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GEOLOGY OF THE CORE OF THE OUACHITA MOUNTAINS OF OKLAHOMA

by

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By

WILLIAM D. PITT

ABSTRACT

The purpose of this study was to investigate in detail the core area of the Ouachita Mountains of southeast Oklahoma. Soon after the study began it was discovered that bedding fissility is the overwhelmingly dominant kind of parting in the mapped area. This fact led to revisions in the stratigraphic as well as in the structural interpretation of the area. As work progressed it was discovered that a sandstone lay beneath the Collier shale. This newly-identified formation was named the "Lukfata sandstone", after the creek along which all three of the formation's members crop out prominently. The lower member, of which an estimated 45 feet is exposed, consists mostly of inter-laminations of thin-bedded, dark silty limestone and shale; the middle member, about 40 feet thick, consists mostly of black fissile shale interbedded with thin beds of silty, quartzitic sandstone; and the upper member, about 60 feet in thickness, is made up mostly of thick beds of quartzitic sandstone, and local thin beds of black fissile shale, especially near the member's base. Several other noteworthy changes in the interpretation of the stratigraphy are suggested for this area:

(1) Evidence is presented to suggest that much of the silica of the highly siliceous Ouachita facies was deposited by ground water.

(2) Previous estimates of formation thicknesses are inaccurate: the Collier shale, previously estimated to be 200 feet plus is found to be 180 feet; the Crystal Mountain sandstone is 50 to 100 feet, rather than 500 feet plus; and the Mazarn shale is estimated to be 600 feet, rather than 1000 feet.

(3) Insoluble residues derived from several samples of limestone from the Collier shale and Lukfata sandstone formations suggests that the amount of insoluble residue in these limestones varies inversely with the bedding thickness.

(4) Mineralogically the Collier shale consists mostly of quartz and sericite, as shown by thin-section and x-ray analyses.

(5) A brief heavy-mineral study of the Crystal Mountain sandstone yielded mostly opaques, especially pyrite and iron

oxides, and only two non-opaque heavy minerals, zircon and garnet.

Structurally the core area is interpreted as part of an anticlinorium rather than as part of a window in a thrust sheet. The most impressive evidence to support the anticlinal interpretation is that the belt of readily identifiable Collier limestone lies inside the Crystal Mountain sandstone, paralleling the outcrop band of the Crystal Mountain sandstone and dipping under it. Both these formations, as well as all other Paleozoic rocks in the mapped area, dip outward from the main anticlinal axis except where minor folds locally affect dip and strike.

INTRODUCTION

The Ouachita Mountains, a belt of heavily forested ridges extending for 200 miles from central Arkansas into southeastern Oklahoma, geologically is an intriguing area. Here unique rock types crop out, rock types that are correlated beneath the surface on the basis of their uniquity from Arkansas through Texas and into Mexico. Much interest is also centered around the structural interpretations of a few areas in the Ouachita Mountains. One of these areas, the one with which this report is concerned, is located in southern McCurtain County, in the southeast corner of Oklahoma (see figure 1). This is an area in which ridges have a maximum relief of 500 feet. In spite of this relief the area is readily accessible to those interested in examining the formations because many roads and logging railroad beds were constructed or improved within the last decade. The formations which crop out in McCurtain County consist mostly of Paleozoic rocks ranging in age from Cambro-Ordovician to Pennsylvanian. These rocks aggregate 6 to 10 thousand feet in thickness and are mostly clastic, especially the upper 3000 feet which embrace the lower half of the Stanley shale.

Definition of the area of study: the "Core" area.

The "core" area of the Ouachita Mountains is the outcrop area of formations within the circular outcrop belt of the Bigfork chert. The Bigfork chert is a resistant, ridge-making formation that comprises a convenient boundary for defining the limits of this report. Outside its outcrop belt a normal succession of younger strata is demonstrable even along roads that traverse the succession. Within the Bigfork chert outcrop belt, however, the stratigraphic succession is not obvious, and it is the geology of this area that is described in this report.

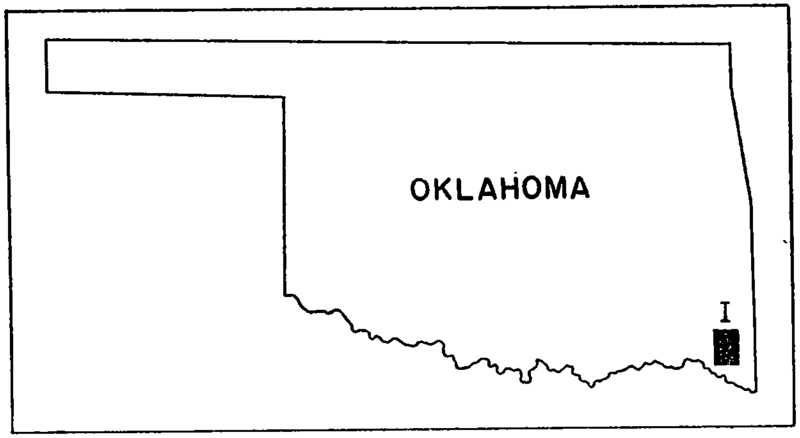

Figure 1, part "A". (for "I" enlargement see page 8) Index Map.

Previous work and statement of problem.

C. W. Honess was the first geologist to map the core of the Ouachita Mountains of Oklahoma. His report (Honess, 1923) includes a geological map, part of which has been interpreted differently. Tomlinson[1] and others interpret the core area as the crest of an anticlinorium. On the other hand Miser and Honess believed that the pre-Bigfork chert area was largely a fenster in a thrust sheet. This report presents the author's attempt to settle this difference of opinion, as well as to present his detailed descriptions of the formations of the core area.

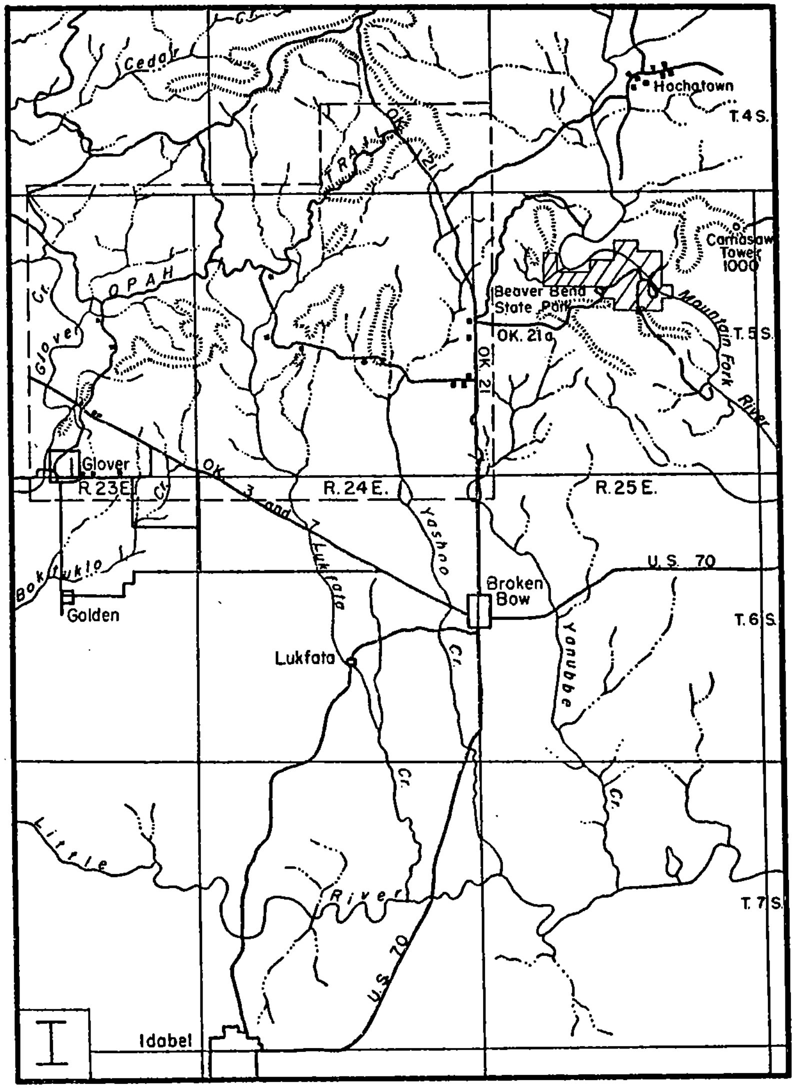

Figure 1, part "B". Index Map.

Field procedure.

In making the geologic map accompanying this report, aerial photographs were used as a base for each square mile mapped. Most of the outcrops were located on this map by means of Brunton-compass traverses because the mapped area is heavily wooded and direct placement of locations on aerial photographs is impossible. The writer plotted the traverses on transparent film, sheets of which were used as an overlays to locate outcrops on the photograph. This worked satisfactorily because the bends of the traverse plotted on the film closely followed the stream bends on the aerial photograph if the bends were at all distinguishable on the photograph. Changes in direction normally were distinguishable because most of the traverses followed prominent dry creek beds or railroad (logging) beds.

At least 90 percent of the rock outcrops are along stream beds, and therefore divides were traversed only if few or no creek beds were in the area being mapped. Columnar sections were also measured along creek beds or at cliffs adjoining them, either by pace traverse if the exposures were along a stream bed, or with a steel tape if the measured interval was a cliff section.

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[1] Tomlinson, C. W., 1952. Personal communication.

STRATIGRAPHY

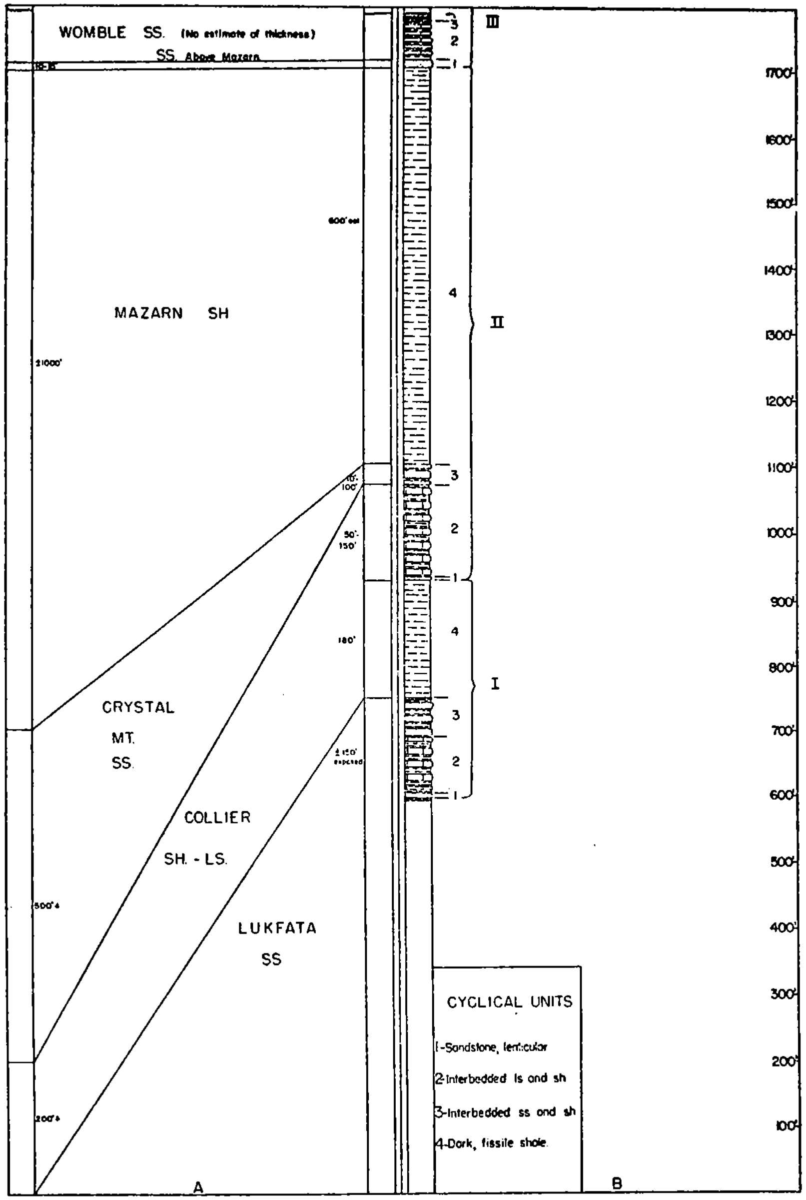
Metamorphism and silicification

Recent investigators (Goldstein and Reno, 1952) have demonstrated the general low-grade metamorphism of the Ouachita facies, which contrasts with Honess' opinion that the rocks of the Ouachita Mountains were "profoundly" metamorphosed (Honess, 1923, p. 36). All the rocks in the Ouachita Mountains show only low-grade metamorphic effects.

Local replacement by silica of formations in the Ouachita Mountains that are adjacent to quartz veins is generally accepted, but Harlton recently proposed (1953, p. 778) that most of entire formations were largely replaced by silica. He believes that the Bigfork chert and the Arkansas novoculite become highly siliceous largely because the silica in ground water replaced the limestone, of which the original material of the two formations largely consisted, according to Harlton.

This idea that much of the silica of the highly siliceous Ouachita facies was deposited by ground water is supported by observations in the pre-Mississippian area of McCurtain County, Oklahoma. There is an interesting distribution in the amount of silica in limestone-bearing formations: the oldest formations generally contain less silica than successively younger ones. Table 1 on page 19, for example, shows that the silica in insoluble residues is much greater in the Womble than it is in the Collier limestone samples. Similarly, the Womble limestone contains much less silica than the cherty limestone of the Bigfork chert, the formation overlying the Womble shale. Furthermore, the Arkansas novaculite is the expected end-member of the transition from less siliceous, older limestones to more siliceous younger ones. Because of this transition, the variation in the amount of silica in these limestones is very likely related to their depth-of-burial.

The principle of dilatancy (Mead, 1925, p. 685) probably explains this variation-with-depth in the amount of secondary silica. According to this principle any distortion of brittle or, especially, of granular substances causes an increase in the volume of the de-



Explanation of Figure 2. The writer's measured or estimated thicknesses of pre-Bigfork chert formations are shown in the right side of part "A" of this diagram, and Honess' estimates are shown on the left side. In order to emphasize the contrast in the two estimates of thickness, lines were drawn "connecting" the formation boundaries. Part "B" illustrates the cyclical units that were recognized in the mapped area shown in plate I.

formed body. This volume-increase facilitates liquid movement because it not only increases porosity and permeability but it also creates a low-pressure area in the newly-formed pore spaces. This principle should explain the downward decrease in the amount of secondary silica especially if there were also a downward decrease in the amount of fracturing. This downward decrease in fracturing indeed is observed by comparing hand specimens of various calcareous formations, excepting those formations, such as the Arkansas novaculite, that are almost completely replaced by secondary silica. A specimen of the Womble limestone for example is much more sheared in appearance than one of the Collier limestone. Furthermore, a downward decrease in the amount of fracturing during deformation is reasonable because deeper limestones tend to be deformed by yielding plastically rather than by fracturing. This is true for two reasons: rocks recrystallize more readily with increased pressure, and conversely volume increases that must attend fracturing are more difficult. The most highly silicified calcareous formations were those that were most thoroughly and repeatedly fractured; and into these permeable low-pressure areas silica-charged water must have migrated, deposited their load and thereby caused the highly siliceous Ouachita facies.

Support for Harlton's idea that the Ouachita facies are largely secondarily siliceous is the fact that the pre-Mississippian formations in the core area seem to have been deposited in a shelf environment, an environment in which "primary" chert certainly would not be an expected sedimentary deposit. In the core area cyclical units are identified, and orthoquartzitic sandstones are present (see Figure 2). Both these facts suggest that the formations in the core area were deposited largely in a shelf environment if the criteria for a shelf environment as proposed by Krumbein (Krumbein et al, 1949, p. 1876) are accepted.

DESCRIPTIONS OF FORMATIONS

Lukfata sandstone formation (new name)

Distribution.—The three members of this formation crop out prominently along Lukfata Creek in sections 8 and 17, T. 5 S., R. 24 E., as shown in Figure 3 on page 14, and for this reason the formation name is taken from that of the creek. The lower member crops out at a concrete high-water ford on Lukfata Creek, near the center of sec. 17, T. 5 S., R. 24 E., and locally within 400 yards up and down-stream from this location. The general location is considered the type area for the lower member. The type section for the middle member is located about 400 yards downstream from the above-mentioned concrete ford, where also the upper member crops out. The type section for the upper member of the Lukfata sandstone, however, is the cliff section in the southwest corner of a corn field on the west bank of Lukfata Creek, SE¼ SE¼ sec. 8, T. 5 S., R. 24 E. The Lukfata sandstone is also exposed along branches of Boktukola Creek in sec. 25, T. 5 S., R. 23 E. The existence of the Lukfata sandstone as a unit is established by its almost continuous exposure and that of the overlying Collier shale along Lukfata Creek, beginning about 300 yards downstream from the concrete ford near the center of sec. 17, T. 5 S., R. 24 E. (see plate I). At these outcrops the dip is uniformly southwest and measures only a few degrees. The contact of the Lukfata sandstone and the overlying massive Collier shale is recognized readily because the lithology of each formation is distinct with respect to that of the other; hence, the contact is readily traceable where outcrops are adequate. The sandstone beneath the Collier shale therefore is designated a formation.

Thickness.—At least 145 feet of the Lukfata formation is exposed in the mapped area shown on plate I. This estimate was made by means of a Brunton-compass traverse along Lukfata Creek in sec. 17, T. 5 S., R. 24 E.

General description.—The Lukfata sandstone formation consists of three members: a lower member made up mostly of interlaminations of thin-bedded limestone and shale; a middle mem-

COLUMNAR SECTIONS OF THE LUKFATA SANDSTONE

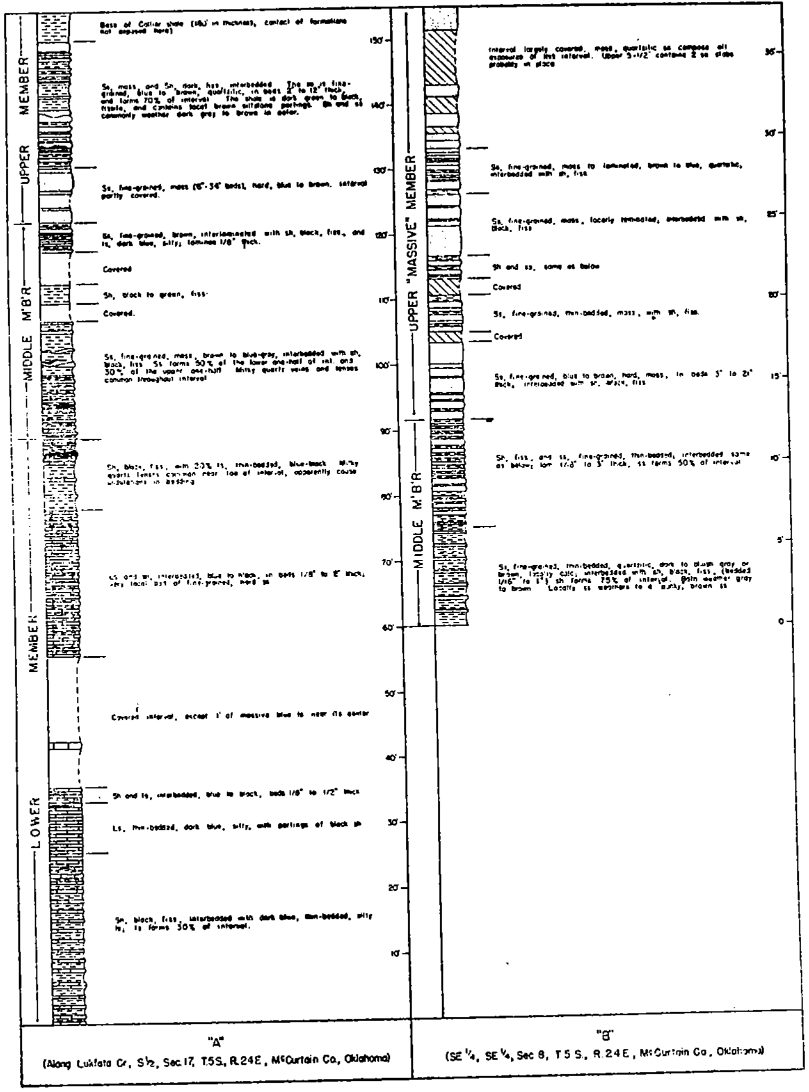


Figure 3.

ber, of interbedded platy sandstone and shale; and an upper member, of more massively bedded sandstone which contains some laminae of shale. Figure 3 on page 14 shows columnar sections of two prominent outcrops of this formation. The lower member,

Figure 4. Panoramic view looking west of an exposure mostly of the upper "massive" member of the Lukfata sandstone. Sandstone beds become progressively thicker near the top. Exposure in SE¼ SE¼ sec. 8, T. 5 S., R. 24 E.

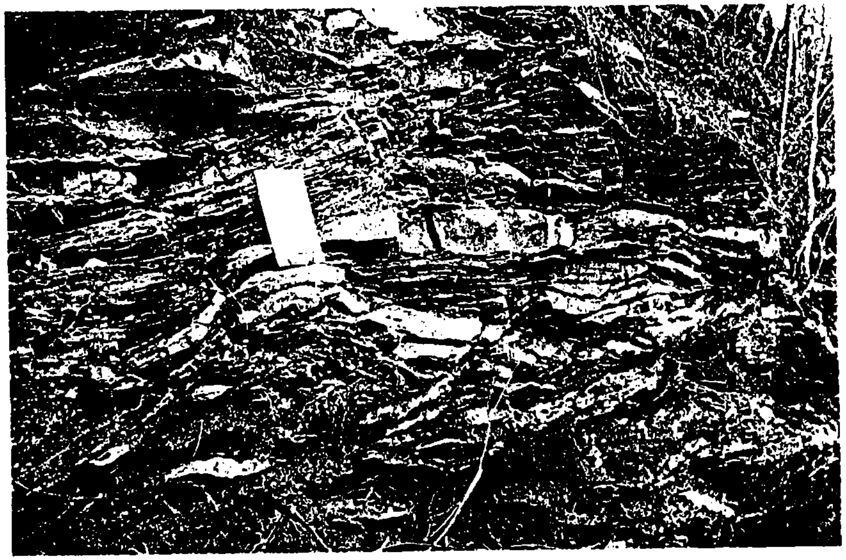


Figure 5. Middle member of Lukfata sandstone showing irregular interbedding of thin laminae of quartzitic sandstone and shale. Note the veins of "milky" quartz that usually parallel the bedding planes. The camera was pointed southeast. On Lukfata Creek, NW¼ SE¼ sec. 17, T. 5 S., R. 24 E.

of which an estimated 45 feet is exposed, consists of about equal proportions of limestone and shale. The limestone beds, ranging in thickness from 0.1″ to 1 foot, are silty, massive, bluish-black, and have local swarms of milky calcite and quartz veins. The shale is gray to black, silty, locally calcareous, and is normally fissile. Locally beds of hard sandstone as much as 6 inches in thickness occur. The sandstone is fine-grained, silty, generally laminated, quartzitic and brown to gray. The middle member of the Lukfata sandstone formation, about 40 feet thick, consists largely of black fissile shale; about one-third of the interval, however, is thin-bedded sandstone. The shale beds of this interval range in thickness from 0.1″ to ½ foot. Veins of quartz parallel to the bedding are common and appear to cause variations in thickness as well as undulations of beds. The irregular bedding of the rocks of this interval is illustrated in figure 5 at page 14. The upper "massive" member, about 60 feet in thickness, has the same kind of silty sandstone typical of the middle member; the sandstone of this interval, however, makes up more than two-thirds of the interval. Another unique feature of this member is that the sandstone beds become progressively thicker bedded near its top, as shown in figure 4 at page 14. The sandstone that composes the thicker beds is largely medium-grained, in contrast to the sandstone of thinner beds, which is fine-grained.

Collier shale formation

Correlation and distribution.—The formation was first named and described by A. H. Purdue in 1909 as the "graphitic. unctuous shales" that occur along Collier Creek, Montgomery County, Arkansas. The Collier shale is thought to be Cambrian in age.

Prominent outcrops of the Collier shale in the mapped area occur along Lukfata Creek, near the SE¼ SW¼ sec. 17, T. 5 S., R. 24 E., and also along Slate Rock Creek in sec. 27, T. 5 S., R. 23 E.

Thickness.—An almost continuous exposure along Lukfata Creek in sec. 17, T. 5 S., R. 24 E. permits the measurement of the Collier shale, here 180 feet thick. A comparison of this measured interval with Honess' estimate of thicknesses of this and other pre-Bigfork chert formations is shown in part "A" of figure 2 on page 11.

General description. — The Collier shale, largely variegated, normally brown, fissile shale, locally has numerous laminations of siltstone, sandstone, and silty limestone. This is true, for example, along much of Slate Rock Creek, an intermittent stream east of the ridge in the W½ sec. 27, T. 5 S., R. 23 E. The typical outcrop appearance of the Collier shale is shown in figures 14 and 15 at page 28. Mineralogically the Collier shale consists mostly of quartz and sericite. This conclusion is based on thin-section examination, later confirmed by x-ray examinations of two specimens of Collier shale. In the x-ray examinations only sericite was identified in the clay fraction; quartz seems to comprise all of the coarser fraction.[1] Other minerals in the Collier shale which appear to be abundant locally, according to Honess, include chlorite, graphite, kaolin, goethite and hematite.

Collier limestone (upper member of Collier shale formation)

Distribution.—Prominent outcrops of the Collier limestone occur along the west side of the ridge in the NW¼ sec. 27, T. 5 S., R. 23 E. Others are along Lukfata Creek and its tributaries, especially in the NE¼ sec. 9, and the NW¼ sec. 20, T. 5 S., R. 24 E. The Collier limestone is considered the upper member of the Collier shale formation by Honess and by Miser. Its contact with the Crystal Mountain sandstone above the massive fissile (Collier) shale below is generally traceable in the mapped area, and it is therefore recommended that this unit be considered a separate formation if it also proves traceable in the type area of the Collier shale in Arkansas.

Thickness.—The thickness of this member is variable, ranging from 50 to 150 feet. The measured thickness on the west side of the ridge in the W½ sec. 27. T. 5 S., R. 23 E., is 140 feet.

General description.—The Collier limestone consists largely of interbedded fissile shale and dark bluish gray, finely crystalline limestone. The shale and limestone beds are normally 0.2 inch to 2 inches thick. The bedding is variable: normally it is evenly

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[1] Osmond, Kenneth, 1953. Personal communication.

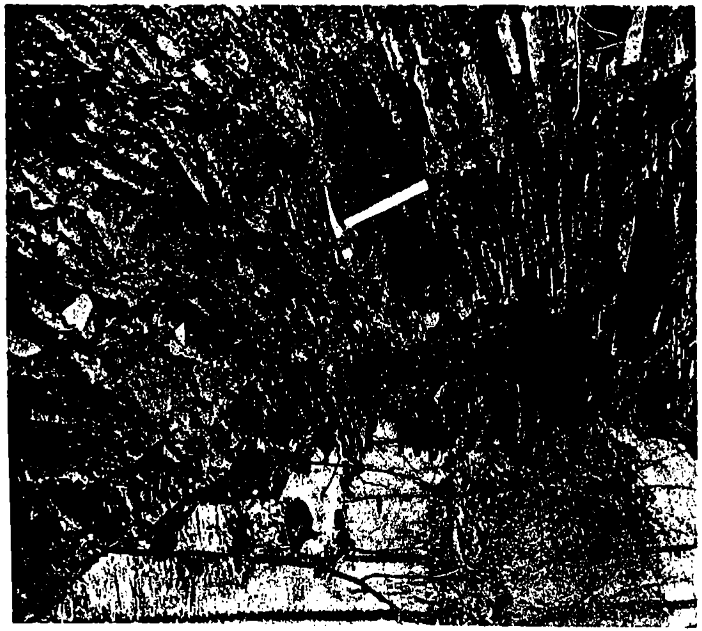

Figure 6. Typical appearance of Collier limestone, on a west-facing cliff of upper Lukfata Creek, NW¼ NE¼ sec. 9, T. 5 S., R. 24 E. Notice the thin, even bedding.

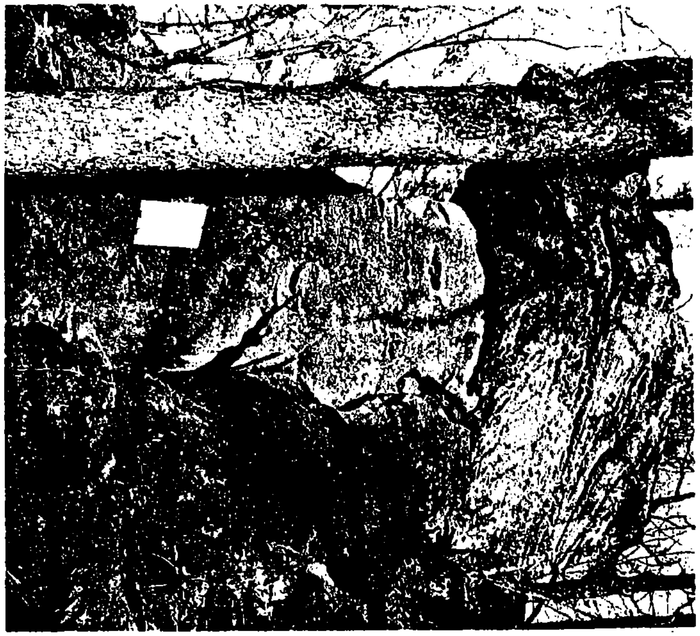

Figure 7. Crystal Mountain sandstone ridge east of Glover Creek, NW¼ sec. 27, T. 5 S., R. 23 E. Upper part of columnar section shown on left side of figure 8. Note contrast in weathering of cross-bedded, punky sandstone at top; hard, massive sandstone above book; and rough "pebbly" surface of conglomerate below book.

bedded, as shown in figure 6; locally, however, the beds are undulating and lenticular, especially where they are permeated with "milky" quartz veins. Other rock types within the formation include massive sandstone beds, near the top and base of the forma-

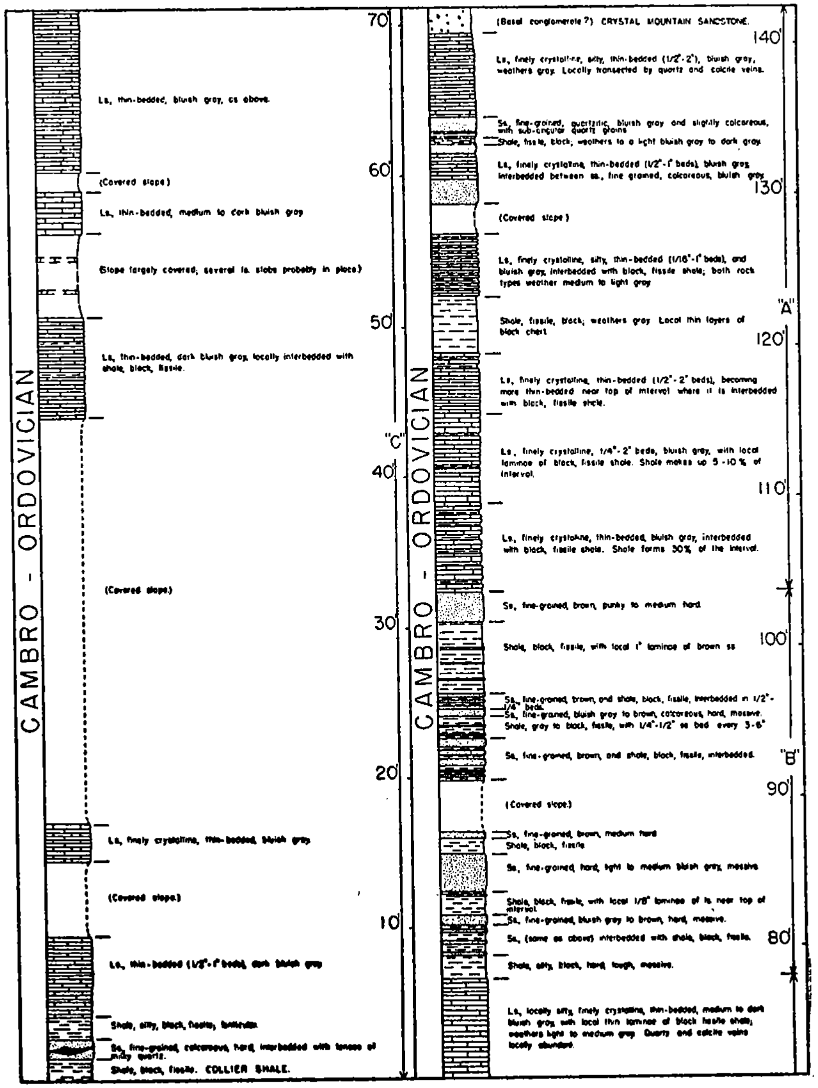

Figure 8. Columnar section of the Collier limestone as measured on the west side of "Crystal Mountain Ridge", NW¼ sec. 27, T. 5 S., R. 23 E.

tion, and local thin beds of chert. A composite section of the Collier limestone exposed on the west side of the ridge in the NW¼ sec. 27, T. 5 S., R. 23 E., is illustrated in figure 8. Microscopically the limestone is largely a medium to finely crystalline limestone composed of small interlocking grains which in few cases show cataclastic structure. The limestone is relatively impure, containing in its insoluble residue mostly quartz grains of silt size, some sericite, and graphite. The results of insoluble residue study are tabulated in table 1 on page 19.

Insoluble residue study.—To determine the nature of the insoluble residue of calcareous rocks in pre-Bigfork chert formations, several insoluble residue analyses were made. Approximately 5 grams of calcareous rock were soaked in 18% hydrochloric acid. The supernatant was decanted from the insolubles and the insolubles were washed twice with water; finally, the water was decanted and the samples were dried. The results are tabulated in the table on page 19.

Conclusions drawn from insoluble residue study.

This brief study shows that most of the insoluble residue in the Collier limestone consists of quartz grains of silt size and minor amounts of sericite flakes. This study further suggests that the amount of insoluble residue varies inversely with the bedding thickness. This is especially evident in the Collier limestone samples, specifically samples 2, 5 and 10. Finally, it is noteworthy that the basal conglomerate of the Crystal Mountain sandstone lies between the Collier limestone and the main body of the Crystal Mountain sandstone in its insoluble residue content as well as in its stratigraphic position.

Crystal Mountain sandstone.

Correlation and distribution. — The name, Crystal Mountain sandstone, was given by A. H. Purdue in 1909 to the sandstone that crops out in the Crystal Mountains of Montgomery and Garland counties, Arkansas. This formation is compared with the McLish sandstone of the Simpson group because both are pure quartz sandstone and both appear to be in about the same stratigraphic position. Although the area of outcrop of the Crystal Mountain sandstone covers many square miles in Arkansas and Oklahoma, the area in which its bedding is preserved in outcrops is comparatively small. Two of the rare prominent outcrops of the Crystal Mountain sandstone in Oklahoma and their locations are given in figure 9 on page 20.

TABLE 1

INSOLUBLE RESIDUES OF PRE-BIGFORK CHERT FORMATIONS

Sample No.	Formation	Bedding Thickness	Wt. of Residue (Grams)	Description of Residue*
9	Lukfata	0.1-0.2″	0.85	Siltstone, mostly quartz grains with some sericite flakes.
3	Lukfata	0.2-0.4″	0.59	Siltstone, mostly quartz grains with dark gray sericite flakes.
8	Lukfata	0.2-0.5″	0.70	Same as above.
2	Collier	0.1-0.2″	1.90	Siltstone as above except about 15% white sericite therein.
5	Collier	0.2-0.4″	0.80	Siltstone as above with about 20% dark gray "gritty" graphite (?).
10	Collier	0.5″	0.20	Siltstone, mostly quartz grains with some gray sericite flakes.
11	Collier	0.75-1.0″	0.47	Same as above.
6	Crystal Mountain conglomerate (member)	Massive	1.47	Sandstone, sub-angular grains, clear, with 50% siltstone; fine-grained with flakes of dark sericite.
4	Crystal Mountain conglomerate	Massive	1.07	Siltstone, fragmental, quartzitic, white, with dark gray "gritty" graphite (?).
14	Crystal Mountain sandstone	Massive	2.81	Sandstone, fragmental, quartzitic; sand grains angular and poorly sorted; silt grains and sericite fragments common.
7	Womble	3″	2.92	Sandstone and siltstone, poorly sorted, sub-angular, fragmental.
1	Womble	10″	1.86	Siltstone and sandstone, fragmental, with dark sericite flakes.

* Color of residue is medium gray, unless otherwise indicated.

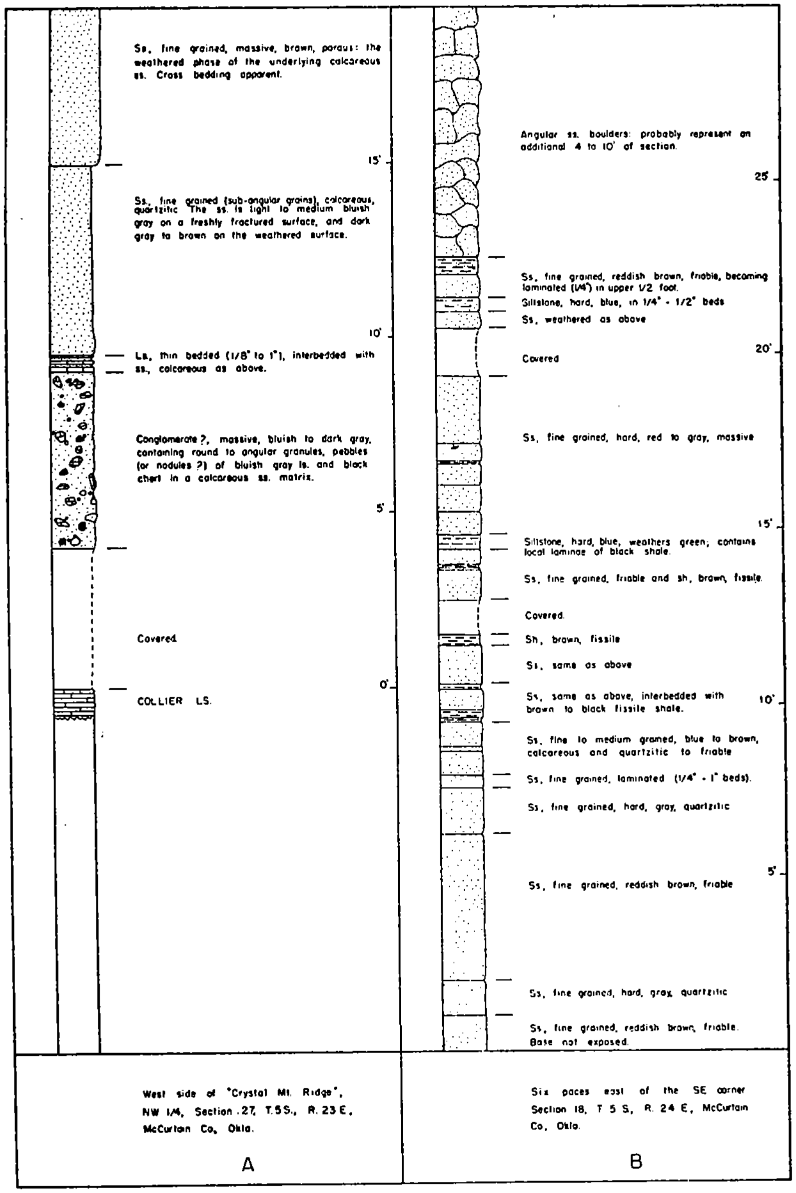

Figure 9. Columnar sections of Crystal Mountain sandstone.

Several methods were employed to map the outcrop area of the Crystal Mountain sandstone. First, the Crystal Mountain sandstone was easily recognized and its boundary mapped if the basal conglomerate was found; this member in itself identifies the formation. On divides the outcrop boundary of the Crystal Mountain sandstone locally was extended by assuming that continuity of sandstone float where abundant means continuity of outcrop. The lower boundary was also drawn at the base of much angular sandstone float on or near the top of hills on the slopes of which Collier limestone or shale is exposed. Finally, the presence of much sandstone and quartz float is locally indicated on aerial photographs by lighter shades, and this fact also was used to extend the boundaries of the Crystal Mountain sandstone.

Thickness.—The thickness of the Crystal Mountain sandstone is estimated by the writer to range from 5 to 100 feet in the mapped area, as contrasted with Honess' estimate of 500 or more feet for the same area.

General description of the basal conglomerate member. — The basal conglomerate of the Crystal Mountain sandstone is a calcareous sandstone with fragments, both rounded and angular, of limestone, chert and micaceous minerals. The calcite in the sandstone locally is recrystallized, as shown by the fact that in thin section the sandstone matrix contains numerous ferruginous calcite rhombs. The conglomerate is massive and in outcrops forms one massive bed. Lenses, 4 to 12 inches in length, of chert and limestone are common; the lenses parallel the known bedding planes. This is true specifically of a zone of thin-bedded limestone near the top of the basal conglomerate, as shown in figure 7 at page 16.

General description of the massive sandstone member.—The Crystal Mountain sandstone is largely a fine-grained, locally medium grained, sandstone, cemented either by silica or calcite. At some localities, such as the top of the ridge, W½ sec. 27, T. 5 S., R. 23 E., the sandstone is generally calcareous. Here the upper 0.5 to 2 feet of beds on the ridge and the beds adjacent to prominent bedding partings normally weather to a punky, poorly cemented mass of sand grains (Figure 7).

Although the weathering of the Crystal Mountain sandstone produces much float, few exposures result therefrom. Hillside exposures are especially rare, but many hills are covered with sharpedged fragments of sandstone float, which suggests that bedded sandstone is within a few feet of the surface. For this reason and because the hills themselves are characteristically gently rolling and locally suggestive of the regional dip, it is believed that some of the hillsides represent "dip slopes".

Heavy minerals.—In a brief qualitative study of the heavy minerals found in the Crystal Mountain sandstone, 8 separations were made on samples of the sandstone using acetylene tetrabromide as the separating agent. Most of the heavy minerals are opaques, especially sulfides and iron oxides, such as pyrite, hematite, and limonite. The separations yielded only 2 non-opaque heavy minerals: zircon and garnet. White to light gray zircon is the most common non-opaque mineral. It is in the form of angular fragments, probably the result of crushing the quartzitic sandstone. Small euhedral crystals of garnet also occur. Most of the garnet is a dark red or dark blue hue, and the mineral is present in only 2 of the 8 slides. Honess mentioned finding rutile and apatite, but these were not found in the slides examined by the writer. Certainly the heavy mineral suite of the Crystal Mountain sandstone is a simple one, similar to that of the McLish sandstone and to "shelf" sandstones in general.

Mazarn shale

Correlation and distribution.—The Mazarn shale was first described by H. D. Miser in 1917 as "dark-colored, carbonaceous, hard clay shales and slates". The type locality of the Mazarn shale is Mazarn Creek, eastern Montgomery County, Arkansas. The Mazarn shale is comparable in stratigraphic position with the upper part of the Arbuckle limestone and the lower part of the Simpson group, and is regarded by many as being the same age as the lower part of the Beekmantown (Miser, 1929, p. 28).

In Oklahoma the Mazarn shale is exposed almost continuously along Lukfata Creek near the center of the E½ sec. 4, T. 5 S., R. 24 E. It is also well exposed along Glover Creek in the E½ sec. 28, T. 5 S., R. 23 E. The Mazarn shale lithologically resembles the Collier shale. The locally interbedded limestones of this formation are, however, distinctive, as briefly described below. In spite of this distinctive limestone, the position of the Mazarn shale in sequence, above the Crystal Mountain sandstone and below the Womble shale, is deemed the only sure method of its identification.

Thickness.—No attempt was made to measure the thickness of the Mazarn shale, but using its areal limits along one stream course as its average outcrop width and the approximate average dip along this same course, a thickness of 600 feet was estimated.

General description.—The Mazarn shale like the Collier shale is mostly a dark fissile shale which also has local laminae of sandstone and limestone. The dark gray limestones are more siliceous and less blue in appearance than the limestones of the Collier limestone. Conversely, the Mazarn limestones are less siliceous than the Womble limestones.

"Blakely" sandstone

As originally defined by Miser, the Blakely sandstone lies stratigraphically above the Mazarn shale and below the Womble shale. In Oklahoma Honess mentioned two general outcrop areas of this sandstone. One is in sec. 16, T. 5 S., R. 23 E., and southwest therefrom, where Honess noticed that the only "good" (Honess, 1923, p. 68) exposure is the lower 10 to 15 feet at the bottom of a cliff on Glover Creek, sec. 16, T. 5 S., R. 23 E. Honess described this exposure as a "dark, smoky quartzite, evenly bedded in layers 0.5 to 2 feet", cut vertically by "thin veins of milky quartz and smoky quartz". He said that "the appearance of the smoky quartzite above the shale is very sudden, but the passage from the quartzite layers to the schistose sandstone is gradual and transitional". A series of beds distinct lithologically from the Mazarn shale below and the Womble siltstone above was also noted by the writer near the above location (Figure 10). This could be designated a separate formation, but if it were designated in this way, it is recommended that it not be called "Blakely" because of the findings of current field work in the Blakely sandstone type area in Arkansas.

The other general occurrence of Honess' Blakely sandstone is in sec. 25, T. 5 S., R. 23 E., and parts of neighboring sections. Honess noted that "there is some doubt about the correlation with the beds to the north" because the "sandstones are not bronzecolored". In this correlation the writer is in fundamental disagreement: Honess' two occurrences of Blakely sandstone are not similar lithologically because the outcrops in the two areas represent two stratigraphic units, as shown in plate I, (pocket), rather than because one stratigraphic unit has several facies. Finally, in both occurrences that Honess cites, the sandstones have little resemblance to the "type Blakely" in Arkansas. The outcrop that Honess describes as Blakely sandstone consists of one sandstone bed 15 feet thick, which is not at all similar to the 400 feet of interbedded shale and sandstone that Miser describes as Blakely sandstone at the type locality.

Womble shale

Definition and correlation.—As defined here the Womble shale includes the stratigraphic interval between the Mazarn shale below and the Bigfork chert above. The formation was named by H. D. Miser after the town of Womble (now Norman), Arkansas, the type locality. The unit is correlated by Harlton (Harlton, 1953, p. 780) with the upper part of the Simpson group of the Arbuckle Mountains.

Thickness.—The cliff exposure of Womble shale, illustrated in figure 10, is 66 feet in thickness. No estimate was made of the thickness of the laminated siltstones and fissile shales that seem to make up the remainder of the interval to the base of the Bigfork chert.

Distribution.—Although the outcrop area of the Womble shale is extensive, only one location was found in the mapped area where a sizeable portion of the formation was exposed. This location is a cliff on the south side of Glover Creek near the center of sec. 22, T. 5 S., R. 23 E. The cliff shows all lithologic variations of the Womble shale formation, including the typical red laminated siltstone at its top. A columnar section of the rocks in this exposure is presented in figure 10.

General description.—The contact of the Mazarn shale and the overlying Womble shale is well exposed at the cliff section mentioned above; the limestone at the base of the Womble shale is unique. It is uniformly cataclastic, actually appearing to be a mylonite in hand specimen. The interbedded shales are dark and fissile, similar to those of the Collier and Mazarn shales. Red and brown laminated siltstones and dark fissile shale make up the upper 9 feet of the cliff section.

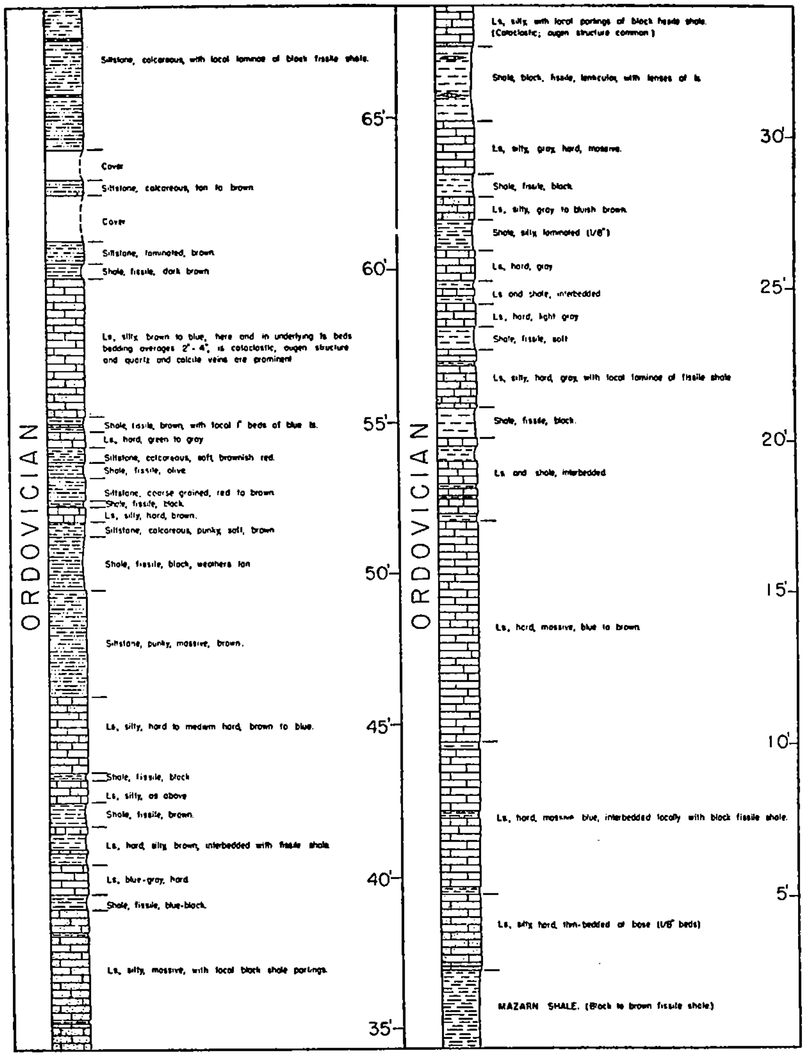

Figure 10. Columnar section of lower part of Womble shale.

STRUCTURAL INTERPRETATIONS OF THE CORE AREA

Determination of bedding

Fundamental in the structural interpretation of any area is the determination of bedding. In a metamorphosed region such as the Ouachita Mountains, planes of parting and color banding are locally the only persistent structural features; and in these areas unless a relationship between persistent features and bedding is determinable, the position of the bedding planes remains unknown. For this reason finding any relationship between bedding and persistent structural features, such as cleavage, color banding and jointing, is a prime endeavor.

Bedding fissility in the core area.—It is assumed that the only outcrops in which bedding planes were identified with any certainty were those in which contrasting lithologic types are interbedded, such as sandstone with shale or limestone with shale. This interbedding is especially indicative of bedding at localities in which the individual beds are an inch or more in thickness. This minimum thickness, almost universally present at exposures in which there is interbedding, practically eliminates the possibility of mistaking "cleavage banding" for bedding. Except for two very local exceptions, the parting of the shale at all outcrops examined is either parallel to the bedding, or less than 5 degrees from being parallel. This kind of parting, bedding fissility, is illustrated in figures 11 and 12 at page 26. In figure 11 the fissility as it commonly appears on a hillside is shown; and figure 12 illustrates bedding fissility as it is commonly seen in a stream outcrop. At both exposures the interlaminations of beds up to 1.5 feet in thickness, either of limestone or of sandstone with shale, establishes there the existence of bedding fissility in the shale.

The fissile shale of the Collier shale formation is interbedded locally with thin (less than ¼ inch) layers of recrystallized siltstone. At these exposures the bedding plane is very likely parallel to these beds, even though they are thin. One of these locations is pictured in figures 14 and 15 at page 28.

Figure 11. Closeup of interbedded sandstone and shale in the Collier limestone, showing bedding fissility in the shale. (West side of ridge, NW ¼ sec. 27, T. 5 S., R. 23 E.)

Figure 12. Interbedded shale and sandstone in the Collier shale along upper Lukfata Creek, NW ¼ sec. 9, T. 5 S., R. 24 E. The notebook, north of the camera, is leaning against an 8-inch sandstone bed.

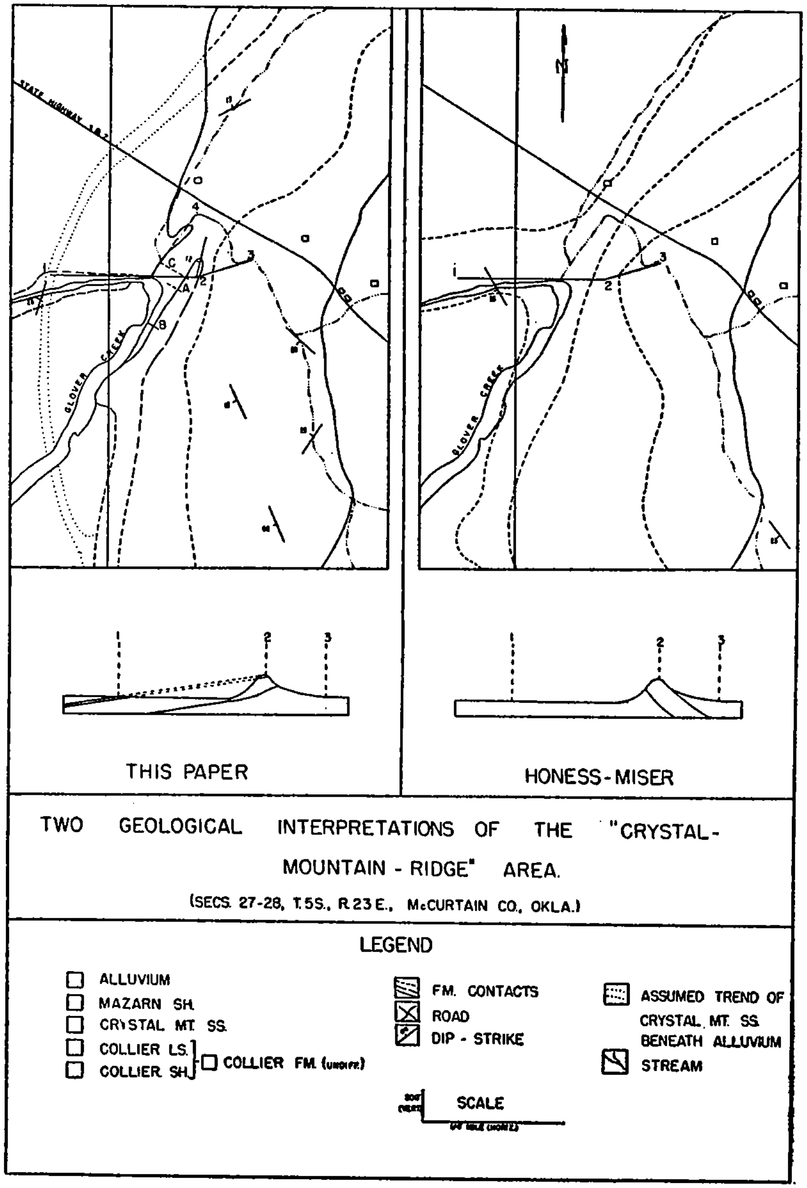

Figure 13.

A very local exception to the general rule of regional bedding fissility is along the axial plane of a sharply folded drag fold at the base of the Lukfata sandstone (Figure 4). The area, which is believed to be one of fracture cleavage, measures only several square inches and is confined to the sharper folded portion of the drag fold at the base of the exposure.

It is concluded that the only likely locations in which fracture cleavage might be present are in the more sharply folded crests of drag folds, similar to the one shown in figure 4. Finally, it is believed that because of the very local nature of the exceptions of bedding fissility, bedding fissility is the overwhelmingly dominant mode of parting in the mapped area. For this reason fissility was assumed to represent the bedding plane at exposures in which no interbedding of rock types was found.

Miser's interpretation of the core area

After reviewing Honess' structural interpretation of the core area, Miser agreed that a fault was needed to explain the contact of the Collier and Womble shales on the northwest flank. According to Honess' mapping, these shales were in contact elsewhere, and Miser therefore followed this interpretation to its logical conclusion by extending Honess' original Glover fault around the northeast "nose" of the anticlinorium and along its southeast flank. The resulting circular fault trace Miser interprets as the boundary of a window in the Boktukola thrust sheet, similar to the window that he postulates for the Potato Hills area in the northwestern part of the Ouachita Mountains. This core area to him therefore is a window in a thrust sheet, and one in which younger beds were thrust over older ones.

"Crystal Mountain Ridge" controversy

The "Crystal Mountain Ridge", a north-trending ridge in the W½ sec. 27, T. 5 S., R. 23 E., of McCurtain County, Oklahoma, is critical in the interpretation of the geology of the Ouachita Mountains of Oklahoma. Two interpretations are illustrated in figure 13 on page 27. As shown in this figure, Miser believes that the shale east of the ridge is Mazarn shale, younger than the sandstone capping the ridge. He bases his conclusion largely on Honess' mapping and on the dip of the color banding which he finds in a roadside outcrop near the center of sec. 27.

The alternate interpretation is that the shale east of the ridge is not Mazarn but Collier and is older rather than younger than the sandstone capping the ridge. This seems to be the correct interpretation for several reasons. First, because color banding in itself cannot be used as a way to determine bedding; nor can one rely altogether on the accuracy of Honess' reconnaissance mapping. Furthermore, small outcrops of the limetsone, undoubtedly Collier, were found on the east side of the ridge, near the northeast "nose" of the ridge. Also the Crystal Mountain sandstone crops out in Glover Creek west of the ridge, as shown in figure 13. Furthermore, the interbedded shale and siltstone east of the ridge dips west. This is seen also on Honess' map, for both of the dip symbols that he plotted for this area show west dip, as shown in figure 13. Finally, the alignment of two locations of drag folds at the base of the west side of the ridge indicates that older beds lay east of the ridge.

Glover fault

Honess and Miser believed that the Collier and Womble shales were in contact with each other along their belts of outcrop, and to explain this juxtaposition the "Glover fault" was postulated. Several good reasons, however, justify the writer's belief that the fault does not exist. Honess himself was uncertain about his correlation of the Collier shale. He correlated the Collier shale as "doubtful Collier with the exception of that portion which lies in secs. 27 and 28, T. 5 S., R. 23 E." (Honess, 1923, p. 39). The most impressive evidence favoring the non-existence of the Glover fault and the anticlinal nature of the mapped area is that the belt of readily identifiable Collier limestone lies inside the Crystal Mountain sandstone, paralleling the outcrop band of the Crystal Mountain sandstone and dipping under it. Both these formations, as well as all other Paleozoic rocks in the mapped area, dip outward from the main anticlinal axis except where minor folds locally affect dip and strike. In short, the entire sequence of formations in the mapped area, from the Lukfata sandstone to the Bigfork chert, lies in normal order and in normal structural and stratigraphic relationship, and for this reason especially the Glover fault does not seem to exist.

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Figure 14. Looking northeast along Slate Rock Creek, an intermittent stream east of "Crystal Mountain Ridge", near center of W½ sec. 27, T. 5 S., R. 23 E. The turn in the stream in left background is cross-section location "3" of figure 24. The fissility of the shale dips southwest, camera facing north.

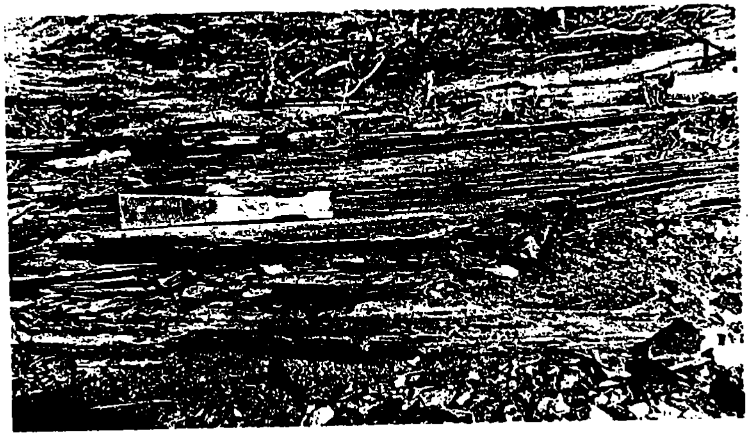

Figure 15. Looking southwest, at the above locality. The white layers are recrystallized siltstone; the dark, fissile shale, largely altered to sericite.

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