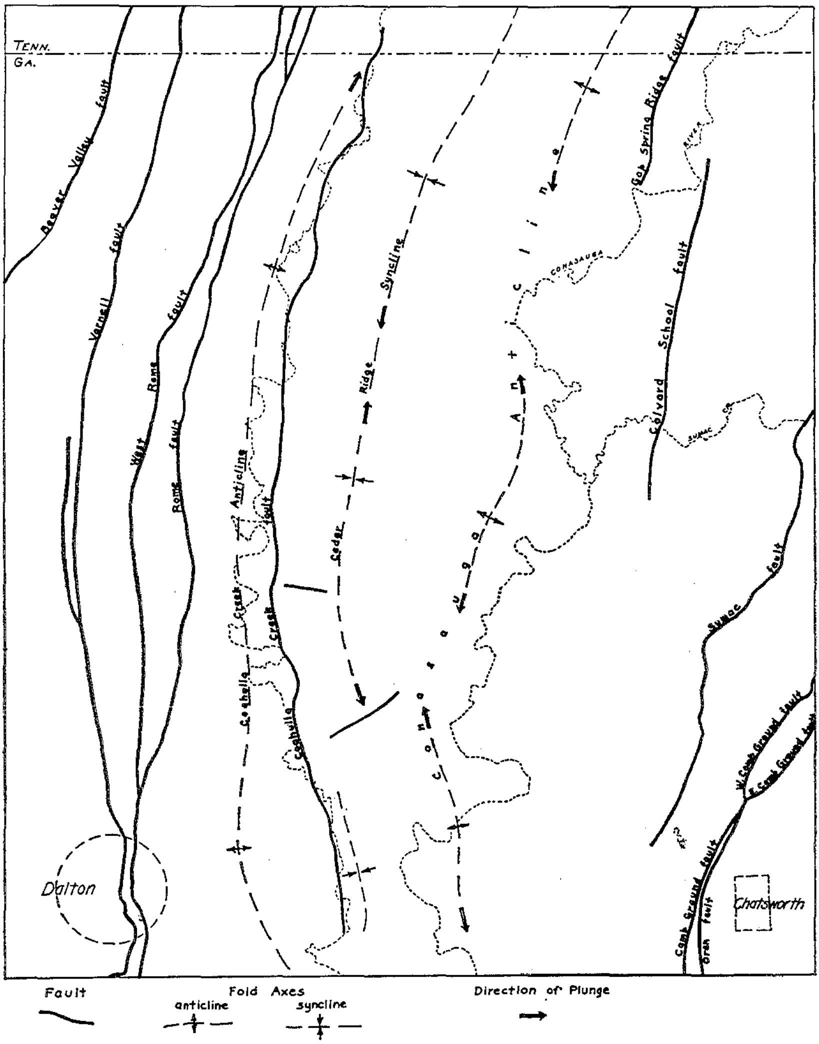
MAJOR LOCAL STRUCTURES

Structures East of Cedar Ridge

Cedar Ridge Syncline—The most prominent fold in the Dalton quadrangle is the Cedar Ridge syncline (Figure 4) which occupies a broad, arcuate position extending north and south across the central portion of the area. Because it seems to be a line of natural division of the quadrangle, the structural pattern of the area will be discussed in two parts: first, the eastern half; and second, the western half. There are no greatly apparent differences in the structure of the two portions except insofar as some different stratigraphic units are concerned.

Cedar Ridge's unity is broken near its southern end so that there is a southern segment isolated from the main body to the north, but thought to be genetically related to it. Structure sections A-A', B-B', and C-C' indicate the asymmetry of the syncline, largely produced, on the west side, by a sinuous fault, situated in the valley of Coahulla Creek, abruptly cutting off the western limb. The east flank of the syncline merges, apparently without great modification, with the west-dipping limb of the Conasauga River anticline.

Cedar Ridge syncline is actually a broad, open synclinorium



STRUCTURES OF DALTON QUADRANGLE

Figure 4

whose central trough is occupied by Knox strata, which, in some exposures transverse to strike, can be seen to possess minor, local variations from the main structure. There are also variations in strike and dip in directions parallel to the larger structure due not only to local but also to more extensive conditions of plunge. Good examples of the minor features occur in road cuts along the Dalton-Chatsworth highway where it is cut through the southern segment of Cedar Ridge (Station 39). On the other hand the narrowing of the Knox area both to the south and the north in main Cedar Ridge, with a complementary expansion of outcrop width toward the central part, in the area west of Beaverdale and east of McGauhey Church, is best explained by double plunge of the synclinal axis toward that locality.

The Maynardville member of the Conasauga crops out along the west limb of Cedar Ridge, and by means of faulting along Coahulla Creek is believed to have been moved up and over Rome siltstones and shales. The stratigraphic displacement, therefore, has involved all of the Conasauga below the Maynardville and an unknown thickness of the Rome.

Conasauga Anticline—East of the Cedar Ridge structure and roughly paralleling the course of Conasauga River is the Conasauga anticline (Figure 4) which is composed of a linear series of enlongate domes, with approximate coincidence of regional strike, exposing the Rome along their crests. Again, these are not simple structures, but are so highly complex in detail, due to infolding and intra-formational faulting of the weak shales and siltstones comprising them, that no attempt was made to measure thickness of beds involved. Two recognizable saddles, preserving the Conasauga in the lower structural positions, have formed between the opposing ends of the three anticlinal structures. One is just east of Dawnville near Prater Island, while the other occurs near Beaverdale. There is also a suggestion of a third near the southern boundary of the quadrangle. The saddle near Beaverdale more or less coincides with the Cedar Ridge sag if it were extended eastward two or three miles, and seems to support the previous contention of a double plunge within the Cedar Ridge syncline toward that point.

Gap Spring Ridge Fault—Conasauga rocks, which pass over the crest of the Conasauga River anticline with an unknown amount of thickening at the saddles, crop out on the east flank of the larger structure and are succeeded in normal sequence by the Knox with the exception of the Gap Spring Ridge exposures. Gap Spring Ridge, situated between Sugar Creek and Conasauga River near the northern border of the quadrangle (Figure 4), is a fault-line scarp ridge, in which Rome sandstones apparently are thrust over Conasauga (probably Maynardville) (Station 40). Thus, all of the upper Rome and about two thirds of the Conasauga thickness represent the stratigraphic displacement along this fault which probably dies out beneath the Recent alluvium of Conasauga River to the south.

Colvard School Fault—The normal succession of formations on the east flank of the Conasauga anticline are once more interrupted by another probable thrust which has been named the Colvard School fault. It trends southward from the vicinity of Gregory's Mill to a point about ½ mile east of Dunn's Store, thence across Sumac Creek to Sumac crossroads and may die out south of there in Knox strata. Its northern extension is unknown because north of Gregory's Mill it passes beneath the Recent alluvium of the river and does not reappear in the quadrangle. It apparently is not related to the Gap Springs fault as Butts and Gildersleeve (1948, Geologic map) believed, because strikes of Conasauga limestone cropping out both in the vicinity of Gregory's Mill and westward across the river valley at the exposure just east of Oak Grove School are N 53° E, and N 27° E, respectively, with both dips being to the southeast. Furthermore, there is no evidence of a disturbed zone striking northwest which would be likely if the two fault zones joined.

Conasauga shales seem to be thrust over Knox beds in the northern part of the Colvard School fault, but the amount of stratigraphic displacement decreases toward Sumac Crossroads where Knox is faulted against Knox. At Station 19, exposures of a highly contorted coarse, saccaroidal sandstone, not found elsewhere in the immediate vicinity, are taken as evidence of extension of the Colvard School fault south of Sumac Creek. It is believed to represent drag in and near the fault zone.

The Colvard School fault may extend some distance south of the Sumac Crossroads locality, but if so, it lies entirely within the Knox, and for lack of critical evidence and exposures could not be traced.

Sumac Fault—No other interruptions of the normal stratigraphic sequence on the east-dipping east flank of Conasauga anticline occur until the sinuous, irregular Sumac fault (Figure 4) is reached at the east base of Sumac Ridge. This fault, which enters the area from the northeast near Fancy Hill, may be traced in a southeasterly direction for seven or eight miles to the north side of Mill Creek, but is thought to continue at least for a short distance south of that stream. The fault trace cuts obliquely across exposures of the post-Knox Ordovician in Sumac Ridge, so that the Knox lies in turn, from the northeast to the southwest, upon the Athens, the Newala and finally, south of Mill Creek, upon more Knox*. Thus at its southwest end, the Sumac fault cuts out the southern extension of both the Newala and all post-Knox Ordovician formations.

The Knox of the eastern block, poorly exposed beneath a heavy alluvial cover, probably dips westward if it exists in normal contact with the Conasauga beds exposed in Eton (Station 10) whose strike is N 30° E and dip is 43° NW.

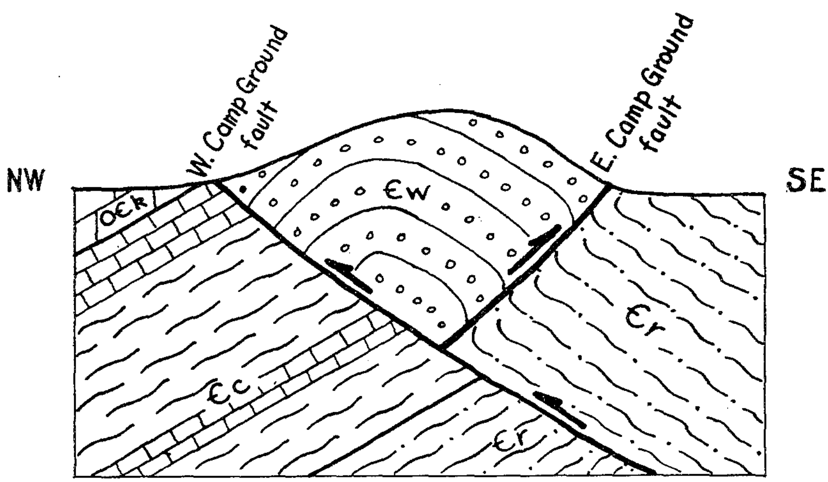
Camp Ground Mountain Faults—Camp Ground Mountain, located about ½ mile east of Eton, is isolated by two faults which flank it on the northwest and southeast sides. Both faults apparently join southwest of the mountain into a single one which continues for about ½ mile to Oran Crossroads where it again splits into two faults that continue southward in a shallow arc west of Chatsworth and eventually beyond the southern boundary of the quadrangle.

The two faults bounding Camp Ground Mountain have been named the East and West Camp Ground faults respectively (Figure 4 and Figure 5), while the single (?) fault southwest of the mountain is termed the Camp Ground fault and is thought to continue southward as the westernmost one of the pair which split at Oran. The eastern one of the pair

*Note: No exposures were noted of the "Mosheim"-"Lenoir" in the Newala-Athens interval just north of Mill Creek.

has been named the Oran fault, but it may be continuous with the East Camp Ground fault, if there are actually two faults in the interval where only one is mapped.

The fault trace, consisting of the West Camp Ground, and the Camp Ground faults, brings Weisner (?) quartzites in contact with the Conasauga east of Eton, then, near the southwestern end of the mountain, Weisner (?) with the Knox, followed by Rome with the Knox, and lastly, from Oran southward, Conasauga with the Knox. The second fault trace, consisting of the East Camp Ground, the Camp Ground and the Oran faults, places Rome successively against the Weisner (?), the Knox and the Conasauga.



-€w-Weisner (?), -€r-Rome, -€c-Conasauga, O-€k-Knox

Fig. 5. Back-thrusting along East Camp Ground fault as a possible interpretation of its relation with West Camp Ground fault near Eton, Ga., Dalton Quadrangle.

The East Camp Ground fault which places Rome shales against Weisner (?) quartzites creates a rather anomalous situation difficult to explain by means of ordinary over-thrusting. Rich (J. L. Rich, personal communication, 1950) has suggested that back-thrusting may be responsible. By that process, the Weisner (?) quartzite mass would have a wedge shape due to an eastward dip of the West Camp Ground fault, and a westward dip of the East Camp Ground fault (Figure 5).

During primary movement along West Camp Ground fault, a secondary, eastward or backward-movement developed along East Camp Ground fault. Thus the Weisner (?) wedge would be elevated *en masse* to a position in which it would be horizontally adjacent to Rome shales to the east.

General dips of each of the formations involved are to the southeast both in the overthrust sheets and in the autochthonous blocks so that the normal stratigraphic sequence is reversed in the area just west of Chatsworth. However, faulting seems to be the cause of this situation rather than overturning to the northwest because of the extreme thinning of the Conasauga formation between the Rome and the Knox. Furthermore, there is a definite contorted zone at the contact between the Conasauga and the Knox. In addition, the juxtaposition of several different formations on either side of the fault traces seem to be conclusive evidence of faulting.

Structures West of Cedar Ridge

It has been previously mentioned that the western flank of Cedar Ridge is broken by a long, sinuous fault extending roughly parallel to the valley of Coahulla Creek. Upper Conasauga probably is thrust over Rome along its entire length within the quadrangle, but at its northern end the fault was undetectable within the Conasauga shales. It could not be followed more than about 1 mile north of McGauhey Church, where it is believed to pass beneath the Recent alluvium of the creek, but it may continue as far north as Tucker's School or beyond.

Coahulla Creek Anticline—West of the fault lies an extensive and nearly continuous exposure belt of the Rome marking the crest of the Coahulla Creek anticline. The northern end of the Rome outcrops apparently plunge below the overlying Conasauga shales only a few hundred yards south of the Tennessee border. Toward the south the belt swings slightly westward in a shallow arc reaching its farthest west point just west of Horseshoe Bend in Coahulla Creek. Both the Rome siltstones and the Conasauga limestones and shales apparently are overturned to the west in that vicinity, with dips to the east ranging from 75 to 47 degrees. Overturning may also have continued as far north as a small branch flowing southeastward from Mt. Olive Church to Coahulla Creek where a dip of 63 degrees southeast was noted in Conasauga limestone near the Rome contact.

The width of this Rome belt increases markedly in the area east of Dalton. The reason for this was indeterminate but may be due to doming or to local intra-formational faulting which has repeated the Rome section. The broad swing of the Conasauga toward the west in a flanking belt of rather regular width, somewhat supports the idea of doming.

Rome Fault—The Conasauga formation is terminated abruptly along the west flank of Coahulla Creek anticline by another fault which extends entirely across the quadrangle and for many miles beyond its limits. It has been named the Rome fault by Hayes (1891, p. 144-147) and is the southern portion of a tremendous and persistent overthrust fault which, when traced across Tennessee (unpublished folios of Arthur Keith and Bailey Wills) into Virginia, coincides with the Saltville fault of Stevenson (1885). Southwestward, it continues at least as far as Gadsden, Alabama and perhaps farther.

The Rome fault for the greater part of its extent in the Dalton quadrangle, or at least that portion north of the city of Dalton, may exist as a double fault trace and, at the Tennessee line, as a klippe. Detailed mapping of the Red Hills mineral belt in the area south of Cleveland, Tennessee (Stose and Schrader, 1923, geologic map by A. C. MacFarlan, opp. p. 130) which corresponds to the Mt. Olive Church fault block of the Dalton quadrangle, shows definite klippe development along the Rome (Saltville) fault at Sugar Loaf Knob 3½ miles north of the Georgia line. Although not so clearly developed in Georgia, a similar structural arrangement may exist. Figure 6 is a series of diagrammatic cross-sections showing a possible explanation of this structure. It will be noted that a plunge of the fault plane to the south is required just south of the Tennessee line. Furthermore, secondary movement is required of the Conasauga shales toward the west in order to account for the existence of the present fault trace separating the Conasauga on the east from the Knox upon which it now rests at points southward along the fault from the klippe vicinity.

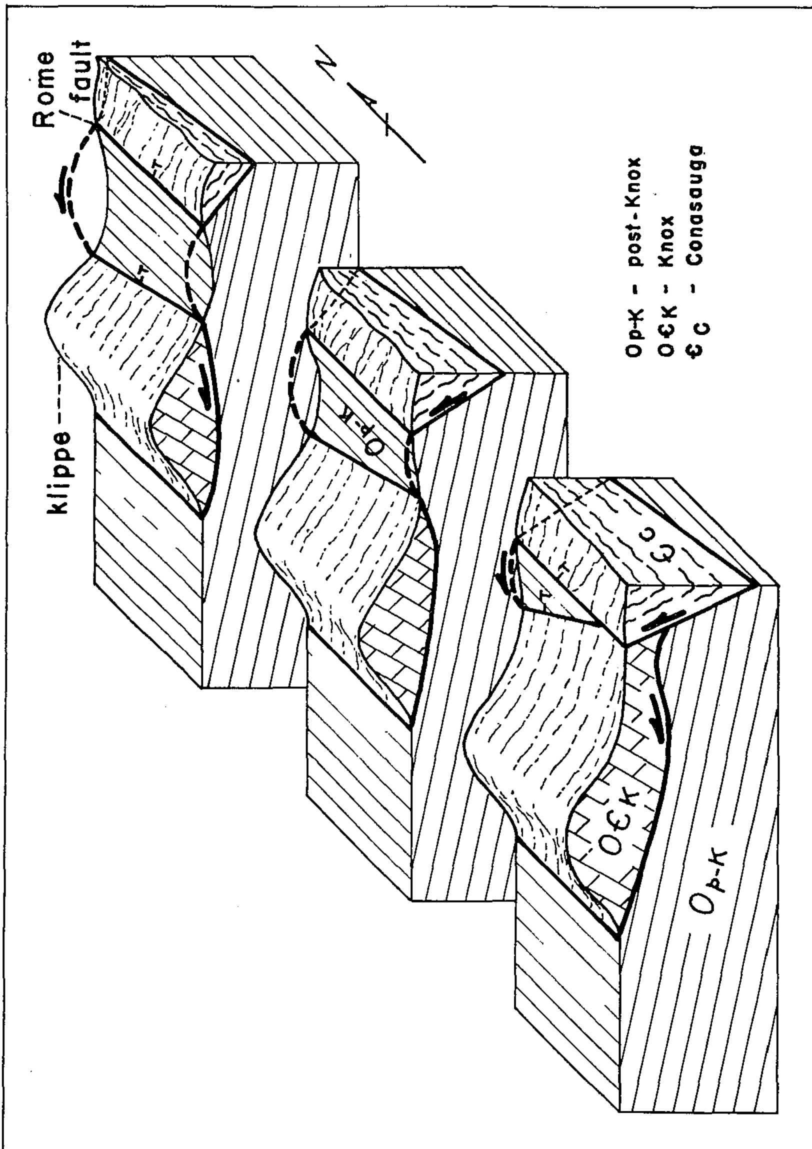


Fig. 6. Diagram of probable relations along Rome fault near Tennessee line.

The sequence of events at the time, or times, of faulting can only be surmised; one explanation is offered in the diagrams of Figure 6, but there are other possible interpretations which may be equally good. For example, the structural situation might have been that the overthrust sheet, consisting of Knox above and Conasauga below, moved westward until crumpling and friction within the lower Conasauga stalled that portion of the sheet. But, at the same time, continued pressure from the east may have shoved the more competent Knox along over the Conasauga and onto the "Sevier" shales. Both shales would act as a "lubricant" for the slip plane upon which the Knox sheet was riding, thus permitting the Knox to continue the displacement to the west and assuming the attitude in which it may now be found.

It should also be remembered that if the time of faulting was late Paleozoic, many beds younger than the Knox group probably were involved in this and all the other faults of the area. Since they are not now present because of erosion, they are omitted from consideration in the diagrams, but may have contributed, in ways not now possible of evaluation, to the tectonic history of the area.

West Rome Fault—The West Rome fault, or the westernmost fault trace of the three shown in Figure 6, marks the boundary between the post-Knox Ordovician beds to the west and overthrust Knox on the east. This particular relationship continues southwest from the northern border of the Dalton quadrangle to a point about two miles south-southwest of Varnell, where the post-Knox beds seem to be completely covered by the overthrust Knox sheet, with the result that, south of that locality, nearly to Mill Creek, Knox may be thrust over Knox. The fault trace could not be followed with certainty within the Knox, but it is thought that the re-entrant just west of the aviation field marks its possible position at that locality. However, due to a lack of suitable exposures, the conclusion is tentative and the re-entrant may indicate only an anticlinal axis or line of local flexure.

If the re-entrant does mark the position of the West Rome fault, this fault probably rejoins the main Rome fault in the area now covered by the alluvium of Mill Creek just north of Dalton, because there seems to be only a single fault between the Conasauga and the Knox south of Mill Creek.

Varnell Fault—The Varnell fault, named for Varnell Station on the Southern Railway, also occurs within the city limits of Dalton on the west side of the Knox ridge whose east base is marked by the Rome fault. The two faults average about ¼ mile apart within the city, but at places approach within 300 yards. Near the city limit indicated on the map, the Varnell fault is thought to swing slightly westward and continue north along the west side of Farrar Branch, thence slightly northeastward to Varnell, Cohutta and finally into Tennessee. The Southern Railway tracks parallel it northward across the quadrangle.

The relations of the Rome fault, the West Rome fault and the Varnell fault in the immediate vicinity of the northern limits of Dalton and Mill Creek are not clear because of a lack of outcrops. The Varnell fault pattern as shown on the geologic map (Plate VIII and Figure 4) indicates that it does not join the Rome fault. This interpretation was made by Butts and Gildersleeve (1948, geologic map) and has been similarly interpreted by the writer, but with the recognition that another explanation is possible.

From Mill Creek southward to the quadrangle boundary along the Varnell fault, Knox chert ledges dipping eastward, occur east of, and in contact with post-Knox Ordovician beds that also dip, in general, toward the east. North of Mill Creek as far as Waring, Conasauga shales and limestones, with eastward dips, lie to the east of and in contact with eastwardly dipping post-Knox Ordovician red beds. North of Waring, the Varnell fault splits into a short western branch and the main eastern fault. Along the latter, Conasauga to the east and Knox to the west occur in faulted relationship as shown by eastward dips in both formations. This places them in reverse positions from their normal stratigraphic sequence. The short western slice at Waring apparently has Knox thrust upon the post-Knox ordovician, and again both formations have an easterly dip indicating an abnormal sequence.

Probably the most important reason for choosing the indicated fault pattern in north Dalton was the fact that the normal west contact between the Knox and the post-Knox Ordovician shows a remarkable parallelism with the trace of the

Varnell fault. This fact is, therefore, thought to be evidence of a genetic relation between the fault and the similar shifts in strike direction within the strata to its west at that point.

On the other hand, it must be suggested that the two fault traces in Dalton may be extensions of the Rome and West Rome faults, rather than the Rome and Varnell faults. If that is the case, then the dual faults could have resulted from a situation much like that indicated for the klippe region near the northern boundary (See Figure 6). The Varnell fault, in that event, could be either a slice fault off the West Rome fault, or a thrust slightly antedating the Rome-West Rome fault zone so that it was partially overridden by the westward-moving Rome fault overthrust sheet, and is now concealed beneath it, in the region south of Mill Creek.

Beaver Valley Fault—Approximately 1¼ miles northwest of Cohutta, the Beaver Valley fault, roughly paralleling the west side of Tiger Creek Valley, extends both northeastward and southwestward beyond the quadrangle limits. Hayes (1895) has mapped it for many miles northeastward across the Cleveland quadrangle, while Butts and Gildersleeve (1948) and Hayes (1891) show its continuation southwestward. Within the Dalton quadrangle, exposures seem to show that thrusting from the east has placed Conasauga shales over Knox to the west along the northern portion of the fault, but toward the south, Knox is faulted against Knox and the relations are more obscure. In both cases formational dips are to the southeast at about 45 degrees.

Structures occupying the northwestern corner of the quadrangle, apparently, from the areal geologic pattern developed, are anticlinal. The axial region of the anticline is marked by a slender band of Rome siltstones, probably plunging to the northeast because the siltstones disappear beneath Conasauga shales about ½ mile south of the Tennessee line. Knox chert rubble was noted along a small ridge in the most northwesterly corner of the area, and may represent either the west flank of the anticline, or may mark another fault (Rodgers, J., Personal Communication, 17 July, 1950).

The area west of Dalton and Hamilton Mountain seems to be for the most part the eastern flank of an anticline striking nearly north. The axis of the fold, lying along Hungry and Crow Valleys, is occupied by very poorly exposed Conasauga shales whose attitudes could not be determined satisfactorily. About 1 mile southwest of Poplar Spring Church, Knox cherts occur on a spur situated on the west side of Crow Valley. This tends to support the interpretation of an anticline in that area.

MINOR FOLDS AND FAULTS

It has been mentioned above that many of the large anticlines and synclines of the Dalton quadrangle are actually anticlinoria and synclinoria. The degree of infolding in some of the formations becomes quite complex and beyond the scope of this investigation to solve. Much of the minor folding, however, apparently is related to the larger folds and faults and is probably contemporaneous with them. This is particularly true of the Conasauga shales which seem to have borne the brunt of most of the large scale faulting, because the shales now show all manner of small, tight, contorted folds and faults especially near major faults. Knox beds also show minor structures, but in general not on so small a scale as those of the Conasauga. The Rome siltstones and sandstones show infolding to a degree somewhat intermediate to that of the Conasauga and the Knox. The Weisner (?) and the post-Knox Ordovician formations seem to show the least effects but this may be only apparent because of insufficient exposures.

Considerable intra-formational faulting occurs on a scale so limited in displacement that it could not be shown on a map with scale of 1/62500.

Structures Transverse to General Trends

The major structural pattern of the Dalton quadrangle, trending northeast-southwesterly (Figure 4), is modified to some degree by other structural features whose trends are oriented in directions which vary appreciably and noticeably from the former. Most of such structures are rather indefinite, but a few are sharply defined. Their magnitude also varies greatly; some, in the Dalton quadrangle, are only fractional portions of larger, regional structures, while others are purely local in character.

Probably the largest of the transverse structures in the quadrangle involves the area of the Cedar Ridge syncline and other structures to its west. The broad, arcuate pattern of strata in that section suggests that this may be a portion of a larger salient which extends northward into Tennessee and farther south into Georgia.

A somewhat smaller transverse feature occurs in the eastern half of the quadrangle. Beginning about 1½ miles northwest of Eton, Sumac fault changes in strike from about N 15° E at Crandall to about N 40° E, east of Center Valley. A similar change in strike can be noted to the northwest along the Newala-Athens contact about 1 mile east of Fashion. The Conasauga-Knox contact just south of Harris Ford also changes direction but not to so great a degree as do the two preceding examples. Then, near Deep Spring School, about two and one half miles northwest of Harris Ford, the Rome-Conasauga contact shifts its strike from about N 5° E to about N 35° E, while the Conasauga-Knox contact changes from about N 5° E to about N 75° E.

While the crests of these individual bends do not line up precisely, they seem to be close enough to warrant grouping them together. A general line from the Eton vicinity toward Deep Spring School on Cedar Ridge gives an approximate trend of about N 65° W, which would place the structure nearly at right angles to the general Appalachian strike. A tentative explanation could be that this is a cross-fold developed in post-Paleozoic time, because of the involvement of Sumac fault which is believed to have formed at the end of the Paleozoic.

An analogous structure seems also to have formed just west of Fancy Hill along Sumac Creek in the area between Halls Chapel and the south side of the stream. It will be noted on the geologic map (Plate VIII) that the northern outcrop band of the Newala is offset nearly ¼ mile to the east from the general strike of the same formation south of Sumac Creek. Butts and Gildersleeve (1948, geologic map) interpreted this to mean that a northwestward-striking fault cut across this locality, but no evidence of faulting was noted during the present investigation. Therefore, the offset is attributed to a lateral monoclinal flexure, or horizontal "twist" of very localized effect because it is undetectable in the area just west of Sumac Ridge.

A third transverse structural feature, more sharply defined than the preceding two, occurs at the south end of the main (northern) Cedar Ridge mass. A cross-fault, probably striking about N 55° E, is believed to terminate this portion of the Ridge abruptly in the vicinity of Ninety Seven Springs. Although there is a general plunge of the strata in Cedar Ridge toward the north as stated previously, many local variations and gentle folding occur along the strike in the southern part of Cedar Ridge. The Knox-Conasauga contact, for a distance of about ¼ mile north of Ninety Seven Springs on the west side of Cedar Ridge, dips noticeably toward the south, changing its general elevations by as much as 40 feet in that distance. A few hundred yards east of the Springs, the Knox-Conasauga contact was determined to be at an altitude of 760 feet. But, not more than three hundred yards south across the small stream and Dawnville road, Conasauga shales crop out at the same elevation and higher. Therefore, it seems justifiable to assume the existence of a normal fault at this locality, in which the upthrown side is to the south, thus placing Conasauga shales stratigraphically higher than the Knox.

However, there was probably movement along this fault in its strike direction, for by such an assumption, a simple explanation of the offset of the isolated southern segment of Cedar Ridge can be made. It is only necessary to move the upthrown block westward or southwestward to accomplish the desired result of placing the southern segment where it is now found, as well as to establish the opposing positions of the Knox and Conasauga along the fault. No vertical movement is required along the fault, so that it may be termed a tear fault similar to those described by Rich (1934) in connection with the Cumberland overthrust block.

Another minor, normal cross fault occurs on the west side of Cedar Ridge about 2½ miles north of Ninety Seven Springs. This displacement is probably only a matter of a few feet, being, as far as could be determined, wholly within the Maynardville limestones. It is also likely related to thrusting in some manner of local adjustment within the Coahulla overthrust sheet.

GENERAL CONSIDERATION OF STRUCTURE IN THE QUADRANGLE

The structural complexity of the Dalton quadrangle is largely due to the presence of numerous overthrust faults trending in a general way from northeast to southwest across the area. The faults, combined with large scale folding, are inclined, with few exceptions it is thought, toward the southeast with low dips which were estimated by Hayes (1891, p. 145) to be between 45 and 60 degrees. It is quite possible, however, that the dips are much less, and as a compromise they have been shown on the cross-sections A-A', B-B', and C-C' (in pocket) ranging between about 30 and 50 degrees to the southeast. No accurate observation of a fault plane could be made in the field because of poor dip exposures on the faults. Furthermore, computations of dip are believed to be not too reliable because of undulations of the fault planes, but a figure of 3 degrees and 25 minutes was obtained on the West Rome fault where it passes along the west side of a prominent hill about 1½ miles northeast of Varnell.

There is a distinct possibility, on the other hand, that the major thrusts of the region may be essentially parallel to at least one of the beds involved in the faulting, and, therefore, the present degree of dip of the fault planes would be, roughly, that of the beds. This, if true, would give an approximate range in dip of 40 to 60 degrees which is close to Hayes' figure.

Hayes (1891, Fig. 1) believed that various formations in the Southern Appalachians reacted to stresses in different ways, and suggested that the most important factor determining their behavior was—"the relation of rigidity to superincumbent load." Pursuing this idea farther, Hayes showed that formations such as the Conasauga would have less rigidity than the Knox dolomites so that a shear would tend to parallel the shales of the Conasauga but break through the more rigid

Knox at higher dip angles. Rich (1934) demonstrated this to be more than theoretical, but actuality in relation to the Cumberland overthrust, where the shear plane not only nearly parallels the less "rigid" formations, but also breaks up and across the more "rigid" ones at steeper angles.

Perhaps the same structural situations existed in the Dalton area, because, in almost every instance, the overthrust faults seem to involve either the Rome-Conasauga formations, the post-Knox Ordovician strata, or both. Both of these probably would have been described by Hayes as possessing "minimum rigidity", due to the fact that they are composed mainly of soft shales, and would offer a minimum resistence to sliding.

It may be that compressive forces from the southeast, in late Paleozoic time, found relief to the west along a path of least resistance which included the Rome shales and siltstones, the Conasauga shales and the post-Knox Ordovician shales, at least within the Dalton quadrangle. The suggestion is, of course, that sliding of the overthrust sheets was accomplished for the greater part of the distance of lateral displacement along the least competent beds, such as the Conasauga shales. Then, perhaps as corrugations within the glide-plane formation developed and gave it greater competency, the break passed at steeper angles across the more "rigid" overlying strata until it could once again reach a less "rigid" bed which it then proceeded to follow in the same way that it followed the lower less competent stratum. Perhaps also, simultaneously with this, the original fracture at the lower level continued along it, producing what Miller (1945) and Rodgers (1950) have termed a "sole" fault. The net effect, in essence, was the formation of a fractured decollement (Billings, p. 55), in which the thrust sheets were imbricated, perhaps, in more than one series of "shingles".

On the other hand, an alternative explanation other than overthrusting is possible for several faults if only their geometric relations to strata are considered. For example, the Coahulla Creek fault could be an east-dipping normal fault in which the eastern block was moved downward thus placing upper Conasauga (Maynardville) in contact along the fault with the Rome. Again, normal faulting might explain repetition of strata in the Beaver Valley and Varnell faults if these fault planes were vertical or dipped westward. The hanging (downthrown) blocks in both of the latter would be on the west side of the faults. A similar movement might also account for the Colvard School fault.

However, the obvious crumpling of incompetent strata, undoubted overthrusting along many faults, and structures in adjacent areas seems to favor the idea of thrust relations for the long, sinuous faults more strongly than normal relations for a few of them. Further, it seems more than unlikely that both tensional and compressional force would have so acted to produce such similar relations of displacement.

MINERAL RESOURCES

INTRODUCTION

Any investigation undertaken for or by a State geological agency must, in order to justify the expenditure of tax money, attempt, insofar as possible, to give a manifold, tangible service or return for such funds. In the area of geological investigation, the immediate and visible returns are most often made possible by means of locating and evaluating mineral deposits that otherwise might be overlooked or erroneously judged. The designation—"mineral deposits"—is used to include not only minerals, *per se,* but also rocks which may be mined or quarried for profit.

A number of different earth materials which are or might be extracted for economic gain occur in the Dalton quadrangle. Some of these substances can best be described as being now in the protore stage, awaiting only a change in market demand, scarcity, or new methods of beneficiation before becoming excellent mining possibilities. Others, because of excess quantities elsewhere of equally good quality, can probably never be of more than local interest.

The examination and description of mineral deposits in Georgia has been extensively treated in more than fifty bulletins of the Georgia Geological Survey, and widely discussed in a great many more reports published in a variety of sources.

Many of these papers refer to the Dalton area and have been used freely in compiling the following information about the mineral deposits of the quadrangle. Each mineral or rock will be taken up separately; they have been arranged in alphabetical order for clarity and ease of reference.

BARITE

Barite, or barytes, is a whitish or light bluish-gray, abnormally heavy mineral composed of barium sulphate. It is rather inert chemically, but moderately soft, being between 2.5 and 3.5 on the Mohs scale. Commonly it occurs as a vein deposit, but often is found as a replacement or in breccia form. Because of its inertness, it is subject to concentration in various ways, such as in residual, colluvial and alluvial deposits. All of the economic deposits now being operated in Georgia are of the concentration type with the larger proportion of deposits being of the residual and colluvial kinds (Kesler, 1950, p. 51).

The primary occurrence of barite in Conasauga limestones as thin, anastomosing veinlets was noted only at one locality (Station 41) a few hundred yards west of Camp Ground Mountain and east of Eton. There, the barite is light bluish-gray, and forms small stringers in the badly fractured limestone pinnacles that are irregularly distributed under a thin cover of stream alluvium (Plate VII, B). Spaces between pinnacles are occupied by a brownish, sandy residuum containing considerable quantities of small barite nodules. A small open pit mine was operated at that location for a short while in 1948 by Mr. Knight of Cartersville, Georgia, who also erected a small log washer nearby to concentrate the ore. The operation did not prove to be successful at that time, however, and has since remained idle.

The genesis of this deposit probably is closely related to fracturing in the limestone during faulting which permitted the entrance of barite-bearing solutions into the reactive limestone host, with consequent formation of barite veinlets. Subsequently, during weathering, probably at a much later date, the limestone was partially dissolved producing a silty, clay residuum in which the less soluble barite was concentrated.

Hull (1920, p. 132-133) described the above occurrence of barite in connection with the Love property across Mill Creek on the west side, which was mined for a short while in 1907.

Hull has also described other occurrences of barite in Murray County at a locality on the Eton-Spring Place road about 2¾ miles southwest of Eton (Station 42), which were also mined about 1907, but have since been abandoned. At present, partially filled depressions mark the positions of the old open pit mines, and fragments of barite are common in the soil nearby.

Three other small deposits of barite were noted by Hull (1920, p. 134-136) in Whitfield County, along a line extending northward from Clines Crossroads to the Beaverdale-Praters Mill road. The pits today are almost completely filled by debris, but fragments of barite are reported to occur in the vicinity. The deposits lie wholly within the Knox dolomite and may mark a persistent fracture or fault of indeterminate displacement within that formation (Stations 43, 44, and 45).

The barite deposits of the quadrangle probably are all limited in size so that no large commercial operation could be supported by the quantity of ore estimated to be present. The quality of the ore at Station 43 in Whitfield County is 95.2% $BaSO_4$, while that from the Murray County deposits averages better than 98%.

CLAY

Clay, in a variety of types, is widespread throughout the Dalton quadrangle, occurring at many localities as well as in most of the formations. Several intensive investigations of the clays of the area have been made in the past, outstanding among them being reports by Smith (1931), and Veatch (1909), both of whom were primarily interested in specific, privately owned properties or exposures rather than the general application of the clay characteristics to the interpretation of the stratigraphic section. Therefore, the characteristics of the clays can now be related to the formations only in a broad sense. But it should be pointed out that a project designed to determine the characteristics of all clays and shales within the quadrangle would require a tremendous expenditure of time and money which, at present, is not feasible. Nevertheless, in order to arrive at a more exact estimate of quality, and, consequently, quantity, some new investigations of clay types should be undertaken. It may be suggested that one method of approach could be differential thermal analysis of the various clays which distinguishes various clay minerals with ease, and permits an entirely new type of classification.

Numerous classifications of clays have been erected in the past, but one which is outstanding and widely employed by geologists was that by Ries (1937, p. 220-221). The Ries classification is principally concerned with the environment of clay formation and secondarily with the minerals composing it. In recent years, classification has trended toward mineral groups of like properties, such as: kaolinite, montmorillonite, and illite. The ceramists (Mitchell, 1950) prefer the latter classification because of its greater usefulness to them, but it should be emphasized that geologists could probably also use a combination of both to advantage, because of its application to both environmental and genetical problems of clay origin and deposition.

For example, Mitchell (1950, p. 97-98) indicates that kaolinite is associated with deeply weathered shales of Paleozoic age, while most of the unweathered parts consist of illite. This fact alone, combined with Ries' environmental classification, might make possible the determination of many stratigraphic units within the shales which are not now recognizable in the deeply weathered outcrops that are so common in the area. Furthermore, it might well be possible to predict the occurrence of commercial, but localized, deposits that otherwise would be discovered fortuitously; or, conversely, it might be possible to eliminate large areas in the search for clays of specific qualities.

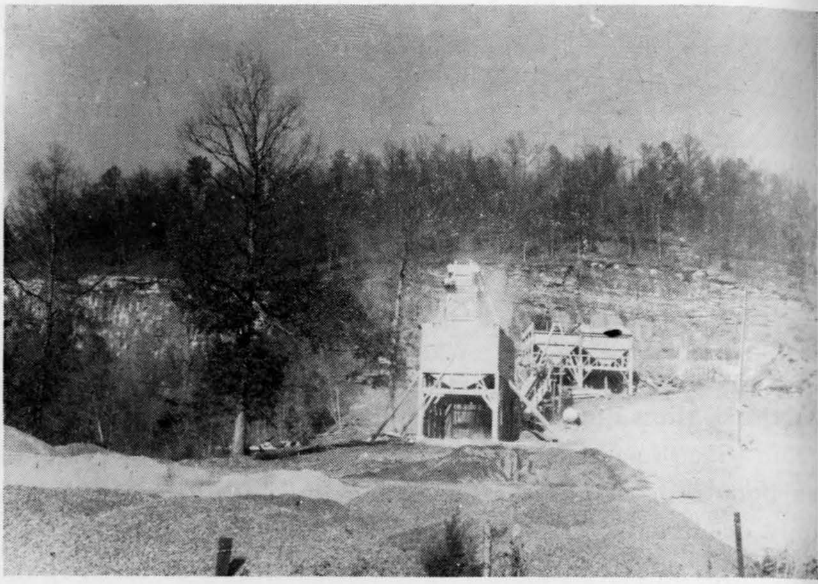
Some elimination is possible now according to Smith (1931, p. 174) who has assembled much data about the various clays in the Dalton quadrangle. He states that the siliceous shales of the Rome formation are of little value in the manufacture of heavy clay products, but the Conasauga formation at places contains shale which is suitable for that purpose. However, some alluvial clay deposits, associated with the streams of the area, are suitable for face brick manufacture. Such a plant, now defunct, was once operated near Chatsworth on clays derived both from Holly Creek flood plain and from the Conasauga shales. Undoubtedly many other localities at which equally good clay could be obtained occur within the quadrangle.

LIMESTONE AND DOLOMITES

A tremendous quantity of limestone and dolomite occurs in the Dalton quadrangle, but its quality is highly variable from place to place. In no localities are either pure calcium carbonate or magnesium carbonate available. Probably the only occurrences in which the percentage of $CaCO_3$ will exceed 95% will be in the small calcite veinlets so often found in the Conasauga limestones. No pure magnesite ($MgCO_3$) is known in the area. Mixtures of magnesium and calcium carbonates, however, are common, and may generally be termed either dolomite or dolomitic limestones depending upon the percentage of admixture of the two substances. Pettijohn (1949, p. 312-313) defines the rock—dolomite—as "those varieties of limestone containing more than 50 percent carbonate, of which more than half is dolomite." He limits limestone to those rocks containing less than 10 percent of dolomite, classifying the intermediate mixtures up to the 50 percent dolomite content as magnesian limestone and dolomitic limestones.

Maynard (1912, p. 258-265) investigated the limestones and dolomites of Whitfield and Murray Counties, presenting in his report a number of sections and chemical analyses of rocks from various localities. Butts and Gildersleeve (1948, Table 9) also give three analyses of rocks from that area. Two of their samples were from the Conasauga and one from the Knox.

Plate VII



A.—Crusher at quarry in Maynardville limestone on west side of Cedar Ridge.

B.—Network of barite veinlets in Conasauga limestone at Station 41, near Eton.

Most of the analyses quoted by Maynard indicate a predominance of dolomitic limestone, although two localities show calcium carbonate contents of approximately 89 percent. One such exposure, listed by Maynard, is one mile north of the Dalton-Chatsworth road on the west side of Cedar Ridge (Southern segment) (Station 46). The other high-calcium limestone listed by Maynard crops out along State Highway 71 about ½ mile north of Mill Creek (Station 47).

Both of the chemical analyses quoted by Butts and Gildersleeve (1948, Table 9) for the Conasauga formation from exposures along the west side of Cedar Ridge, indicate a calcium carbonate content of more than 91 percent. One sample was taken from the County Road quarry two miles northeast of Pleasant Grove (Station 48); the second was from the O. O. Davis quarry four miles east of Dalton (Station 49). The third analysis, of the Knox, shows a dolomitic limestone with the composition of 51.2% calcium carbonate and 12.1% magnesium carbonate.

Few chemical analyses have been made of the dolomites and dolomitic limestones in the Dalton area, but from superficial tests with dilute hydrochloric acid in the field, apparently very large quantities of this type of rock exist. Probably some of the better localities worthy of additional investigation as potential quarries for such rock are situated in the Newala belt of outcrops in Murray County, extending northward from the north side of Mill Creek for several miles at the west base of Sumac Ridge. Also, some outcrops of Knox dolomite along the Cleveland road near Colvard School appear to be situated so that a quarry opening would be feasible. The Knox dolomite outcrop areas in the western part of the quadrangle also warrant investigation for possible quarry sites.

The Maynardville member of the Conasauga, which has been sampled and tested by Maynard (1912), as well as by Butts and Gildersleeve (1948), crops out in several localities as mentioned above. One small quarry, now abandoned, was opened on the east side of Conasauga River about 1/3 of a mile south of the mouth of Mill Creek (Murray County) (Station 50). Small quantities of rocks from the same formation have also been quarried for local use just north of the same Mill Creek junction with the river. Another locality in which similar material might be obtained, perhaps on a commercial scale, is west of Gap Spring Ridge in the vicinity of Oak Grove Church (Station 51).

The preceding descriptions have reference to the use of limestone and dolomite primarily for aggregate, cement, agricultural or chemical purposes, but in certain localities some of the carbonate rocks might be quarried for ornamental or dimension stone purposes as well.

McCallie (1905, p. 73-76) reported the occurrence of "marble" from several localities in Whitfield County within the Dalton quadrangle. One type he named the "black marble" from thin, non-persistent beds along the west side of Cedar Ridge which are now known to be Maynardville. It is a finely crystalline, nearly lithographic-textured, dark-gray to black limestone with conchoidal fracture.* McCallie noted that upon exposure to the weather, the "marble" undergoes a color change. He doubted that a commercial quarry could be operated there because of the color change and because of small quantities available.

McCallie also noted the occurrence of a second type of "marble" which he called the variegated type, in the exposure belt about 1 mile east of Varnell, which herein is referred to post-Knox Ordovician beds, or more specifically, the "Holston". He says that these exposures are "nearly pure

*Note: This description was made from a sample in the possession of the Georgia Talc Company. Company officials report that the sample was obtained a number of years ago from the Cedar Ridge exposures. The writer did not see the beds in question in the field, or at least, did not recognize them as such.

calcium carbonate, almost crystalline"—and that the "marble" is well suited for both building and ornamental purposes. Analyses are unavailable, but it would appear that most of the "Holston", although consisting of a high percentage of $CaCO_3$, will probably also have considerable quantities of iron and manganese oxides, which impart the dark red colors so characteristic of it. Several localities near Cohutta (Stations 32 and 52) offer possibilities for quarrying dimension stone. Quarries operated on similar material in Tennessee (Gordon, 1924) have been successful.

MANGANESE AND IRON

The Varnell-Cohutta district (Butts and Gildersleeve, 1948, p. 140) is an extension to the south of the Bradley County district in Tennessee (Stose and Schrader, 1923, p. 130) which is sometimes referred to as the Cleveland (Tenn.) district. Numerous manganese mines, both in Tennessee and Georgia, were once operated along this strip in which the "Holston", "Ottosee" and other post-Knox Ordovician beds are exposed. In this report the area is referred to as the Mt. Olive Church fault block.

Hull (1919, p. 189-201) investigated the Varnell-Cohutta district in the Dalton quadrangle and reported rather extensive deposits of both manganese and iron. Among others, he noted two commercial mines from which these minerals were being extracted at the time of his investigation. One, owned by the Chicago-Tennessee Coal and Oil Company was located "about 3 miles" (actually about 2 miles) south of the Tennessee border (Station 53). The second open pit mine was located about 1½ miles northeast of Varnell on the west side of a prominent hill capped by Knox chert ledges (in overthrust sheet of West Rome fault). The old pit could not be located by the writer.

Analyses (Hull, 1919, p. 192) of manganese and iron from the latter property show a metallic manganese content of 43.11%, while metallic iron is reported as 61.22%. The manganese occurs as psilomelane, the iron as hematite.

Metallic manganese was even higher at the Chicago-Tennessee Coal and Oil Company mine, averaging about 44.76%, but the iron was lower, being 42.56%, and occurred in a "black dirt", as a manganiferous iron ore. A loose sample examined by the writer, although not analyzed, was exceptionally heavy, dark bluish-gray in color and contained replaced fossil fragments. It is likely that its content of manganese and iron is high.

The deposits of manganese and iron are closely associated with the contact between the "Holston" reef material and the overlying calcarenite. This is true of the entire belt in Georgia as well as in Tennessee. Stose and Schrader (1923, p. 131) discussing the D. A. M. mine, about 3 miles north of the Georgia line in Tennessee, state:

"The deposit occurs chiefly in the basal part of the so-called 'Tellico sandstone' at its unconformable contact with the underlying Holston marble.—The iron and manganese set free by rock weathering were redeposited in seams or certain porous layers in the underlying rocks but were largely concentrated into a definite bed of ore at the base of the weathered zone near the contact with the marble."

These authors further noted that the ore consists chiefly of psilomelane, but includes manganite, wad and pyrolusite, and is closely associated with very pure hematite. Reichert (1942, p. 14-15) who re-examined the old mine workings of the Cleveland District, showed that some of the ores from that vicinity probably contain hausmannite (Mn_3O_4), which, when chemically pure, contains 72% Mn. He attempted to explain the abnormally high metallic manganese contents of some ores in this manner. Laurence (Laurence, R., Personal communication, 15 July, 1950) states that this has since been confirmed for both the Tennessee and Georgia portions of the district.

It is probable that the ores of this district are the secondary result of meteoric water concentrations and oxidation of primary depositional materials. Petrographic examination of some heavy liquid concentrates of sandstones from Zone F ("Sevier") of the Hamilton Mountain section, shows small sub-rounded quartz grains containing an opaque, earthy, red mineral which is probably hematite. In some cases, such grains may be picked up by a probe made from an Alnico magnet, thus suggesting that the source of the iron may originally have been magnetite.

It is also possible that the ores represent diagenetic changes at the time of deposition of the enclosing rocks, similar to the origin commonly attributed to the Clinton "fossil hematites". In order to determine whether the ores are secondary concentrations or due to diagenetic processes, it will be necessary to obtain fresh samples which are not presently available. A core drilling program in the district would solve not only this problem but that of the reserves and quality of the ores at depth.

Less important deposits of lower grade iron ores in the form of limonite and manganiferous limonite have been reported by Haseltine (1924, p. 65-67; 81-82) from the portions of Murray and Whitfield Counties comprising the Dalton quadrangle. Most of the deposits in Whitfield County are associated with the Knox dolomite, while those of Murray County are related to the Tertiary (?) alluvium.

Some minor occurrences of limonite boulders were observed along both sides of Camp Ground Mountain. The deposits of the east base of the mountain extend along the strike for several hundred yards south of the Eton-Hasslers Mill road, and are apparently related to the East Camp Ground fault. The limonite boulders, which reach several feet in size, are typically honeycombed by irregular openings, in a few of which small masses of pyrite could be observed. The quantity does not appear to be sufficient to warrant mining.

TRIPOLI

The name "tripoli" has been generally applied to sedimentary, micro-crystalline silicas that are comparatively soft, friable and porous (Heinz, 1937, p. 911). Such material has been variously described as "amorphous silica", "cryptocrystalline silica" and other like terms, so that there is no mineralogical uniformity in application of the name "tripoli" beyond the fact that it is all siliceous. Originally it was described from diatomaceous earth deposits in the vicinity of Tripoli, Libya, but through error the name was used to describe similar-appearing deposits in Missouri composed of chalcedonic quartz. The name now is more or less a commercial term used to describe a fine-grained, soft-silica abrasive.

Crickmay (1937) investigated the tripoli deposits of Georgia and examined deposits in the area of the Dalton quadrangle. He states that the deposits are composed of chalcedonic quartz grains which are, in general, coarser than the Missouri material, and which, with a few exceptions, also have a greater size range. Its color range, in the Dalton area, seems to be from buff or cream to light brown.

Most of the deposits reported by Crickmay as well as those noted during the present investigation are associated with the Knox, but, as previously suggested, some may belong in the Maynardville member of the Conasauga. This may be the case with a zone of interbedded tripoli and thin, oolitic chert occurring in a bed ten or fifteen feet thick just above the massive limestones forming the lower slopes of both the southern and northern segments of Cedar Ridge. Crickmay (1937, p. 6) also describes material from the old Hamilton mines located along the west side of the N. C. and St. L. Railway, 1.5 miles north of Dalton and ¼ mile north of the Dalton water works. Open pits and underground workings are reported to have been operated there at one time on buff to yellow-brown tripoli in the Knox.

Undoubtedly large quantities of usable material occur in the Dalton quadrangle, but it will be necessary for potential producers to clean and size their product closely in order to be able to compete with the Missouri industry.

GEOLOGIC HISTORY

The historical pattern of North American geological science is intimately related to investigations in the Appalachian Mountains, for from such studies have come many of our modern concepts of geosynclines, structures and sedimentation. James D. Dana (1847) and James Hall (1859), in the middle years of the nineteenth century, proposed the principles of tangential stress and abnormal thickening of sediments, respectively, to explain the geology of the Appalachian Mountains. These principles have been widely accepted and are now regarded as fundamental to an understanding of Paleozoic geology in the eastern United States. Since that time, many illustrious geologists have added to the literature a great wealth of information about the details as well as the broad concepts of the geology in the region and have successfully applied the knowledge to many other areas. But differences in opinion have inevitably arisen concerning various interpretations; some of these can be reconciled, others cannot (Rodgers, 1950).

One of the basic assumptions that has become entrenched in the precepts of historical geology is that of a vast landmass lying to the east of the geosyncline. This has been named Appalachia, a slowly, intermittently, rising area from which debris was being eroded throughout Paleozoic time. Concomitantly, the geosyncline to the west and northwest was a gradually sinking area receiving the products of erosion. The geosyncline was conceived to be a comparatively narrow trough normally filled with sea water of relatively shallow depth in which the sediments were distributed, sorted and deposited by means of various hydraulic, chemical and biologic agents. A picture of the results of these interactions emerged in which it was assumed that certain depositional environments during a given interval of geologic time were persistent over vast areas of the floor of the geosyncline. Relative time of deposition of different formations was, therefore, simplified to the point of establishment of a vertical section into which the lithologic and biologic succession could always be fitted with minimum discrepancy.

But, as more details were gathered, it became evident that the simple, original picture needed revision because not all portions of the geosyncline could be correlated. Ulrich (1911) was one of the first to recognize this fact, suggesting that the entire Paleozoic system deserved revision. His proposals, particularly those concerning the southern Appalachians, carried great weight, and, although rejected by some, were fully accepted by other geologists working in that area for years afterward. Charles Butts, and others, as late as 1949, were strongly influenced by the Ulrichian philosophies, but many investigators have diverged acutely from his viewpoints, seeking explanations for anomalous stratigraphic situations which would be more compatible with recent advances in the related fields of sedimentation, paleontology and structure. Specifically, there grew up a new concept of three dimensional variations in lithology and organisms. This is the facies concept in which the dual classifications of time and rock type are required for stratigraphic identification.

The recognition of facies is not new (Moore, 1949, p. 5), nor is the application of the idea to Appalachian stratigraphy new, but full awareness of its relative value or magnitude is just now being attained by many investigators. On the other hand, some workers have already proceeded so far along this line of reasoning that considerable doubt may be cast on the existence of a persistent borderland to the east (King, 1950, p. 653), while others (Kesler, 1950) argue that much of the "Pre-Cambrian" gneisses and schists of the supposed borderland are actually much younger, probably Paleozoic in age. If this is true, and the weight of evidence at present seems to point in that direction, our former ideas of geosynclinal deposition, the shape and extent of the geosyncline and its dynamic history need re-examination.

Acceptance of the newer theories demands, in turn, revision of the historical geology of the Paleozoic era in the Appalachians. The following discussion does not pretend to concern itself with all of these broad problems except insofar as some of the newer concepts may make it possible to draw a clearer picture of the sequence of events in the geologic history of the Dalton area.

A critical point worthy of more consideration is the overall form or shape of the geosyncline in relation to depositional environments, because sediments reflect not only their sources but also the conditions under which they are formed. A nearly endless variety of environments may be visualized as constantly changing in both time and space, with the result that any stratigraphical analysis of sediments is dynamic in the sense that it attempts to interpret and evaluate all factors contributing to the creation of a given rock. The factors may be of small or great magnitude, but their impress, obvious or not, influences the net result to some degree. Thus, in the case of the form and shape of the geosynclines, or depositional basins, definite considerations must be given them in order to make interpretations of the geologic history of the region. Currently, several interpretations are extant. Among them is one which is apparently gaining in favor among many stratigraphers because it purports to explain and integrate more known facts than do other theories. This is the idea that rocks of the Ridge and Valley province represent but a part, perhaps only a small part, of all the rocks comprising the sediments of the Appalachian geosyncline.

Conclusions regarding the marginal characteristics of the Ridge and Valley sediments seem to be a direct outgrowth of observations about the tectonic aspects of the whole Southeastern region, including the Blue Ridge and Piedmont areas. In many instances geologists have felt that the Ridge and Valley structures did not arise independently but are marginal to features farther southeast (Bucher, 1933, p. 156-157). Keith (1923, p. 312), for example, treated—"the eastern and older rocks as part of the Appalachians", while King (1950, p. 641) states flatly—

> "The Valley and Ridge province does not, however, encompass the entire width of the geosyncline, which must have extended farther southeastward, where deposits of other facies were probably laid down under conditions of greater crustal mobility."

If these interpretations are correct, then it must be inferred that the sediments deposited along the western margins of the old geosyncline differed from those of the eastern portion, although a large part of the debris of both areas may have been derived from the eastern areas. Kay (1942, p. 1642) refers to the portion closer to the craton as the miogeosynclinal phase, while Pettijohn (1949, p. 443) assigns the Ridge and Valley rocks to the foreland or "platform", in order to distinguish them from the deeper, more easterly phase which he calls simply the "geosynclinal phase" (Kay—"eugeosynclinal" phase).

The "foreland", or better, marginal facies represents comparatively thin, shallow water accumulation (Pettijohn, 1949, p. 451-452) where the materials are well sorted and more cleanly washed. This contrasts strongly with the "geosynclinal" facies in which poorly sorted graywackes have accumulated in great thicknesses. It is assumed that much of the "foreland" facies was directly derived from the destruction of pre-existing "geosynclinal" materials, by a re-working of the "geosynclinal" sediments and the formation of younger deposits containing materials of two or more sedimentary cycles. On the other hand, strong evidence exists that post-Weisner (?)—pre-Blackford sediments were derived chiefly from northwestern sources. All gradations between these two end sedimentary products exist, producing rocks that Pettijohn (1949, p. 255) has termed, in one instance, "subgraywacke". Most of the rocks in the Dalton quadrangle would be classified, according to this scheme, in the marginal or "foreland" phase, but a few like the Weisner (?) might conceivably be placed in the subgraywacke stage or "wave-worked unda material" (Rich, 1951, p. 10-12).

Even within the "miogeosynclinal" phase, however, facies are developed which, although relatively restricted in area, must be thoroughly evaluated to understand the time-rock relations from which the broader geologic aspects of the region are deduced.

The following statements about the historical geology of the Dalton guadrangle are based upon the evidence derived both from exposures in the area and from existing reports upon the Southern Appalachian region as a whole.

PALEOZOIC

Cambrian

Weisner (?)—The beginning of Cambrian time in the Dalton quadrangle was probably marked by local subsidence to low source areas. Erosion apparently was not great nor the stream gradients high because the initial deposits of quartz sands and pebbles indicate that the streams probably had only moderate transporting capacities. It also is likely that deposition of the localized Weisner (?) sands occurred in relatively shallow water. The Weisner (?) characteristics suggest that the source of its material was a pre-existing sediment.

If, as previously indicated, the Weisner (?) is actually Cochran, then its deposition was followed during the rest of Chilhowee time (King, 1949, p. 519) by a gradual subsidence of the depositional trough which is suggested by the change from coarser clastics below to finer-grained, cleaner sandstones above. King believes Chilhowee beds represents a single depositional cycle in which there were few or no interruptions to deposition.

Shady Dolomite—Succeeding the upper quartzites of the Weisner (?) or Chilhowee group is the Shady dolomite, not recognized in the Dalton quadrangle. Where present, the Shady is conformable upon the underlying Weisner (Kesler, 1950, p. 11) and thus indicates no appreciable interruption to deposition but merely a cessation of sand influx. Perhaps it may be equivalent to the basal beds of the Rome.

Rome—The rather coarse, cross-bedded, ripple-marked sands of the lower Rome progressively change to finer-grained materials near its top, so that the beds near the Conasauga contact are fine-grained siltstones and shales. Earlier interpretations of such a textural change would have stated that uplift of the source areas, permitting partial stream rejuvenation, resulted in the introduction of a great pall of mud and silt during this interval. Then, as erosion wore down the elevated source area, finer-grained materials were introduced and deposited in the geosyncline.

On the other hand, by contrast, Rich (1951) might interpret this sequence to be: unda sands, near shore, which would be coarse and cross-bedded; and clino and fonda siltstones, and shales off shore, both forming contemporaneously. (The criteria for recognition of the possible clino and fonda environments have not been identified in the Rome of the Dalton quadrangle. It is suggested, therefore, that search for these should be made in other areas of Rome exposure.)

No apparent break separates the Shady dolomite from the basal Rome, nor is there, in the Dalton quadrangle, a determinable interruption of deposition between the Rome and the overlying Conasauga.

Conasauga—The influx of muds and clays with variable amounts of carbonates continued seemingly without interruption through the time interval represented by the Conasauga. At least twice during this period, sufficient amounts of carbonates were present, or muds were enough reduced in quantity, to produce limestones in the Dalton area. Relatively massive, persistent, oolitic limestone beds (Maynardville) mark the younger phase of the Conasauga, and may very well represent a shallowing of water at the point of formation of the oolites, although the oolites may have formed elsewhere and subsequently were transported to the point of deposition. Alternatively, it is possible the oolites may have formed in place.

The Conasauga-Knox contact is poorly exposed in the Dalton quadrangle, but insofar as possible to observe it, seems to indicate no divergence of bedding of the two formations. On the contrary, a rather extraordinary parallelism exists between the uppermost Conasauga and lowermost Knox, with no discoverable evidence of an old erosional surface developed on the Conasauga. The zone between the Conasauga and the first, well developed dolomites of the basal Copper Ridge is occupied by a tripoli zone with interbedded thin layers of siliceous oolites. A few feet above the tripoli zone, a thin, but unmistakable, bed of limestone-edgewise-conglomerate may be found locally. The thickness of the tripoli zone does not vary greatly from place to place, thus indicating that it formed on a nearly plane surface. The oolites, now replaced by silica, are not uniform in shape or size, and show no identifiable nuclei. It is quite possible that the oolites formed as carbonates in waters sufficiently turbulent to permit their formation by accretionary processes but they also may have formed in place, subsequently being replaced by silica. The edgewise-conglomerate could be interpreted as evidence that partially consolidated carbonate muds either were exposed during low tide, or were subject to wave-current action intense enough to disrupt and scatter fragments of soft rock laminae.

The age of the tripoli, *per se,* is at present indeterminate, but may represent secondary alteration and silica replacement of carbonates; perhaps silicification took place when much of the chert was formed in the Knox dolomite. It is noteworthy that the Conasauga limestones below show no comparable amounts of silica.

The absence of disconformable relations at the Conasauga-Knox contact does not agree with the evidence presented by Butts (1926, Pl. 10) in Alabama because he shows three formations in this interval. Butts and Gildersleeve (1948) did not discuss this question in the report on the Paleozoic rocks of Georgia, but did identify the lowermost beds of the Knox as Copper Ridge, thereby suggesting an hiatus.

The evidence, in the exposures of the Dalton quadrangle, therefore seems to point more strongly toward conformity between the Conasauga and the Knox than otherwise. This, in turn, suggests that simultaneously, to the west, under different conditions, other carbonate muds with a higher magnesia content may have been forming. These, upon consolidation, may have produced the dolomites of the lower Knox in the Alabama region. Then, subsequently, gradual subsidence of the geosyncline in the Georgia area might have permitted encroachment of the magnesium limestone environment toward the east and northeast, thus superposing the Copper Ridge dolomites upon the Maynardville limestones without appreciable break between the two formations.

The inference is, therefore, that uppermost Conasauga in the Dalton quadrangle, may be the time equivalent of the lowermost Knox in the Alabama area. Such a situation is reported northwest of the Dalton area at the south end of the Cincinnati Arch in Tennessee (Freeman, 1949, p. 1658, Fig. 2) for pre-Knox horizons.

Cambro-Ordovician

Knox—Carbonate deposition seems to have continued without significant interruption during Knox time. The geosyncline apparently subsided gradually and nearly constantly, permitting the Knox environment to transgress farther and farther northeastward. The seas may have shoaled intermittently when oolites formed, while the presence of thin quartz sandstones may indicate that at times conditions temporarily permitted streams or currents to transport light sand loads across tidal flats or low lands, or out across the "shelf", as at the beginning of Chepultepec time. Formation of carbonate rocks, however, prevailed until the end of the Newala, at least.

The absence of any great interruption of sedimentation from lowermost Cambrian to the end of Newala time is remarkable. Not only does it represent a great length of time. but also it indicates a notable stability of depositional conditions in which there was slow, but nearly constant subsidence of the marginal portion of the Appalachian geosyncline. It is unnecessary, therefore, in contrast to statements made in many historical geology textbooks, to require periodic draining of the geosyncline in order to produce the observed stratigraphic sequence. If it were not for the organic record noted in this rock sequence from many localities outside of the Dalton quadrangle, there would be no necessity to subdivide it into the Cambrian and Ordovician systems as is now done.

Middle Ordovician

Post-Knox Ordovician—Post-Newala time was marked by the inception of broad warping of the sea floor. It is likely that the sea was drained from many areas as the folds rose above sea-level, with the result that erosion of the exposed fold crests truncated them rather deeply. This seems to have been the case in the western part of the quadrangle where beds of Chepultepec age are in contact with post-Knox Ordovician strata. Toward the east, on the other hand, it may be that complete emergence did not occur, but shoaling is probably indicated because wave-cutting, along with possible submarine landslips, probably are responsible for the limestone breccias of the Blackford immediately overlying the Newala. If the assumption that subaqueous erosion on the east was contemporaneous with subaerial erosion to the west is correct, then the eastern and western Blackford types are demonstrated to be equivalent.

Although the magnitude of the orogeny responsible for the warping in the Dalton quadrangle cannot be determined, for the present, outside of the area, it seems reasonable to assume that more intense folding and faulting could have occurred southeast of the area. Furthermore it seems quite likely that subsidence of the depositional basin, temporarily interrupted by warping, continued.

The sediments of the eastern side of the area, beginning with a much thinned "Mosheim" and "Lenoir" limestone zone, changed to a more clastic type with the beginning of Athens time when muds and silts were first laid down. During the Athens interval, moderately coarse clastics replaced the mud materials once during mid-Athens time and again later when coarse, discontinuous limestone conglomerates were formed at the beginning of Tellico time.

Simultaneously, to the west, the "Mosheim" and "Lenoir" limestones accumulated in greater thickness, and for a short while, during "Holston" time, small reefs formed. But a steady inflow of sand and mud from the east overwhelmed both the limestone environment and the reefs, with the result that during post-Holston time ("Sevier" and "Bays") more and more clastics were being deposited farther and farther west from source areas to the east.

It is uncertain, however, whether one or two periods of movement took place in early post-Knox Ordovician time. The relatively thin limestones overlying the Blackford clastics may indicate a time of quiescence or stability in the part of the depositional basin represented by the Dalton quadrangle. Both the "Mosheim" and the "Lenoir", although thinning toward the east, were probably once present over the whole area. On the west side of the quadrangle, these limestones are overlain by small reefs and clastic limestones of the "Holston", but, to the east, are overlain by the Athens siltstones and sandstones. Two alternatives are suggested, therefore.

First, the movement which produced warping in immediate post-Newala time, might not have been confined to the depositional basin alone, but simultaneously may also have elevated areas to the east and southeast. Then, shortly thereafter, continued subsidence of the geosyncline re-submerged most or all of it, and the "Mosheim"—"Lenoir"—"Holston" limestones formed at a great enough distance from the source areas so that the sands and silts derived from the newly elevated land did not invade the limestone environment at once. It may have been, as a consequence, not until late "Holston" or early "Ottosee" time that the muds and silts reached the western part of the quadrangle, although during early "Holston" time, the clastic Athens was being laid down further east.

A major objection to this hypothesis seems to be that no eastern clastic equivalents are known, or recognized for the "Mosheim" and "Lenoir". Nevertheless, it is quite possible that such materials once existed, but are now unexposed due to later covering by thrust sheets, or have since been destroyed.

A second alternative is that there were two orogenic pulses —the first taking place in immediate post-Newala time, but confined chiefly to the geosyncline. Then, after a period of quiet but continued subsidence of the geosyncline during which the limestones formed, a second post-"Lenoir" uplift occurred in the area to the southeast of the quadrangle. If secondary orogenic movement occurred to the east, it may have elevated land areas, activated streams and increased the pace of erosion so that great quantities of sands, gravels and muds entered the sea.

In either event probably much of this debris was deposited as deltas and bars that soon coalesced and were buried deeper and deeper by the constant in-pouring of clastic materials. However, neither the rate of deposition nor the type of sediment were constant, although a maximum in both, at least in the Dalton area, seems to have been reached after passage of considerable time in the "Bays".

The last echoes of the Middle Ordovician orogeny finally died away by Clinch time in the Silurian (King, 1950, p. 661), but these and younger Paleozoic rocks are not represented in the Dalton area. King states that middle Paleozoic time in the southern Appalachians was quiet, and that the next period of disturbance took place in late Mississippian and early Pennsylvanian time foreshadowing the Appalachian revolution of the Permian, which was the culmination of the ever-increasing orogeny in the later Paleozoic.

The Appalachian revolution probably saw the creation of great nappes and fault blocks in the eastern regions which pushed westward and northwestward against the weaker rocks of the "miogeosyncline" sliding the stronger strata over one another along fault planes formed in weaker materials, creating a series of intensely crumpled blocks, more intricately fractured and more closely folded toward the east than to the west. The structure might be described broadly as tectonic shingling, with imbrication generally inclined toward the southeast.

MESOZOIC

The mountains formed from the geosyncline at the end of Paleozoic time may have persisted for a considerable length of time in the Mesozoic. The area seems to have existed as a positive mass subjected to deep erosion and weathering (King, 1950, p. 663) for a large part of the era, reaching peneplanation late in the Cretaceous.

CENOZOIC

Additional warping of the Appalachian, Blue Ridge and Piedmont areas may have taken place in the Tertiary, so that the streams were again rejuvenated and re-adjusted, producing several new erosional surfaces at successively lower elevations. At least two and perhaps three distinct uplifts occurred during one of which the Tertiary (?) alluvium of the eastern part of the Dalton area was deposited. Perhaps the erosional capacity of the streams was not only increased by steeper gradients, but it may also have been augmented by excessive precipitation. A great notch was cut into the Cohutta Mountain front just east of Eton in the Holly Creek re-entrant at this time.

RECENT

A slight additional uplift of the Dalton area may account for the incision of streams down to the level at which they have now produced flood plains. Furthermore, much of the present relief in the area may be the result of this final uplift, although some may be of a preceding cycle.

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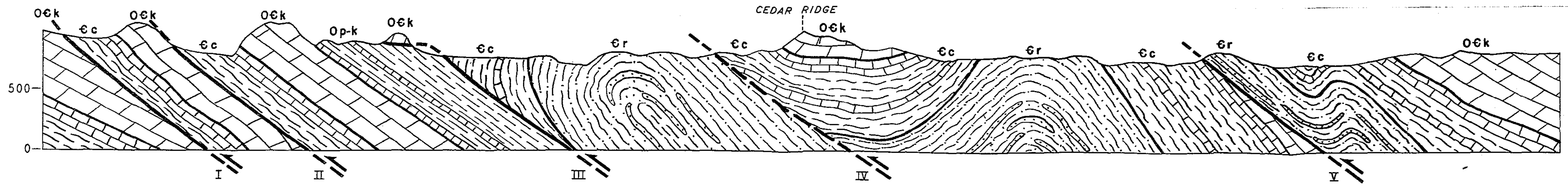

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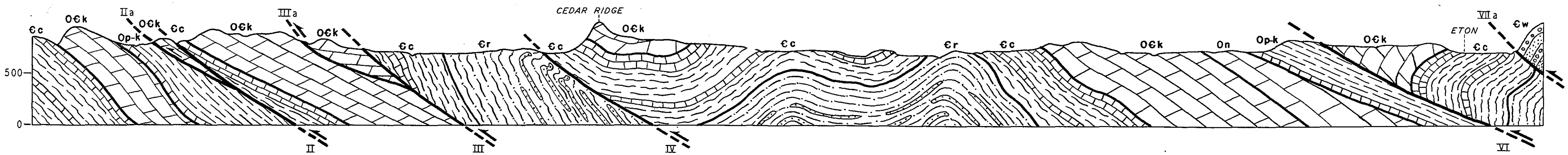

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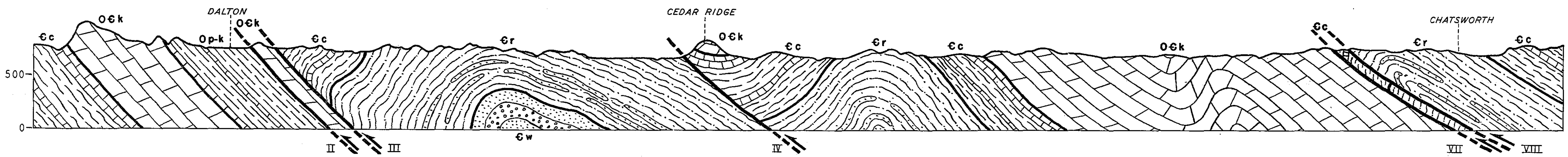


SECTION C-C′

GEORGIA DEPARTMENT OF MINES, MINING AND GEOLOGY, 1951
GARLAND PEYTON, DIRECTOR

ARTHUR C. MUNYAN, GEOLOGIST

FAULT KEY

- I Beaver Valley
- II Varnell
- IIa Waring Ridge
- III Rome
- IIIa West Rome
- IV Coahulla Creek
- V Gap Spring
- VI Sumac
- VII Camp Ground
- VIIa West Camp Ground
- VIII Oran

GEORGIA — TENNESSEE
DALTON QUADRANGLE

STRUCTURE SECTIONS

SCALE OF MILES
1 0 1 2
1951

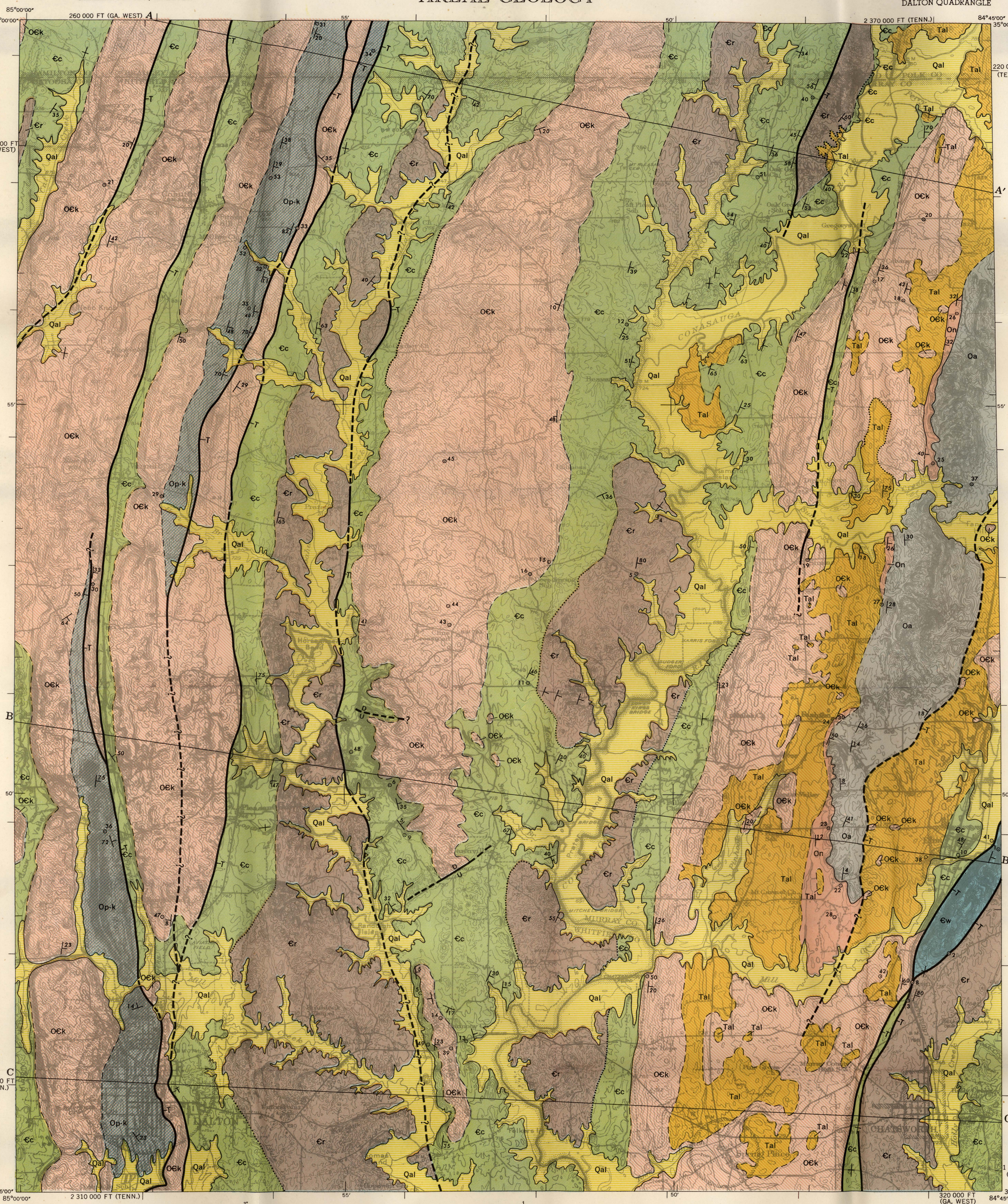
LEGEND

- Op-k post-Knox
- On Newala
- O€k Knox
- €c Conasauga
- €r Rome
- €w Weisner

GEORGIA DEPARTMENT OF MINES, MINING AND GEOLOGY
GARLAND PEYTON, DIRECTOR

AREAL GEOLOGY

GEORGIA-TENNESSEE
DALTON QUADRANGLE



EXPLANATION

CENOZOIC

- Qal — Quarternary alluvium
- Tal — Tertiary (?) alluvium

PALEOZOIC

Ordovician

- Op-k — post-Knox shales and sandstones
- Oa — Athens sandstone
- On — Newala limestone
- O€k — Knox dolomite

Cambrian

- €c — Conasauga shale and limestone
- €r — Rome shale and sandstone
- €w — Weisner quartzite

Topographic base by U. S. Geological Survey 1943 Edition

Cartography and Reproduction by TVA, Maps and Surveys Branch

TRUE NORTH · MAGNETIC NORTH · 2°

APPROXIMATE MEAN DECLINATION, 1950

Scale $\frac{1}{62500}$

1 ½ 0 1 2 3 4 Miles

Contour interval 20 feet

Geology by Arthur C. Munyan 1950-1951

- Contact between formations
- Approximate formational contact
- Less certain formational contact
- Thrust fault
- Intra-formational or concealed thrust
- Probable thrust
- High-angle fault
- Station location
- Strike and dip of beds
- Strike of vertical beds
- Overturned beds