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THE SYCAMORE LIMESTONE

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THE SYCAMORE LIMESTONE

INTRODUCTION

PURPOSE

Very little work of a detailed nature has been done on this formation, consequently there are some problems concerning it which have been unsolved. First of these problems is a detailed lithologic description, and second, is the placing of the formation in its proper position in the columnar section. Dr. Chas. N. Gould[1] states:

"The age of the Sycamore has been a matter of controversy and it is altogether possible that the last word on the subject has not been written. * * * Following the preponderance of opinion, the Sycamore is here assigned to the basal part of the Mississippian and correlated with the Boone limestone."

Since the above quotation is the last that has been written, it is readily seen that there is much to be done on the subject of the age and correlation of the Sycamore limestone.

LITERATURE

Only a small amount of information has been published on the Sycamore limestone. Five articles are found in the literature giving as much as a paragraph to the description of this formation, and in only two of these have the writers done anything that might be called detailed work. J. A. Taff[2] named the formation in 1903 in his report on the Tishomingo Quadrangle. The type locality, from which the formation is named, is located in T. 3 S., R. 4 E., where the limestone is crossed by Sycamore Creek.

Taff describes the formation as being "lentils and wedges," because of its increasing thickness westward while to the east it thins, and at the border of the quadrangle along Buckhorn Creek Valley it is about 50 feet thick. In the vicinity of Gilsonite near the northwest corner of the quadrangle, a thin, somewhat cherty limestone occurs at the horizon of the Sycamore. In a later publication Taff[3] describes the limestone as outcropping very near the base of the Carboniferous throughout the southern side of the Arbuckle uplift. It also occurs on the north side of the Arbuckle Mountains, and extends eastward into the central part of the uplift, almost to the granite. Near the extreme western end of the Arbuckle Mountains he gives the for-

1. Gould, Chas. N., Index to the Stratigraphy of Oklahoma: Oklahoma Geol. Survey Bull. 35, p. 23, 1925.
2. Taff, J. A., U. S. Geol. Survey, Geologic Atlas, Tishomingo Folio, (No. 98) p. 5, 1903.
3. Taff, J. A., U. S. Geol. Survey, Prof. Paper 31, pp. 13, 32, 33, and 48, 1904.

mation a thickness of nearly 200 feet, and near the central part of the Arbuckle uplift a thickness of about 50 feet, thinning eastward near the granite in the northeastern corner of T. 2 S., R. 3 E. Elsewhere in the uplift, towards the northeast, it is absent or represented by local thin siliceous limestone strata. At the top of the Devonian in the same report, the above writer describes the occurrence of the Sycamore in the Criner Hills as follows:

"The relation of the Pennsylvanian to the older rocks is essentially the same as in the Arbuckle Mountains as far as could be determined by a general survey. The Sycamore limestone and the Caney shale of the Mississippian occur infolded with older rocks and it seems evident that in this area as elsewhere in the Arbuckle Mountain region, active disturbances of the rocks did not occur until about mid-Carboniferous time."

The next man to do detailed work on the Sycamore was Geo. D. Morgan[4], who describes the formation in the Stonewall Quadrangle. The Sycamore limestone had not been previously recognized in the Stonewall Quadrangle until Morgan's work in that area. Its occurrence is now clearly established on the Lawrence uplift, where the outcrop is continuous, forming an excellent key horizon. Morgan also finds that the formation in this area has thinned greatly, averaging less than five feet in thickness. Its lithologic character is almost identical with that occurring in the main Arbuckle Mountain uplift. However, in contrast with other localities, the formation in the Stonewall Quadrangle contains a number of fossils, and Morgan's discovery of this fauna is the first recorded from the Sycamore limestone. Due to the similarity of the fauna beneath and above the Sycamore and the extreme thinning of the formation in that area, Morgan thinks that the deposition was continued from late Woodford throughout Sycamore and into early Caney times. The list of fossils collected by Morgan is as follows:

Menophyllum sp.
Polypora sp.
Productella n. sp.
Chonetes geniculatus
Ambocoelia levicula
Brachythyris n. sp. (?)
Brachythyris peculiaris
Martinia n. sp.
Composita buckleyi
Proetus (2 species)
Ostracoda (smooth)

4. Morgan, Geo. D., Geology of the Stonewall Quadrangle, Oklahoma; Bur. of Geology, Bull. 2, pp. 48-50, 1924.

This list was sent to Prof. Schuchert of Yale University who stated, in a personal communication to Mr. Morgan, that although guide forms were lacking, he is satisfied that the fauna is Kinderhook. In view of the Moorefield and Fayetteville-like fauna of adjacent portions of the Caney and Woodford formations, Prof. Schuchert's interpretation of the Sycamore fauna suggests a condition which is difficult to explain. That is, it appears that what might be normally considered as pre-Boone fauna is included in a formation which occurs between two other formations both of which carry a fauna which might be normally considered as post-Boone. Mr. Morgan, regardless of Prof. Schuchert's Kinderhook-like interpretation of the Sycamore fauna, concludes that: "* * * the formation together with the upper portion of the Woodford and the lower portion of the Caney, is partially equivalent to the Moorefield shale, the Batesville sandstone and the Fayetteville shale of Arkansas."

Other writers mentioning the Sycamore limestone in the literature are Reeds[5], Hutchison[6], Wallace[7], and Gould[8].

The following section of Paleozoic rocks in the Arbuckle Mountains shows the relation of the Sycamore limestone to other formations in that region:

Paleozoic Section in the Arbuckle Mountains

(After U. S. Geol. Survey)

		Feet
	?	
Mississippian	Caney shale	800-1600
	SYCAMORE LIMESTONE	0-200
	?	
Devonian	Woodford chert	600-650
	Bois d'Arc limestone	0-90
	Haragan shale	0-166
Silurian	Henryhouse shale	0-223
	Chimneyhill limestone	0-53
Ordovician	Sylvan shale	50-300
	Viola limestone	500-800
	Simpson formation	1200-2000
Cambrian	Arbuckle limestone	4000-8000
	Reagan sandstone	0-500
	Average total	10,866

5. Reeds, Chester A., A report on the Geological and Mineral Resources of the Arbuckle Mountains, Oklahoma: Okla. Geol. Survey, Bull. 3, p. 41, 1910.
6. Hutchison, L. L., Preliminary report on the Rock Asphalt, Asphaltite, Petroleum and Natural Gas in Oklahoma: Okla. Geol. Survey, Bull. 2, p. 15, 1911.
7. Wallace, B. Franklin, The Geology and Economic Value of the Wapanucka Limestone of Oklahoma: Okla. Geol. Survey, Bull. 23, pp. 28-29, 1915.
8. Gould, Chas. N., op. cit.

ACKNOWLEDGMENTS

The writer is indebted to Dr. Charles E. Decker of the University of Oklahoma, under whose supervision this work has been done. Whatever merit this article may have is due in a large measure to his interest and helpful criticism.

Dr. George H. Girty of the U. S. Geological Survey has kindly checked the fossils collected, and has given many helpful and pertinent suggestions concerning their identification.

The map accompanying this report is the compilation of of material published by the U. S. Geological Survey, the Oklahoma Geological Survey, and Morgan's report on the Geology of the Stonewall Quadrangle, which has been supplemented by field work done by the author.

LOCATION AND THICKNESS

The outcrops of the Sycamore limestone are found in parts of Pontotoc, Murray, Carter, Johnston, and Marshall counties. The principal areas are associated with the Arbuckle Mountain uplift, where the longest and most continuous outcrops flank the Arbuckle anticline (See map). The formation is brought to the surface by faulting at the Criner Hill uplift, T. 5 S., R. 1 E., in secs. 22 and 23, T. 1 S., R. 3 E., in sec. 4, T. 4 S., R. 5 E., and sec. 34, T. 2 S., R. 3 E. In Pontotoc County the formation is found in two outcrops, the first occurring in the southern part of T. 3 N., R. 6 E., extending southeast into the northeastern part of T. 2 N., R. 6 E.; the second from the center of T. 1 N., R. 7 E., to the southeast corner of the township ending in the northeast corner of sec. 1, T. 1 S., R. 7 E. This is the thinnest

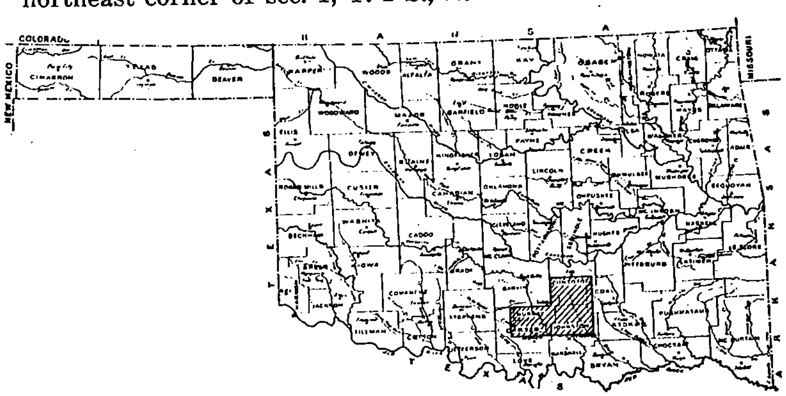


Figure 1. Map of Oklahoma, showing area covered by this report.

phase of the formation found, and is on the average less than five feet thick. However, fossils are abundant in these two exposures. In Murray County the formation borders the Washita River on the north, beginning in the NE. ¼ sec. 30, T. 2 S., R. 3 E., extending northwest bordering the northeast flank of Dougherty Basin, until it is lost in sec. 2, T. 1 S., R. 2 E. The thickness here is more than 100 feet. It is also found at the base of the slope of Vine's Dome, secs. 28, 33, and 34, T. 1 S., R. 2 E. Due to the fact that the Woodford-Sycamore contact could not be located at this place, the thickness is estimated at 140-150 feet. On the opposite flank of the basin on the southwest side of the river, it is found as a disconnected outcrop from the southeast corner of sec. 3, T. 2 S., R. 2 E., thence northwest to the west side of sec. 13, T. 1 S., R. 2 E., the formation is 140 feet thick.

Just southeast of Davis and northeast of Dougherty, there is a long sinuous outcrop, less than 50 feet thick and thinning eastward, beginning in sec. 2, T. 2 S., R. 3 E., extending northeast and ending in sec. 26, T. 1 S., R. 2 E. This outcrop is roughly the shape of a figure nine and occurs in the northwestern end of the Tishomingo anticline. North of this outcrop is found the small up-faulted portion mentioned above, which is exposed as a thin cherty limestone (T. 2 S., R. 3 E., northwest of Buckhorn). The formation enters Carter County in sec. 13, T. 3 S., R. 3 E., and extends northwest to sec. 4 of the same township, where it is concealed by Washita River sediment. It is again picked up in sec. 6 of the same township, and extends roughly westward through Tps. 2 and 3 S., and Rs. 2 E., 1 E. and 1 W., to the town of Woodford, where it again trends northwest and ends in sec. 12, T. 2 S., R. 2 W., where it is covered by Permian sediments. The formation is nearly 200 feet thick west of Woodford, thinning eastward until in the railroad cut it is 140-157 feet thick. In Johnston County the formation runs southeast from sec. 18, T. 3 S., R. 4 E., across the township and leaves the county in the southeast corner of sec. 36, and thence across secs. 5 and 6, T. 4 S., R. 5 E., ending just across the line of sec. 4, where it is terminated by a fault.

This long outcrop, which is continuous for nearly forty miles, forms a part of the southern limb of the Arbuckle anticline. It is not exposed on the northern limb of this anticline and it is thought the long fault immediately north of the outcrop in eastern Carter and western Johnston counties, has concealed the formation at this place. That this is probable, is shown by the fact that small patches of the Sycamore are brought up and exposed on the surface by branching faults off this main fault in sec. 4, T. 4 S., R. 5 E., and in secs. 33 and 34, T. 2 S., R. 3 E.

In the Crimer Hills area, T. 5 S., R. 1 E., the formation is exposed in secs. 10, 15, and 36. The exposures are here brought to the surface by a number of complex faults which are found in that region.

In northern Marshall County there occurs an inlier of Paleozoic sediments surrounded by Cretaceous rocks (Trinity sandstone). The older rocks are exposed in the Valley of Turkey Creek in sec. 3, T. 5 S., R. 4 E., and secs. 34 and 35, T. 4 S., R. 4 E. This inlier was first noted by Mr. C. W. Tomlinson[9] while working in that area. (See Fig. 2).

The following is a section of Sycamore limestone given in Mr. Tomlinson's paper:

Section of Sycamore Limestone, near Mannsville, Okla.

	Feet
Limestone, dense, drab, massive, blocky, very finely crystalline: in beds 2 inches to 1 foot thick, no fossils found	45
Concealed interval	35
Limestone, same as above	9
Concealed interval	3
Limestone, dense, drab, blocky, very finely crystalline, no fossils found	10
Shale, greenish, calcareous	2
Sandstone, white, calcareous, medium-coarse grained	1
	105

From the above section it would seem that the Sycamore is at least 100 feet thick at this place. The occurrence is on the south limb of the anticline as shown in Figure 2. As to the structure, Mr. Tomlinson states that in the northernmost outcrops there is a distinct semi-circular swing of the strike around the nose of an anticline which is plunging steeply to the southwest, so that the extreme north end of the Viola exposures the strike is due northeast. These pre-Pennsylvanian outcrops on Turkey Creek occur exactly in the trend of a plunging anticline exposed in the Pennsylvanian rocks (Glenn formation) four or five miles to the northwest.

DESCRIPTION OF STATIONS

Station No. 1. N. ½, NE. ¼, sec. 30, T. 1 S., R. 2 E. Location near Davis farm where road crosses creek. Thickness 140

9. Tomlinson, C. W., Buried Hills near Mannsville, Oklahoma: Bull. Am. Assn. Pet. Geol. Vol. 10, p. 139, 1926.

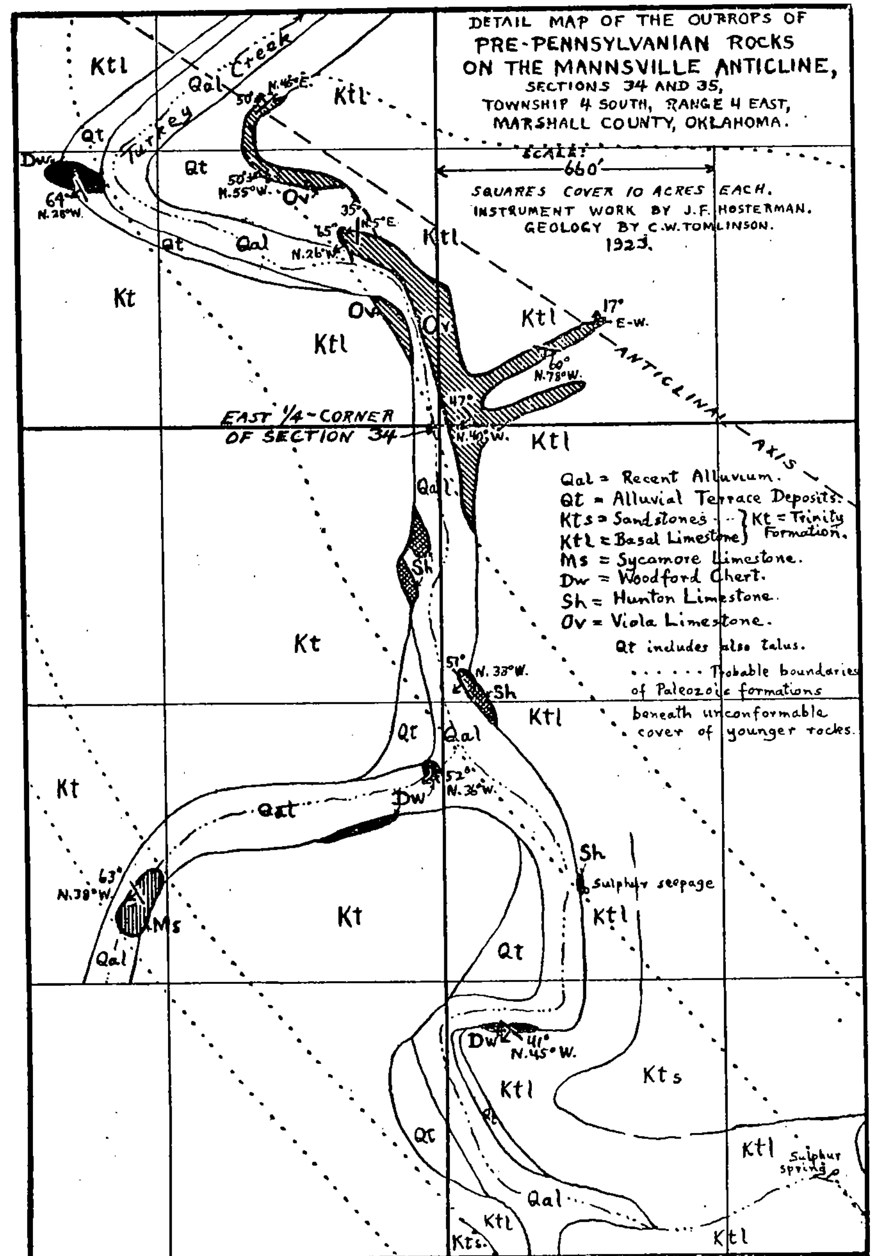


Figure 2. Pre-Pennsylvanian rocks on the Mansville anticline. (Courtesy Am. Assoc. Pet. Geol., Geology by C. W. Tomlinson)

feet. Dip vertical. Strike approximately N. 45° W. Rock massive, weathered to a dull yellow. Contact at bottom found with Woodford chert member, but no contact found at the top due to the weathering of the Caney shale. Uppermost beds exposed in the creek probably indicate where the overlying Caney shale comes in. The formation is much fractured, breaking into rectangular blocks. In places the fractures are filled with veins of calcite, which seems to be concentrated along particular beds, where the limestone was pulled apart by tensional stress at the time of the folding. The formation appears to be uniform throughout, except in a few places which are thinly stratified, indicating a higher amount of clayey material than is found in other places. The formation is overlain locally by one of the latest beds of Franks conglomerate which makes a contact with the older formations below it that is an uneven, approximately horizontal surface. The conglomerate consists mainly of limestone boulders ranging up to two feet in diameter, with numerous boulders of Colbert porphyry of the East Timbered Hills. The porphyry boulders in the conglomerate show that the overlying conglomerate was not deposited until the porphyry deposit was exposed to erosion at the end of Pennsylvanian or the beginning of Permian time. Samples were taken at about 10 foot intervals from the base upward.

Station No. 2. Near center of NE. ¼, sec. 12, T. 2 S., R. 2 E. The Caney shale is found along the bed of a small creek at the east end of Main Street of Dougherty. On following the bed of the creek northeast some 200 feet, the Sycamore is encountered in the stream bed and on the hillside to the right and left of the stream. The thickness is estimated at 140-150 feet, with the strike almost northwest-southeast. Dip 40 to 45 degrees to the southwest and the hill is a dip slope. On going up the hill the contact is found between the Caney and the Sycamore just beyond a small bridge over the stream gully. On continuing up the slope the Sycamore is covered by stream deposits, but is found again outcropping about 200 feet from where it is first concealed. The rock is broken up by the characteristic block fracture, and in places the individual blocks project above adjacent blocks which have been removed by erosion, forming a distinct ridges in the stream bed. The distinctive yellow color due to weathering can especially be noted in the stream bed, but on either side the limestone is covered with moss or other growths which give the rock a dirty brown or gray appearance. Calcite veins filling the fractures are not present in this section as in Station No. 1. The formation is very uniform throughout, except for the presence of a fossil lens, being a hard, even, massive rock, very tenaceous, and breaking with a characteristic conchoidal fracture. On following up the dip, a shale is encountered about the 120-130 feet horizon which is about 20 feet in thickness. The contact with the Woodford chert is not found, but the chert forms the top of the ridge, of which the Sycamore forms the southwestern slope.

Station No. 3. NW. ¼ sec. 2, T. 2 S., R. 2 E., along Davis-Dougherty road which runs on east side of river, at point where road branches to Vine's Dome. Sycamore found along bed of creek west of road and on hillside of the road where it is in contact with the Woodford chert. Along the creek there is a gap or offset in the formation which is probably due to a fault. The beds have a different attitude on each side of the gap. Dip 50° west, strike N. 10° E. Fossils were collected at the foot of the east slope of the ridge at what should be near the bottom of the formation near the contact with the Woodford.

Station No. 4. NE. ¼, sec. 6, T. 3 S., R. 3 E. Formation exposed in railroad cut south of bridge across the Washita River, south of Crusher. Dip 60° southwest, strike N. 30° E. Heavy bedded, except for two partings of shale. The upper bed of shale may be Caney, lower one 15 feet thick and is six feet from the top. One small shale parting three inches thick is found about 70 feet from the top of the formation. The shale parting is composed of alternating layers of black and gray shales. The Sycamore is 157 feet thick at this place, including 140 feet of limestone and 17 feet of shale.

Station No. 5. SW. ¼, sec. 25, T. 2 S., R. 1 W. Section taken 500 yards east of the road running north from the town of Woodford. The Sycamore here forms a prominent ridge running east and west, and consists of alternating layers of massive, blue to brown limestone and brown limy shale. The broad band of shale at Crusher is absent here, but the formation as a whole is much more shaly than has been noted elsewhere. Sampling was started at the base, or as near the base as could be determined (the contact with the Caney shale could not be found) and taken at equal intervals to the top. Two parallel ridges are formed by the Sycamore (on the south) and the Bois d'Arc limestone (on the north), separated by a valley of Woodford chert. The shale phase which forms a valley where the formation is crossed by Cool Creek in NW. ¼, sec. 1, T. 2 S., R. 2 E., is not present at this place.

Station No. 6. SE. ¼, SE. ¼, sec. 18, T. 3 S., R. 4 E. North of the old town of Sylvan, Johnston County, on the north side of road crossing Oil Creek. The Sycamore is almost vertical at this place. The large oil spring, located at this place is in the middle of the Sycamore. Contacts with the Woodford and Caney were found. Shale parting present, about six feet in thickness, about the middle of the formation, and just below the large oil spring.

LITHOLOGY

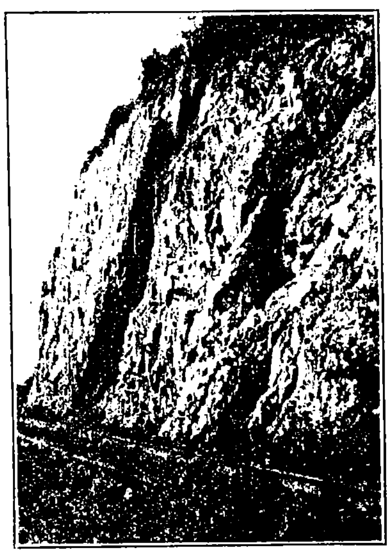
MEGASCOPIC

The Sycamore limestone has a number of characteristics by which it is easily recognized wherever it occurs. In different places the formation varies considerably in thickness, but it possesses to such a remarkable degree its uniformity of color, texture, jointing and method of weathering, that it makes an excellent key horizon.

The limestone on fresh fracture varies from a distinct slate-blue color to a dirty bluish-brown. On weathering this color changes to a characteristic light brownish-yellow hue, due to the presence of small amounts of iron.

The Sycamore limestone has a dense, even texture, is exceedingly tough, and so hard that often it breaks with a distinct conchoidal fracture. A fresh fractured surface is harsh to the feel, and does not have the flint-like appearance of limestones that are more pure.

PLATE I.



A TYPICAL EXPOSURE OF SYCAMORE LIMESTONE.

The bedding of the formation causes the rock to separate into very distinct layers six inches to two feet, more or less, in thickness. In places, notably east and west of Station No. 4, south of Crusher, and at Station No. 2, east of Dougherty, there is a distinct shale parting 6 to 20 feet in thickness, almost in the center of the limestone. At Crusher this shale is an alternating bluish-black and gray shale, somewhat fissile, separated into thin sheets. This shale is soft and weathers easily, as evidenced by a small valley where Cool Creek crosses the formation west of Station No. 4. West toward Woodford in northeastern Carter County, this shale parting is absent, so this shale is a lenticular mass occurring within the formation. Just north of Woodford there are a number of horizons in the Sycamore where the formation is apparently a very shaly lime. However, the shale is not present as a distinct member, as in the occurrences farther east, but is included with the layers of the hard, bluish limestone, which is characteristic of the other exposures. In other words, in this special area the limestone itself has graded into a rock that seems to be for the most part a limy shale.

In the Stonewall quadrangle the formation does not reach nearly the thickness found in other exposures. In this area it has been observed to have a thickness of not more than five feet, with a probable average of about two feet. In comparing this thickness with other exposures it might be suspected that the lithologic character of this outcrop would be entirely different; but the formation here is still a hard, tough, slate-blue limestone, weathering to the characteristic bright yellow hue.

At Station No. 6 on Oil Creek, the shale parting near the center of the formation is extremely gritty, thinner (6 feet thick) and somewhat harder and consequently more resistant than the other occurrences noted. At this place a large oil spring, from which the creek is named, is located at the top of this shale parting.

At Station No. 2, east of Dougherty, the shale near the center of the limestone is very bluish in color and extremely fissile, giving it the appearance characteristic of much of the Caney shales. The shale at this place reaches a thickness of 20 feet.

The formation is broken by two sets of joints and a primary plane of parting along the bedding plane which separates the limestone into layers, 18 inches more or less in thickness. The two sets of secondary joints are at right angles to each other, one normal to the bedding and the other at an angle to the bedding.

Approximate Chemical Analysis of the Sycamore Limestone[10]

	Percent 114	Percent 115
SiO_2	40.85	39.03
Al_2O_3	3.48	3.48
Fe_2O_3	0.43	0.19
FeO	0.74	1.01
MgO	1.02	1.15
CaO	20.09	28.92
H_2O	0.23	0.25
TiO	0.266	0.266
CO_2	23.89	24.40
MnO	0.01	0.01
	99.006	98.716

Note: No. 114, 65 feet thick above shale parting, one and one half miles south of Crusher, south of railroad bridge over Washita River, in NW. ¼, sec. 6, T. 3 S., R. 3 E., in Carter County. Alkalies not determined.

No. 115, same as 114, except the limestone is 56 feet thick and lies below shale parting. Alkalies not determined.

Mineral Content Calculated from Chemical Analysis

	Percent 114	Percent 115
Quartz	26.760	34.930
Kaolin	7.570	7.590
Calcite	47.420	48.550
Dolomite	6.010	6.780
Iron Oxides	1.170	1.200
Rutile	0.266	0.266
	99.196	99.316

The above table shows the minerals making up the Sycamore as calculated from Shead's analyses. The striking feature brought out is the large amount of quartz contained in the formation. That a limestone, appearing quite pure on casual examination, should contain almost 45 per cent quartz and clay, is very unusual. Because of this, a number of thin sections and heavy mineral determinations have been made, the results of which are discussed in the following paragraphs.

HEAVY MINERAL DETERMINATIONS

The sixteen samples secured at Station No. 1 on Honey Creek have been used in the heavy mineral determinations because the formation as exposed at that point represents a typical exposure of the Sycamore. As already mentioned in the description of stations, samples were taken at equal intervals from the bottom to the top of the formation. These samples were crushed in a mechanical crusher almost to a fine powder. Weighed samples of 200 grams each were digested

10. Shead, A. C., Physical and Chemical Analyses of Oklahoma Mineral Raw Material. Unpublished manuscript.

with hydrochloric acid which removed all of the calcium carbonate. The samples were then washed free from acid and shale, leaving the sand and heavy minerals remaining, which, after drying, were again weighed. The results of this second weighing show a sand and heavy mineral content ranging from 3.6 to 21.0 per cent, with a total average of 12.6 per cent. There is no regular variation in the percentage, sample No. 8 being the highest and No. 16 the lowest in the amount of sand.

After the second weighing a small amount of the dry sample was treated for its heavy mineral content. The heavy liquid used for the separation was bromoform (sp. gr. 2.8), which floats such minerals as quartz and feldspar, and allows the heavy minerals such as magnetite, zircon, rutile, garnet, etc., to sink. The apparatus used is shown in Figure 3. The procedure is as follows:

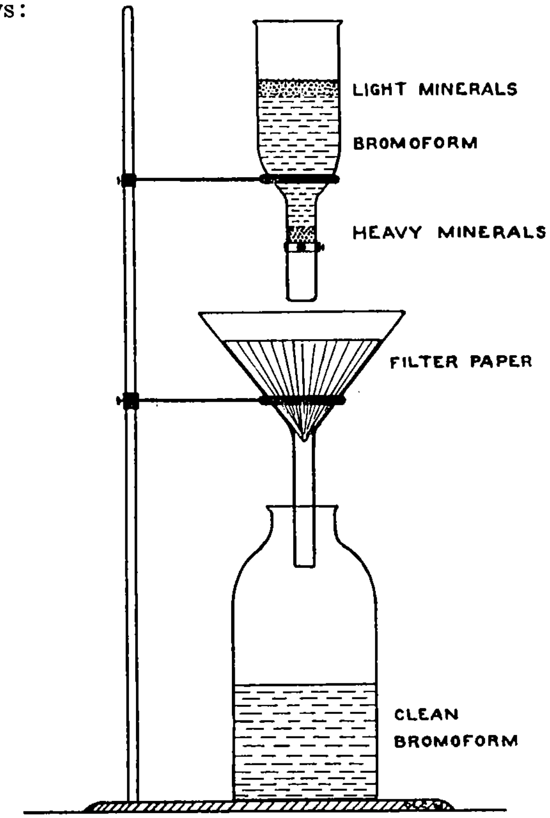


Figure 3. Apparatus used in heavy mineral determinations.

The bromoform is poured into the upper vessel as carefully as possible to eliminate the formation of vertical currents which will carry the light as well as the heavy minerals to the bottom. The sample to be treated is then sprinkled lightly on the top of the bromoform, and the minerals having a higher specific gravity than the liquid will sink to the bottom. It is sometimes necessary to agitate the layer of light minerals which accumulates at the top of the liquid so that the heavier minerals will have a chance to fall to the bottom of the vessel. As soon as the separation is complete the heavy minerals may be drawn off through the pet cock into the filter paper in the funnel below, and the bromoform caught in the bottle below the funnel is then ready for use in another determination. An empty bottle is then substituted for the bromoform bottle and the minerals on the filter paper are then washed with benzol to cleanse the material and save the bromoform. These washings should be kept in a bottle used only for this purpose, so that the dissolved bromoform can later be recovered by fractional distillation.

The washed minerals and the filter paper are then placed in a drying oven and when dry are ready for mounting on slides for study under the microscope. The light minerals remaining in the upper vessel are then drawn off onto a second filter paper which has been placed in the funnel. They are washed with benzol in the same manner as the heavy crop, and, if they are to be studied, placed in the drying oven.

If it is not desired to keep the heavy mineral grains for future study, it is not necessary to make a permanent mounting. If future use of the grains is necessary, it is recommended that they be mounted on a glass slide in Canada Balsam.

Using the mineral content calculated from an ultimate analysis of the Sycamore as given on page 16, the limestone shows that the general composition is:

	Per cent
Sand (quartz—heavy minerals)	12.6
Shale	30.7
Limestone (calcite and dolomite)	54.4
Iron oxides	1.2
	98.9

In the above table it is probable that the percentage of sand is low and that of shale is high because of the fineness to which the sample was ground, which broke up some of the quartz fragments to such a degree that they were washed out of the sample with the acid and shaly material.

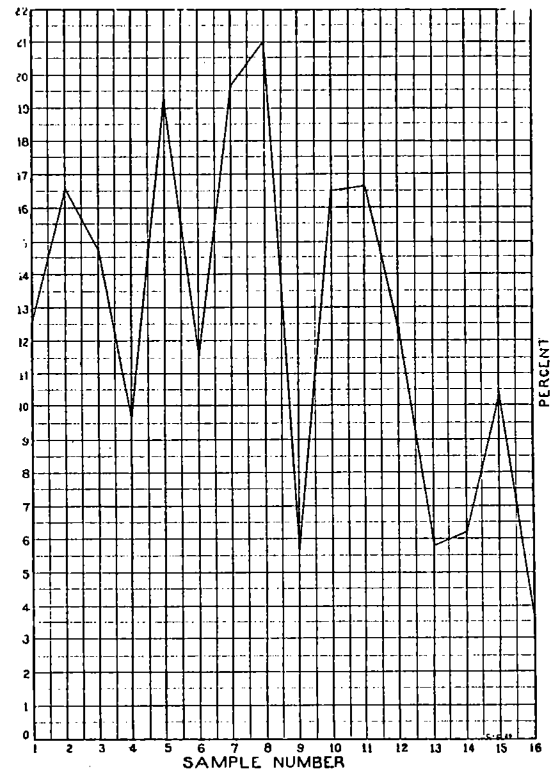


Figure 4. Graph of heavy mineral content.

PALEONTOLOGY

In all there are four horizons in the Sycamore limestone that are found to be fossiliferous, two of which were found by the author. Morgan's collection, described in his report on the Geology of the Stonewall Quadrangle, was made in the east-central part of sec. 11, T. 2 N., R. 6 E., and a small collection made by Boone Jones while a student at the University of Oklahoma was obtained near the town of Franks. The writer's specimens were collected from Station No. 2, NE. ¼ sec. 12, T. 2 S., R. 2 E., and Station No. 3, NW. ¼ sec. 2, T. 2 S., R. 2 E. Only those forms that have never been described in the literature as occurring in the Sycamore will be described in this report, and will include Mr. Jones' collection as well as the author's.

Fossils in the Sycamore Limestone

	Collec-tor*	STATION†			
		A	B	2	3
Porifera					
Sponge Spicules			X	X	X
Corals					
Menophyllum sp.	M	X			
Crinoidea					
Stems, several species	A			X	X
Bryozoa					
Fenestella sp.	A			X	
Polypora sp.	M	X			
Brachiopoda					
Composita buckleyi	M	X			
Lingula aff. gorbyi	A				X
Lingulodiscina newberryi	U		X		
Chonetes aff. laevis	A			X	
C. geniculatus	M	X			
Productella n. sp.	M	X			
P. pyxidata	A			X	X
Pustula planiconvexa (?) may be n. sp.	A			X	
Ambocoelia laevicula	M	X			
Martinia n. sp.	M	X			
Pelecypoda					
Caneyella sp.	U		X		
Cephalopoda					
Brachythyris n. sp.	M	X			
B. peculiaris	M	X			
Adelphoceras meslerianum	U		X		
Orthoceras wapanuckense	U		X		
Goniatites choctawensis	UA		X		X
Goniatites aff. choctawensis n. sp. (?)	A		X		X
Trilobita					
Proetus 2 sp.	M	X			
Ostracoda					
Ostracoda smooth	M	X			

*COLLECTOR

M—Morgan, Geo. D., Bur. of Geol. Bull. 2, 1924.

U—Univ. of Okla. coll. made by Boone Jones.

A—Author's collection.

†STATION

A—East-central sec. 11, T. 2 N., R 6 E.

B—Near town of Franks.

2—NE. ¼ sec. 12, T. 2 S., R. 2 E.

3—NW. ¼ sec. 2, T. 2 S., R. 2 E.

DESCRIPTION OF SPECIES

PORIFERA

A number of sponge spicules collected from several localities.

CRINOIDEA

A number of unidentified stems found in several localities.

BRYOZOA

Fenestella sp.

Several small fragments collected from Station 2, with mesh much coarser than *F. tenax*.

BRACHIOPODA

Productella pyxidata[11]

Width greater than length. Hinge line shorter than greatest width of shell. Pedicle valve somewhat flattened and slightly recurved at the cardinal extremities; umbo narrow. Surface of both valves marked with lamellose growth lines; spine-bearing radiating ridges at times present on pedicle valve.

Kinderhook of Illinois and Missouri.

CEPHALOPODA

Adelphoceras meslerianum[12]

Shell small, discoidal, the largest specimen seen having a diameter of 21 mm. and a thickness of 8 mm. When mature the cross section of the whorls is very high and helmet shaped, deeply embracing, so as to largely inclose the preceeding volution and leave a narrow though deep umbilicus. The sculpture of the mature portion consists of rather fine, regular transverse striae, separated by delicate though strong folds. These are well defined toward the umbilicus, but die out over the venter or become very faint. The direction of these lines is sinuous—concave over the ventral portion, then convex, with another reentrant curve half way towards the umbilicus. The venter, which is almost free from transverse costae, is crossed by extremely fine, delicate revolving striae, so faint that they might be readily overlooked even with a moderately strong lens. These revolving striae are continued laterally until they become implicated with the transverse wrinkles or plications, to which, however, they are very subordinate, and they may continue quite to the umbilicus. The constrictions are usually deep and occur a quadrant apart. They follow the course of the plications in the main, but are strong over the ventral region, where they show a deep sinus. The sutures are those of *Glyphioceras* and *Gastrioceras*.

11. North American Index Fossils, Vol. 1, p. 242.
12. Girty, George H., U. S. Geol. Survey, Bull. 377, p. 66, pl. XII, figs. 1-3c, 1909.

Orthoceras wapanuckense[13]

Shell rather small, long and very gradually tapering. The type specimen has a length of 52 mm. with a diameter above of 5½ mm. and below of 4 mm. The section is circular and the siphuncle central. The septa are moderately far apart, the interseptal distance to any point being to the diameter as 1 is to 1½, varying almost to the ratio of 1 to 2 in young specimens. The largest specimen observed has a diameter of 12 mm. The surface is apparently entirely smooth.

Goniatites choctawensis[14]

Shell is discoidal, broadly and strongly rounded on the abdomen, and flattened laterally, inner volutions entirely concealed by the outer ones; umbilicus small, it's diameter scarcely equal to one-sixth the breadth of the volution; transverse diameter of the volution about equal to the breadth from the dorsal to the ventral side; aperture lunate, much wider than high; surface marked with fine distinct revolving lines, less than the width of the intervals in between, crossed by extremely fine, crowded transverse striae. Septa having but one lateral lobe, on either side; dorsal (ventral) lobe wide as long, divided into two lanceolate branches as an accessory saddle, which is tranuncated and bifid at tip and extends almost to the middle of the lobe; dorsal (ventral) saddle of the same form, but wider and double the length of the branches of the dorsal (ventral) lobe; superior lateral lobe wider than the dorsal (ventral) saddle, and contracted at extremity to an acute point.

Lower Carboniferous, St. Louis-Chester stage (?), Bend formation, Oklahoma.

CONCLUSIONS

The Sycamore formation is a lenticular mass of siliceous limestone occurring above the Woodford chert and below the Caney shale in the area of the Arbuckle Mountain uplift. It varies in thickness from 200 feet at its most western exposure in sec. 12, T. 2 S., R. 2 W., west of the town of Woodford, to less than five feet in thickness in the Stonewall Quadrangle in the eastern part of the mountains. The formation without exception thins everywhere to the east, and is not found east of the exposures mapped in the Stonewall Quadrangle by Morgan. In a number of places, notably on the southern limb of the Arbuckle anticline and on the eastern edge of the Dougherty basin, there is found a distinct shale parting near the middle of the formation. This is well shown in Plate II. This shale is black to gray

13. Girty, George H., U. S. Geol. Survey, Bull. 377, p. 44, pl. VI, figs. 11, 12, 1909.
14. Smith, James P., U. S. Geol. Survey, Mon. XLII, p. 67, 1903.

PLATE II.

SHALE PARTING IN THE SYCAMORE LIMESTONE.

in color and in places somewhat fissile in character, with pyrite the dominant heavy mineral, almost to the exclusion of all others of the heavy mineral group. The shale is a lenticular mass as shown by the absence of this feature in the exposure at Woodford and on the western limb of the Dougherty basin where the formation is crossed by Honey Creek.

With the exception of magnetite, the character of the heavy minerals present shows that the sediments which formed the Sycamore came very largely from acidic or intermediate igneous rocks, but whether they came directly from these primary rocks is a matter of conjecture, as some of the samples show distinctly rounded specimens of quartz, magnetite, rutile, and zircon.

Anderson[15] is of the opinion that, "sand grains approaching spherical shape may be of considerable age. No such grains should be regarded as having been derived from their primary source, the igneous rocks, during the present cycle of erosion."

15. Anderson, G. E., Experiments on the rate of wear of sand grains: Jour. of Geol., Vol. XXXIV, No. 2, 1926.

In the light of Dr. Anderson's experiments it is evident that the Sycamore is the result of the deposition of material derived from the erosion of an old sedimentary land mass. It is possible that these sediments came from the rocks which once covered the Arbuckle and Wichita Mountains, and which have since been more or less removed and the granite cores exposed. It seems more probable that the source of the sediments is to be found to the west, from the fact that the Sycamore and Caney formations very decidedly thin to the east.

While it is evident that the data seems to place the Sycamore and Caney at a lower level, paleogeographic maps by Schuchert[16] show that the area in which the above formations are found, was covered by epeiric seas throughout Tennessian time, so it would be possible for the Sycamore limestone and the Caney shale to represent the St. Louis stage in this sea, during which sedimentation was quite active as evidenced by the shale parting and the relatively large amount of sand and heavy minerals found in the Sycamore and the large number of sandy and limy lenses found in the Caney, especially the lower part.

After considering all the evidence that is contained in the literature and the writer's observations in the field, it appears that the Sycamore limestone is the result of continuous deposition which occurred throughout upper Woodford, through Sycamore and into Caney time, or in other words, that the deposition was continuous through the upper Devonian and into Mississippian time. Perhaps this statement should be explained since it apparently leaves the lower Mississippian out of consideration. Taff[17] states that the upper part of the Woodford doubtless includes strata corresponding in age with the formations of northern Arkansas and Tennessee, which are believed to be of Kinderhook age, or earliest Carboniferous.

Girty[18] recognizes the fact that, "the Woodford, where the Sycamore is absent, appears to graduate into the overlaying Caney * * * * * and that the Woodford and Caney might be regarded as a local or regional modification of the Caney deposition. As there are few species of invertebrates upon which, if occurring in similar conditions, one would place absolute reliance. it does not seem to me that the Devonian age of the lower Woodford is beyond the reach of future revisions. * * * * * the Woodford and the Caney appear from lithologic and stratigraphic evidence to present continuous sedimentation. The typical Woodford has thus far furnished very little in the way of organic

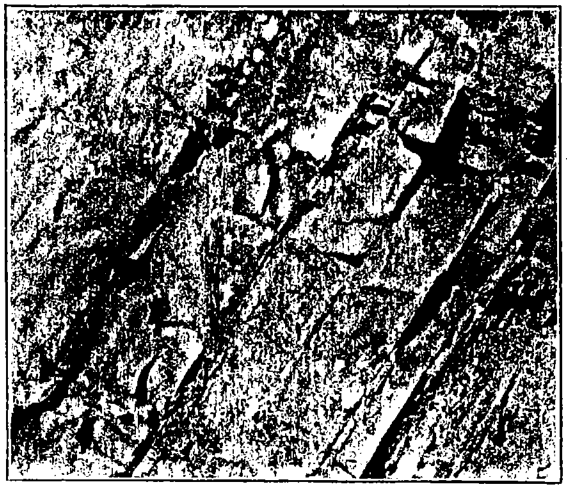
16. Schuchert, Charles. Text-book of Geology. Part II, Revised edition, 1925.
17. Taff, J. A., U. S. Geol. Survey, Prof. Paper 31, p. 33, 1904.
18. Girty, George H., U. S. Geol. Survey, Bull. 377, pp. 5-7, 10-11 and 13, 1909.

remains, but such little as we possess does not tend to ally it with the Caney." Morgan[19] finds that, "the general lithologic similarity of the two formations (Caney and Woodford) is so close as to make it quite difficult to distinguish between them where only this criterion is used. * * * * * The fauna of the upper part of the formation contains a number of species common to the Moorefield, Batesville and Fayettville formations of Arkansas, and together with the overlying Sycamore limestone and the lower part of the subsequent Caney formation, is thought to be at least partially equivalent to the Arkansas formations." Although the base of the Woodford rests uncomfortably on the underlying Hunton terrane, there is no observable break within the formation. Gould[20] summarizes the present opinion on the age of the Woodford as follows: "The Woodford has usually been considered upper Devonian. It correlates with the Chattanooga shale of Oklahoma, Arkansas and Tennessee, and since the age of this shale is in question, being assigned by some geologists to the Carboniferous and by others to the Devonian, the Woodford is here doubtfully assigned to the Devonian."

The above quotations of earlier writers agree wholly on the point that there is no break of sufficient magnitude between the Woodford and the Sycamore to represent a time of no deposition during lower Mississippian. Some, especially Morgan, thinks that the faunal evidence tends to show that a part of the Woodford is basal Carboniferous. The Woodford chert is distinctly marine in lithologic character, although as might be expected, the fauna is very scarce. Both the Caney and the Sycamore carry a distinctly marine fauna, which is so nearly alike, that the Sycamore may be said to be an early phase of the Mississippian sea in which the Caney was deposited. The exact age of the Caney has not been satisfactorily determined, nor has the age of the Moorefield shale, with which the Syamore closely agrees in terms of fauna and time. At present Dr. Girty (in a personal communication) is of the opinion that the Moorefield shale is about St. Louis in age, but that the evidence is still incomplete and uncertain. Which all means that there is a great need for further exhaustive study and careful collecting in the very few localities of the Sycamore that are found to be fossiliferous. It is hoped that the material thus obtained may contain some diagnostic forms which will help to determine the age of the over and underlying formations, as well as the Sycamore.

19. Morgan, Geo. D., Bur. of Geol., Bull. 2, pp. 44, 46, 1926.
20. Gould, Chas. N., Okla. Geol. Survey, Bull. 35, p. 22, 1925.

PLATE III.



CLOSE VIEW SHOWING BEDDING AND JOINTING PLANES.

PHOTOMICROGRAPHS OF MINERAL GRAINS

Explanation of Plate IV

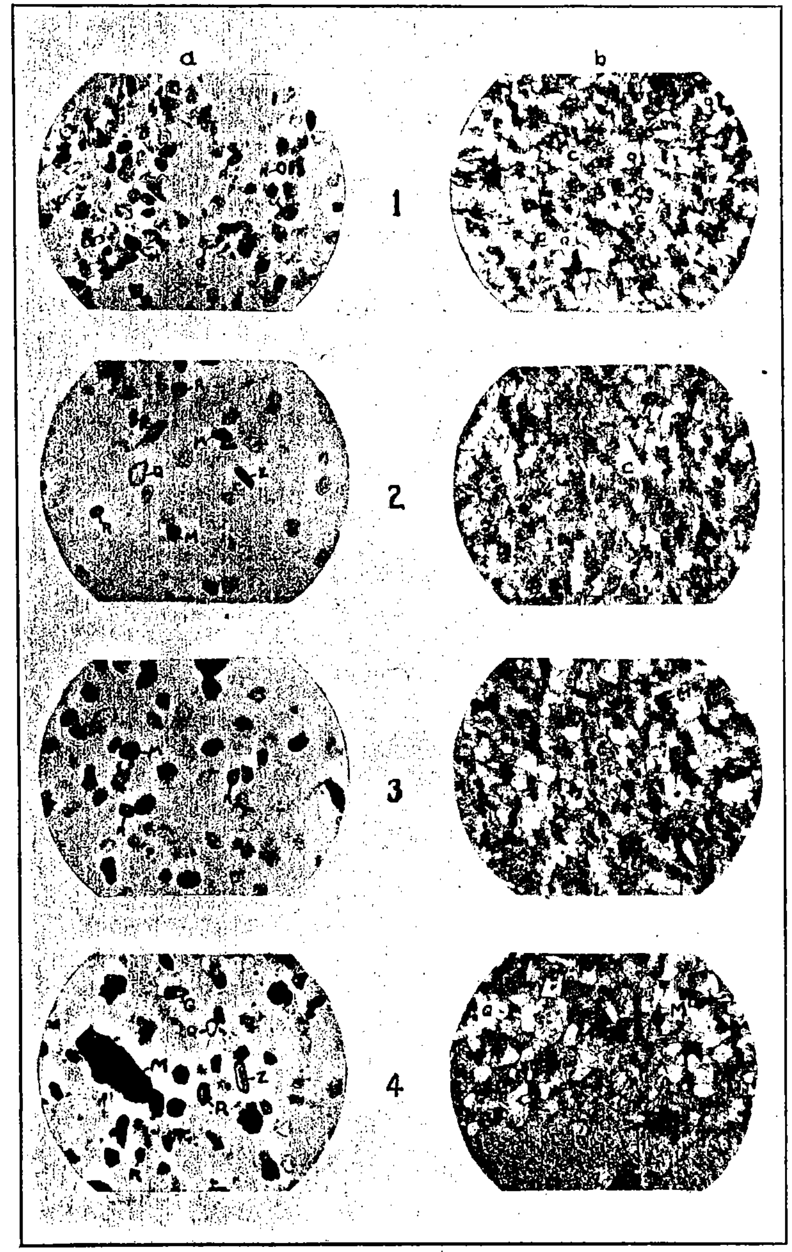
R—Rutile	Q—Quartz
M—Magnetite	C—Calcite
Z—Zircon	G—Garnet

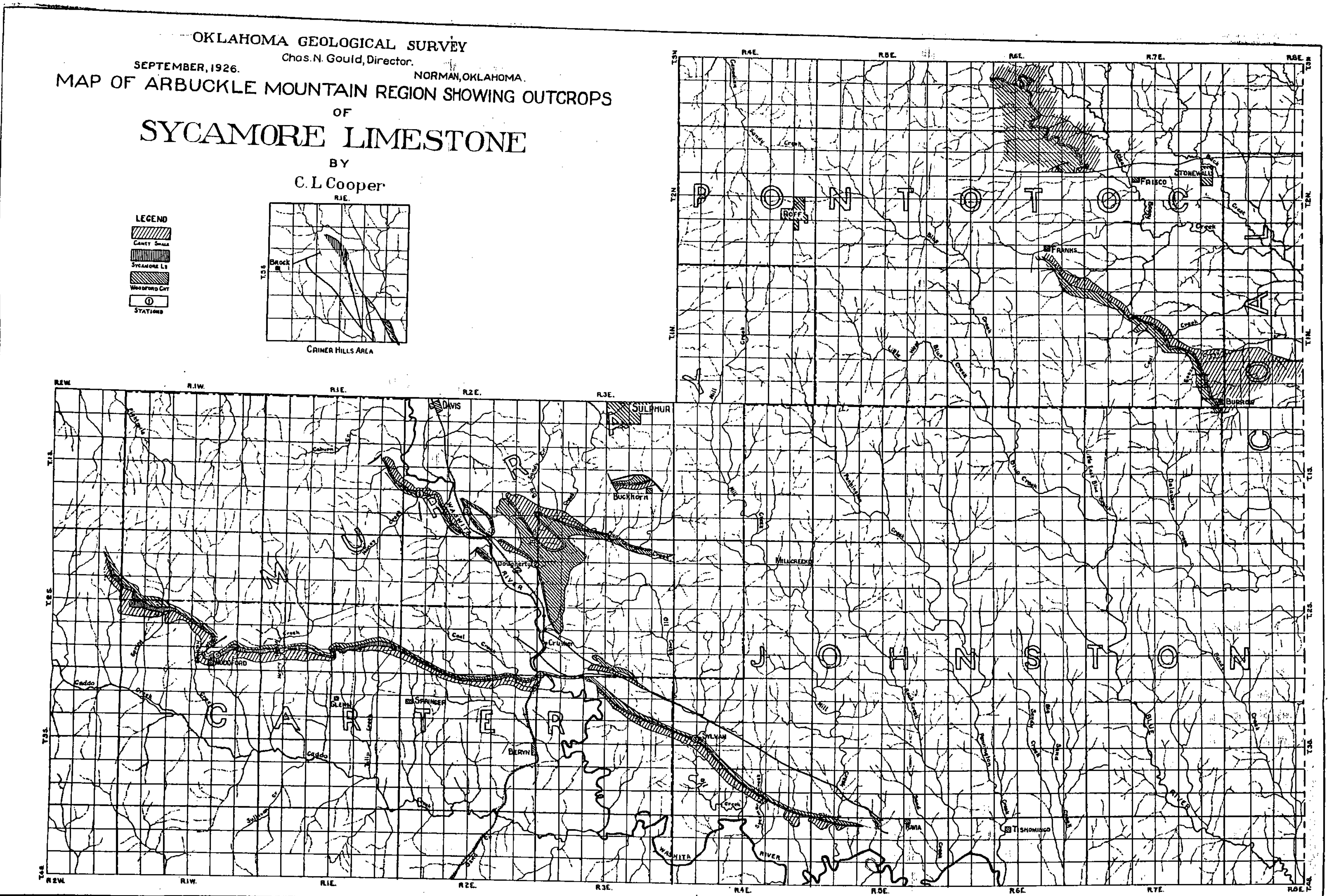
a—Photomicrographs of heavy mineral grains

b—Photomicrographs of thin sections

1—Specimen No. 2	3—Specimen No. 14
2—Specimen No. 3	4—Specimen No. 15

PLATE IV.




OKLAHOMA GEOLOGICAL SURVEY
Chas. N. Gould, Director.
SEPTEMBER, 1926.
NORMAN, OKLAHOMA.
MAP OF ARBUCKLE MOUNTAIN REGION SHOWING OUTCROPS
OF
SYCAMORE LIMESTONE
BY
C. L. Cooper
LEGEND
CANEY SHALE
SYCAMORE LS.
WOODFORD CHT.
STATIONS
CRINER HILLS AREA
Brock
PONTOTOC
JOHNSTON
CARTER
MURRAY
DAVIS
SULPHUR
Buckhorn
ROFF
FRISCO
STONEWALL
FRANKS
Dougherty
Crusher
WOODFORD
GLENN
SPRINGER
BERWYN
SYLVAN
MILLCREEK
RAVIA
TISHOMINGO
WASHITA RIVER
R.2W.
R.1W.
R.1E.
R.2E.
R.3E.
R.4E.
R.5E.
R.6E.
R.7E.
R.8E.
T.3N.
T.2N.
T.1N.
T.1S.
T.2S.
T.3S.
T.4S.