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Correlation of Paleozoic Rocks from Coal County, Oklahoma, to Sebastian County, Arkansas

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CONTENTS

ILLUSTRATIONS

TABLE

CORRELATION OF PALEOZOIC ROCKS FROM COAL COUNTY, OKLAHOMA, TO SEBASTIAN COUNTY, ARKANSAS*

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ABSTRACT

The Arkoma basin is an arcuate tectonic element that extends from the Arbuckle Mountains in south-central Oklahoma northeastward and then eastward across Oklahoma and Arkansas. The Paleozoic rocks east of the basin are overlapped by rocks of post-Paleozoic age in the region of Little Rock, Arkansas. In Arkansas, the basin lies between the relatively positive areas of the Ozark uplift on the north and the Ouachita Mountains on the south. The Oklahoma part of the basin is commonly referred to as the McAlester basin. It is bounded on the northeast by the southwestern part of the Ozark uplift, on the northwest by the Northeast Oklahoma platform, on the southwest by the Arbuckle Mountains and on the south by the Ouachita Mountains.

Logs of 17 selected wells along a line from western Coal County, Oklahoma, northeastward to western Sebastian County in western Arkansas show correlation of subsurface rock units in the McAlester basin with surface units of the Arbuckle Mountains of Oklahoma and the Ozark uplift of northeastern Oklahoma and northern Arkansas.

The 17 wells from which samples were examined for this report include rocks that range from Pennsylvanian to Ordovician in age. Four formations of the Des Moines Supergroup, including one of the Marmaton Group and three of the Cabaniss Group, are found only along the northwestern side of the McAlester basin and were encountered in six of the well sections. The four formations of the Krebs Group (basal group of the Des Moines Supergroup) crop out in the McAlester basin and can be correlated in the subsurface. The Atoka Formation (Atoka Group) crops out in the basin and is present in all sections. Rocks of the Morrow Group of northwestern Arkansas and northeastern Oklahoma are correlated with the Wapanucka Limestone and the upper part of the Springer Formation of the Arbuckle Mountain area. The Caney Shale of Chesterian and Meramecian age in the southwest is equivalent to four formations in the Ozark uplift in northeastern Oklahoma. The Boone Formation and the Welden (?) Limestone of Mississippian age are locally present in separate areas. The Woodford Shale (Mississippian and Devonian) is equivalent to the Chattanooga Shale. The Sallisaw Formation, of Devonian age, is present in northeastern Oklahoma and its equivalent, the Penters Chert, is present in western Arkansas; equivalent rocks are absent in the Arbuckle Mountains. The Hunton Group (Devonian and Silurian) includes five formations in the Ar-

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buckle Mountains. One formation of Silurian age is present in the Ozark region in northeastern Oklahoma. Two of the three formations of post-Simpson Ordovician age in the Arbuckle Mountains are present in the subsurface in eastern Oklahoma and northwestern Arkansas. Four formations of the Simpson Group of Ordovician age are present in wells at the west end of the cross section; only one of these formations is present in the outcrop in northeastern Oklahoma. The Arbuckle Group of Ordovician and Cambrian age underlies the Simpson Group. Most deep stratigraphic-test wells are discontinued when the Arbuckle Group is reached, so it is impossible to correlate in the subsurface the formations of the Arbuckle Group in the Arbuckle Mountains with possible equivalents in the Ozark uplift.

INTRODUCTION

Purpose and Scope of the Report

In the fall of 1954 the U. S. Geological Survey initiated a subsurface study designed to aid in the search for gas and oil in the Oklahoma part of the Arkoma basin. This report presents data concerning the extent and lithology of the Paleozoic rock units present in the subsurface in part of the basin and the correlation of these rock units with formations that crop out in the Arbuckle Mountains of south-central Oklahoma and the Ozark uplift of northeastern Oklahoma and northern Arkansas.

Regional Structure

The Arkoma basin is an arcuate tectonic element which extends from south-central Oklahoma to east-central Arkansas (fig. 1). From the northeastern end of the Arbuckle Mountains in south-central Oklahoma, the basin trends northeastward into the area of Pittsburg and McIntosh Counties, Oklahoma (pl. I, index map). In this area the axis of the basin turns eastward, and extends across eastern Oklahoma and across Arkansas to east-central Arkansas where Paleozoic rocks are overlapped by rocks of Cretaceous and later age. The Oklahoma part of the Arkoma basin and the part discussed in this report is generally called the McAlester basin.

The areas that delimit the Arkoma basin include both simple and complex structural features (pl. I, index map). The basin is bounded on the north by the relatively simple structure of the Ozark uplift in northern Arkansas and northeastern Oklahoma. Southwest of the Ozark uplift in Oklahoma, the basin is bounded on the northwest by the Northeast Oklahoma plat-

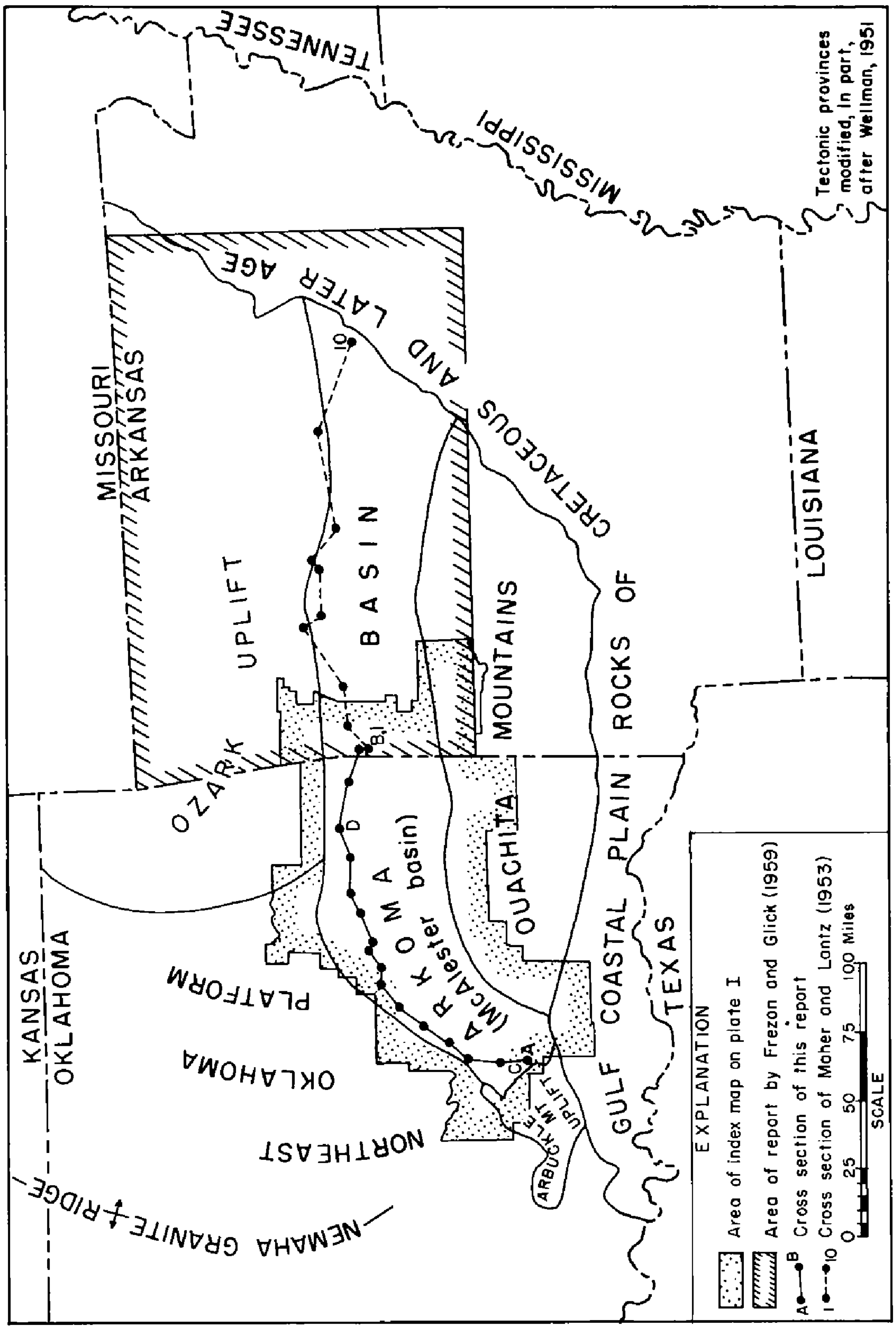

Figure 1. Index map showing tectonic provinces of Arkansas and eastern Oklahoma, and the locations of the cross section of this report and of that of Maher and Lantz (1953).

form and on the southwest by the Arbuckle Mountains. Complexly folded and faulted rocks in the Ouachita Mountains bound the basin on the south in Arkansas and Oklahoma.

Previous Investigations

Surface rocks in the McAlester basin are Pennsylvanian in age; on the margins of the basin rocks of pre-Pennsylvanian age crop out along the northern flank of the Arbuckle Mountains and locally in the northern tier of townships (T. 13 N.) in Sequoyah County. Areal geologic maps, representing approximately 75 percent of the surface area of the McAlester basin, have been published by the U. S. Geological Survey and the Oklahoma Geological Survey during the last 25 years. These maps are included in publications by Dane, Rothrock, and Williams (1938); Hendricks (1937 and 1939); Knechtel (1937 and 1949); Oakes and Knechtel (1948); Weaver (1954); and Wilson and Newell (1937). Surface geology of areas within the McAlester basin not included in the above reports is known from unpublished geologic maps used in the compilation of the Geologic Map of Oklahoma (Miser, 1954, key map).

Studies on which this report is based are a continuation of a series of studies conducted by the U. S. Geological Survey in the Arkoma basin in Arkansas (Maher and Lantz, 1953; Frezon and Glick, 1959). Section 17 of plate I of this report is the same as section 1 of cross section A-B of Maher and Lantz (1953). The cross section of this report thus forms the western half of a line of well sections that extends from White County, Arkansas, westward to Coal County, Oklahoma (fig. 1).

Methods of Investigation

The lithology of the 17 well sections used in this report was determined by detailed microscopic examination of well samples. All samples were examined with a binocular microscope using magnifications of 6.3x to determine the general lithology and greater magnifications to study special minute rock features. This type of examination enables the geologist to determine the rock type, color, texture, mineral composition, cementing material, and type and character of accessory inclusions such as chert, oölites, dolomite and calcite crystals, fossils, glauconite, pyrite, and siderite.

Rotary drilling methods, which were used in drilling 10 of the 17 wells, do not yield samples that are totally representative of the rocks in the footage drilled; the sample generally contains many rock fragments from shallower depths. Electrical logs are available for the rotary-drilled wells, and during the examination of samples from these wells, the electrical logs were used to help make lithologic and fluid-content interpretation and thus helped determine the true depth of the various strata represented by the samples.

Lithologic data obtained from the sample examination were plotted on log strips with an abbreviated description of the rocks present in the sampled interval. The lithologic data from these log strips are presented in the sections of the cross sections of this report.

The terminology of lithologic descriptions used in this report follows standard subsurface usage. Color descriptions are the names used in the Rock-Color Chart distributed by the National Research Council (Goddard and others, 1948). The grain-size terms of clastic rocks (very fine, fine, medium, coarse, and very coarse) are used in accordance with the dimensions of the Wentworth Grade Scale. When crystal faces are not apparent in carbonate rocks at magnification of 6.3x and the texture is smooth, the rocks are called "dense;" if the texture of these rocks is rough, the rocks are described as "granular." The terms "siltstone" and "shale" are names used to denote rocks composed of silt- and clay-sized material respectively.

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STRATIGRAPHY

General Statement

Rock units present in the subsurface of the McAlester basin are correlative with formations that crop out either in or around the basin, but some of the formations have different names in the various areas of outcrop. The Atoka Formation and rocks of post-Atokan age have the same names throughout the area of this report, whereas some rock units of pre-Atokan age have different names. Lantz (1950) and Maher and Lantz (1953) used the names of rock units that crop out in the Ozark region of northern Arkansas for equivalent units in the subsurface of the Arkansas Valley in Arkansas. The rock units in the subsurface in the McAlester basin are designated by the names of equivalent rock units of the Ozark uplift of northeastern Oklahoma or of the Arbuckle Mountains. The stratigraphic nomenclature in the vicinity of the line of sections is presented in table 1. The nomenclature used in this report is not entirely that used by the U. S. Geological Survey.

In the discussion of stratigraphic units in this paper the nomenclature of the rocks in the area north of the Arbuckle Mountains (table 1, left column) is used for introductory headings in the text, and correlations are made between these units and equivalent units, with different names, to the northeast. This method is followed because the stratigraphic section in the area north of the Arbuckle Mountains is more complete than is the section to the northeast.

The sequence of discussion of the stratigraphic units in this report is from youngest to oldest. This is the order in which the units are encountered and identified in the examination of well samples.

The cross section on plate II duplicates the presentation of lithologic data of part of 14 well sections of plate I. Plate I is based on a sea-level datum, and the differences in elevation of rocks of Devonian, Silurian, and Ordovician age between the well columns prohibit the differentiation of the 10 formational units of the Hunton Group, post-Simpson rocks of Ordovician age, the Simpson Group, and the Arbuckle Group. On plate II, the base of the Woodford Shale (Mississippian and Devonian) is utilized as a datum and the 10 formational units are shown.

Rocks of Pennsylvanian Age

DES MOINES SUPERGROUP
MARMATON GROUP

Calvin Sandstone

The Marmaton Group, which crops out in Hughes and northern Pontotoc Counties, Oklahoma, is divided into four formations. The basal formation of the group, the Calvin Sandstone, is the only one encountered in the wells of this report. The Calvin Sandstone, which was named by Taff (1901) for exposures at Calvin in Hughes County, strikes northeastward through northeastern Pontotoc County and central Hughes County. Wells represented by sections 3, 4, and 5 penetrated the Calvin Sandstone, but samples of the Calvin were not available from those 3 wells so neither the lithology of the formation nor its thickness could be determined. Weaver's report (1954) on the geology of Hughes County contains a description of the lithology of the Calvin Sandstone in the area in which those wells are located.

The Calvin Sandstone conformably overlies and intertongues with the Senora Formation of the underlying Cabaniss Group. Weaver (1954, p. 50-54) described and mapped the intertonguing between the Calvin and the Senora.

CABANISS GROUP

The Cabaniss Group, which was described by Oakes (1953) and named for the village of Cabaniss in Pittsburg County, Oklahoma, includes three formations. These formations, in descending order, are the Senora Formation, Stuart Shale, and Thurman Sandstone. The Thurman Sandstone strikes in an easterly direction from eastern Pontotoc County to northeastern Coal County and from there northeastward across southeastern Hughes County and western Pittsburg County (Miser, 1954). Because the formations of the Cabaniss Group dip into the subsurface north and northwest of the area of outcrop, only rocks older than the Cabaniss Group are present in most of the McAlester basin. Rocks of the Cabaniss Group unconformably overlie rocks of the Krebs Group.

TABLE 1.--SEQUENCE OF FORMATIONS IN THE VICINITY OF THE WELLS OF THIS REPORT

SYSTEM	GROUP	(Wells 1-14)	(Well 15)	(Wells 16-17)
PENNSYLVANIAN	MARMATON	Calvin Sandstone		
	CABANISS	Senora Formation		
		Stuart Shale		
		Thurman Sandstone		
	KREBS	Boggy Formation	Boggy Formation	Boggy Formation
			Bluejacket Sandstone Member	
		Savanna Formation	Savanna Formation	Savanna Formation
		McAlester Formation	McAlester Formation	McAlester Formation
		Hartshorne Sandstone	Hartshorne Sandstone	Hartshorne Sandstone
	ATOKA	Atoka Formation	Atoka Formation	Atoka Formation
	MORROW	Wapanucka Limestone	Bloyd Formation	Bloyd Formation
			Brentwood Limestone Member	Brentwood Limestone Member
		Union Valley Sandstone Member*	Hale Formation	Hale Formation
			Prairie Grove Member	Prairie Grove Member
			Cane Hill Member	Cane Hill Member
		Springer Formation		
MISSISSIPPIAN	CHESTER		Pitkin Limestone	Pitkin Limestone
			Fayetteville Shale	Fayetteville Shale
		Caney Shale		Batesville Sandstone
			Hindsville Limestone	Hindsville Limestone Member
	MERAMEC		Moorefield Formation	Moorefield Formation
	OSAGE		Boone Formation	
	KINDERHOOK	Welden (?) Limestone		

DEVONIAN		Woodford Shale	Chattanooga Shale	Chattanooga Shale
		(Wells 1-6)	Sallisaw Formation	Penters Chert
DEVONIAN	HUNTON	Frisco Limestone		
		Bois d'Arc Limestone		
		Fittstown Member**		
		Cravatt Member**		
		Haragan Limestone		
SILURIAN		Henryhouse Limestone		
		Chimneyhill Limestone	(Wells 7-14)	
		Clarita Member**	St. Clair Limestone	
		Cochrane Member**		
		Keel Member**		
		Ideal Quarry Member**		
ORDOVICIAN		Sylvan Shale	Sylvan Shale	
		Fernvale Limestone	Fernvale Limestone	
		Viola Limestone		
	SIMPSON	Corbin Ranch Formation	Fite Limestone	
		Bromide Formation		
		McLish Formation	McLish Formation	
			Tyner Formation	
		Oil Creek Formation	Burgen Sandstone	
	ARBUCKLE (UPPER)		Powell Dolomite	
		West Spring Creek Formation	Cotter Dolomite	
		Kindblade Formation		

*Hollingsworth, 1934
** Amsden, 1957

Senora Formation

The Senora Formation, the upper unit of the Cabaniss Group, was named and described by Taff (1901). The formation was named for the former post office of Senora in southern Okmulgee County, Oklahoma.

The Senora Formation is present in five wells from which samples were examined. Samples of the upper part of the formation are not available from three of the wells (3, 4, and 5) even though the surface formation at the well sites is younger than the Senora. The other two wells (6 and 7) are located on the Senora outcrop so the upper part of the unit is lost by erosion. The maximum thickness represented by samples is 396 feet (well 4).

The Senora Formation is dominantly interbedded shale and sandstone which can be divided into subformational units for surface mapping (Weaver, 1954). Although Weaver's subdivisions of the Senora in Hughes County are not used in this report, they probably can be traced into the subsurface. The sandstone of the Senora is very light gray to medium gray or shades of greenish gray, and is composed of fine to medium quartz grains. The sandstone commonly has calcareous cement. The shale of the formation is dark gray to medium gray, pale brown, or pale red; it generally is silty and locally is calcareous. A few thin limestone beds in wells 3, 5, and 6 are medium gray, brownish gray, or yellowish gray, finely granular to medium crystalline, and generally contain silt and clay. In well 4 the formation contains two beds of dark- to medium-gray finely granular to finely crystalline calcareous dolomite. One bed of coal is present in the formation in section 3.

In Hughes County the Senora Formation is conformable on the underlying Stuart Shale (Weaver, 1954, p. 42). In southwestern Muskogee County the Senora overlaps the underlying Stuart Formation, and north of that area the Senora unconformably overlies the Boggy Formation.

Stuart Shale

The Stuart Shale, which is the middle formation of the Cabaniss Group, was named by Taff (1901) for the town of Stuart in Hughes County, Oklahoma. In his original description Taff stated that the formation is dominantly shale, which ranges from 90 to 280 feet in thickness, and includes 10 to 50 feet of sandstone near the middle of the unit. In Hughes County, Weaver (1954, p. 40) described the formation as a shale with two included sandstone units; the average thickness of the formation in that area is 250 feet. According to Weaver, the lower sandstone unit wedges out northward, and the upper sandstone unit wedges out southward within Hughes County.

The Stuart Shale is present in six wells on plate I. In five of these wells (3 to 7) the Stuart is overlain by the Senora Formation. Samples were available for the complete formation in wells 3-6. The Stuart is the surface formation at well 8, and the thickness of the formation at that locality is 150 feet. The maximum thickness of the Stuart, where the formation is overlain by the Senora, is 356 feet (section 4); the minimum thickness of a complete section of the formation is 158 feet (section 3).

As shown by the well sections of this report, the Stuart is dominantly shale that contains relatively thin beds of sandstone and siltstone. The shale is gray, greenish gray, grayish red, and yellowish brown. Much of the shale is slightly silty, some is calcareous, and some contains very fine to fine sand grains. The sandstone is white to medium gray and consists of very fine to fine quartz grains. Some sections of the formation have beds of very light-gray to medium-gray finely micaceous siltstone, which is locally finely sandy. In section 4 the formation contains two thin beds of medium-gray finely granular to finely crystalline dolomite.

Although there is some suggestion that equivalents of the two sandstone units of the Stuart Shale described by Weaver (1954) may be present in wells of this report (section 6), no attempt is made to correlate Weaver's units with sandy zones in the subsurface.

Along the outcrop in southeastern Hughes County the Stuart Formation conformably overlies the Thurman Sandstone. Northeastward along the outcrop the Stuart overlaps the Thurman and north of the South Canadian River it unconformably overlies the Boggy Formation (Miser, 1954).

Thurman Sandstone

The Thurman Sandstone, the oldest formation of the Cabaniss Group, was named and first described by Taff (1899). The formation was named for the former village of Thurman which was situated in northwestern Pittsburg County, Oklahoma. Taff originally described the formation as a 200-foot-thick sequence of sandstone and shale beds. One of the most distinctive lithologic features of the formation, a basal chert-pebble conglomerate, also was noted in this original description.

The Thurman Sandstone is present in wells 3 to 6 where it is overlain by the Stuart Shale. Well 7 is located northwest of the area where the Thurman is overlapped by the Stuart. On plate I the Thurman is indicated as being questionably present in section 7 because samples were not available for the upper 250 feet of the section. The formation ranges in thickness from 118 feet in section 6 to 218 feet in section 3.

Interbedded sandstone and shale that comprises most of the Thurman would be difficult to differentiate as a separate formation were it not for glauconite and detrital chert found in some of the sandstone units. The shale is medium gray to black, grayish red, and yellowish brown, and is locally calcareous. It is similar to other shale units found in overlying and underlying formations. The sandstone ranges in color from white to dark gray, is composed of very fine to medium grains of quartz, contains chips of chert and glauconite pellets, and locally is slightly calcareous. Weaver (1954, p. 35), in his discussion of chert conglomerates of the Thurman, pointed out that these conglomerates are composed of a matrix of medium-grained to silt-sized quartz in which subrounded chert gravel and sand is included. Medium sand grains in the Thurman are found only in the two cherty sandstones in well 3. Probably chert chips observed in samples from this well were broken from chert fragments larger than sand size during the drilling operation.

The Thurman Sandstone unconformably overlies the Boggy Formation in wells 3 to 6.

KREBS GROUP

The Krebs Group, which was named by Oakes (1953) for the town of Krebs in Pittsburg County, Oklahoma, includes the lower four formations of the Des Moines Supergroup in east-central and northeastern Oklahoma. In descending order these are the Boggy, Savanna, and McAlester Formations and the Hartshorne Sandstone. Formations of the Krebs Group crop out in most of the McAlester basin. This group attains its maximum thickness in the deeper part of the basin south of the line of cross section (Oakes, 1953). The rocks of the Krebs Group overlie the Atoka Formation conformably in most areas and unconformably locally.

All formations of the Krebs Group have sandstone, shale, and coal units which have been named and mapped in parts of McIntosh, Le Flore, and Muskogee Counties and in all of Haskell County (Wilson and Newell, 1937; Knechtel, 1949; and Oakes and Knechtel, 1948).

Boggy Formation

The Boggy Formation was originally described by Taff (1899) for exposures along North Boggy Creek in Pittsburg and Atoka Counties, Oklahoma. The formation was initially named the Boggy Shale and described as a sequence of shale beds approximately 3,000 feet thick containing not less than 16 sandstone beds which range in thickness from 20 to 150 feet.

The Boggy Formation is present in 10 of the wells on plate I; it is the uppermost formation in four wells and is overlain by younger rocks in six wells (3-8). Samples were not available for the upper 250 feet of well 7 so it was impossible to determine the depth of the top of the Boggy. In the five complete sections of the Boggy the formation is thickest in section 3 (547 feet) and thinnest in section 4 (317 feet). The thickest section of the Boggy (1,277 feet) occurs in well 10, which is on the outcrop of the formation.

The Boggy Formation where examined is dominantly shale with interbedded sandstone and siltstone. In sections 6 to 10 the shale of the Boggy is medium dark gray to black and locally silty and finely micaceous. The shale in sections 2 to 5 is mostly light gray to medium gray and some is grayish red. The sandstone is, with very few exceptions, very fine to fine grained and is very light gray to dark gray and olive gray. Some of the sandstone is calcareous, and the basal sandstone in section 10 is glauconitic. The siltstone is dark gray and finely micaceous. Coal beds are present locally in the formation (wells 9 and 10).

Correlations between wells 10 and 6 suggest that the basal sandstone of the formation, the Bluejacket Sandstone Member, grades into shale in the western part of the cross section. The lower 150 feet of the Boggy Formation in sections 8 to 10 is dominantly sandstone. The basal 100 feet of the Boggy in section 7 is medium- to dark-gray shale and micaceous siltstone and the basal 250 feet of the formation in section 6 is predominantly gray to dark-gray shale. Within the area of this report the Boggy rests conformably upon the Savanna Formation.

Savanna Formation

The Savanna Sandstone was first described by Taff (1899) as a series of sandstone and shale beds, about 1,150 feet thick, in which the combined shale thickness probably is greater than the sandstone thickness. Taff named this formation for the town of Savanna in Pittsburg County, Oklahoma. Taff's use of the term sandstone in the formation name resulted from the fact that "... the sandstones are better exposed and their presence is so strongly impressed upon the observer in the prominent ridges which they make ..." (Taff, 1899, p. 437).

The Savanna Formation is present in wells 2 to 11 where it is overlain by the Boggy Formation. The formation ranges in thickness from 413 feet in section 10 to 758 feet in section 4. Samples of the formation were not available from well 11.

The Savanna, as shown by the sections of this report, is mostly a sequence of shale beds and interbedded sandstone. For the most part the shale is dark gray to black, but some is brownish gray, brownish black, medium red, reddish brown, and grayish red. Hendricks (1937, p. 18-19) pointed out that red and green shale is present in the Savanna west of a north-south line drawn through the town of Kiowa (T. 3 N., R. 13 E.). On plate I the Savanna contains dark-gray to black shale east of section 5; southwest of section 5 the formation is dominantly interbedded gray and red shale. The sandstone of the Savanna consists of very fine to fine quartz grains except for the basal sandstone bed in section 7 which contains fine to medium quartz grains. The sandstone commonly is white to light gray, but some beds are greenish gray or olive gray.

Beds of limestone, siltstone, and coal are present in the Savanna, but they comprise less than 10 percent of the thickness of any single section. The limestone is dark gray or brownish gray and ranges in texture from dense to very finely crystalline. The siltstone is medium gray to dark gray and generally is finely micaceous; some siltstone contains very fine quartz grains. The formation has as many as three coal beds in the sections but because of the lack of control between the surface and subsurface sections no attempt is made in this paper to correlate the coal beds in the subsurface sections with named coal beds at the surface.

A northward thinning of the formation, accompanied by a change in lithology, is illustrated by Oakes and Knechtel (1948, p. 51) in a general south-to-north section across Haskell County.

A similar thinning of the unit from southwest to northeast is apparent in the sections of this report, and this thinning is accompanied by a decrease in the proportion of sandstone in the formation. The Savanna Formation unconformably overlies the McAlester Formation.

McAlester Formation

The McAlester Formation was originally described and named from exposures in the area of McAlester, Pittsburg County, Oklahoma (Taff, 1899, p. 437). In the original description Taff divided the formation into three unnamed units which are: 1) an upper unit, 800 feet thick, that is essentially shale, 2) a middle unit, 500 feet thick, that contains sandstone beds, and 3) a lower unit, 700 feet thick, that is predominantly shale. Hendricks (1937, p. 13) recognized and mapped this three-fold division of the formation in the Pittsburg district. The subsurface studies of Dane, Rothrock, and Williams (1938) in the Quinton-Scipio district, north of the Pittsburg district, indicate that these three units of the McAlester can be recognized in the subsurface in northern Pittsburg County.

Complete sections of the McAlester Formation are available from nine wells of this report. The formation ranges in thickness from 208 feet in section 2 to 980 feet in section 8, and it shows a trend of increasing thickness northeastward between section 2 and section 10. Samples of the formation were not available from well 11, and only those from the lower part of the formation were available from well 12, which is located on the outcrop.

Although the predominant rock type of the McAlester Formation is shale, the formation includes siltstone, sandstone, limestone, and coal. In all the sections, however, shale and siltstone make up at least two-thirds of the thickness of the formation. The shale of the McAlester is dark gray or black and, for the most part, finely micaceous and silty; some shale beds are calcareous. The siltstone is medium to dark gray, micaceous, and some contains sand. The sandstone of the formation, which varies in color from light gray to dark gray, is composed of very fine to fine-grained quartz and commonly is micaceous. The thickest sandstone units in sections 7 and 8 contain medium sand grains. Hendricks (1939, p. 268) stated that coarse sand is present in abnormally thick beds of sandstone in the McAlester Formation in the Howe-Wilburton district in Oklahoma. The limestone of the McAlester is dark gray or brownish gray, and finely granular to finely crystalline; it generally contains a large residue of silt or clay.

The McAlester Formation apparently contains as many as five coal beds in some areas (sections 9 and 10). Two coal beds of regional extent are known to occur within the formation (in descending order, the Stigler and Upper Hartshorne coal beds). Although these beds probably are present in the wells of this report, no attempt is made to identify them on the cross section.

The McAlester Shale conformably overlies the Hartshorne Sandstone. In this report the author has followed the standard practice of placing the base of the McAlester at the top of the highest sandstone or siltstone of the Hartshorne. This division places the Upper Hartshorne coal in the lower part of the McAlester Formation. Although the above described division of the McAlester and Hartshorne is a satisfactory method for determining a contact between the two formations it appears that rocks which are laterally equivalent to the upper part of the Hartshorne may be included in the McAlester. This problem is presented in the following discussion of the Hartshorne.

Hartshorne Sandstone

The Hartshorne Sandstone was originally described and named by Taff (1899) for exposures in the area of Hartshorne, Pittsburg County, Oklahoma. Taff (1899, p. 436) described the formation in the McAlester-Lehigh coal field as "sandrock," which has a maximum thickness of 200 feet. The Hartshorne coal of Taff is present in a shale which overlies the Hartshorne Sandstone. Taff and Adams (1900) described the Hartshorne Sandstone in the eastern Choctaw coal field and stated that the thickness of the unit ranged from 100 to less than 200 feet. In the same report these authors named the Upper and Lower Hartshorne coal beds and pointed out that there are also two sandstones in the section. Taff and Adams (1900) did not correlate the Hartshorne Sandstone and coal of Taff (1899) with their upper and lower Hartshorne Sandstone and coal. Oakes and Knechtel (1948, p. 23) stated that the Hartshorne coal and underlying Hartshorne Sandstone of Taff (1899) probably is the lower Hartshorne Sandstone and coal of current Oklahoma usage.

In Arkansas the top of the Hartshorne Sandstone is placed at the top of the sandstone underlying the Lower Hartshorne coal (Hendricks and Read, 1934, p. 1052). Thus, the Hartshorne Sandstone of Arkansas is equivalent to the lower Hartshorne Sandstone of Oklahoma.

In its complete development in Oklahoma the Hartshorne consists of an upper and lower sandstone and an intervening shale unit which contains the Lower Hartshorne coal. The Upper Hartshorne coal is present in the lower shale unit of the overlying McAlester Formation. Knechtel (1949), Knechtel and Souder (1944), and Oakes and Knechtel (1948) stated that the Upper and Lower Hartshorne coals converge in northern Le Flore County and eastern Haskell County and in these counties they are mapped as a single bed. Diagrams illustrating this northward convergence of the coal beds (Oakes and Knechtel, 1948, fig. 3, p. 23; and Trumbull, 1957, fig. 40, p. 333) show that the upper sandstone of the Hartshorne pinches out in the areas of convergence of the coal beds and that the lower Hartshorne Sandstone is a continuous unit. In the well sections of this report the northward pinchout of the upper sandstone of the Hartshorne cannot be illustrated; samples of the Hartshorne are not complete east of section 10.

The Hartshorne Sandstone is present in wells 2 to 12 and 17. Wells 1 and 13 to 16 were drilled on the outcrop of the underlying Atoka Formation. No samples of the Hartshorne were available from wells 11, 12, and 17 although these wells were drilled at localities where rocks younger than the Hartshorne are present at the surface. The thickness of the Hartshorne ranges from 21 feet in well 3 to 121 feet in well 10.

The rocks comprising the Hartshorne are similar to the rocks in the overlying and underlying formations. The sandstone is mostly very fine to fine grained; some medium-sized grains occur locally in the lower unit. The sandstone is white to dark gray, yellow gray, and shades of olive gray. Shale of the Hartshorne is dark, commonly medium gray to dark gray; it generally is finely micaceous and contains silt-sized grains of quartz.

Complete development of the Hartshorne Sandstone is represented in sections 7 to 10 where the formation is composed of an upper and lower sandstone unit and an intervening shale unit. The Lower Hartshorne coal is present in the shale unit only in section 8, but the Upper Hartshorne coal at the base of the overlying McAlester Formation is present in all these sections. In sections 2 to 6 the Hartshorne consists of a single sandstone unit which is the apparent equivalent of the basal Hartshorne sandstone in sections 7 to 10.

A comparison of the stratigraphic intervals between the top of the lower Hartshorne Sandstone and coal beds above the sandstone suggests that the upper Hartshorne Sandstone may be laterally equivalent to shale beds which in some sections would be included in the McAlester. In well 7 the Upper Hartshorne coal, which overlies the upper Hartshorne Sandstone, is 47 feet above the top of the lower Hartshorne Sandstone. In well 6 the uppermost of the two coal beds in the lower 50 feet of the McAlester is 40 feet above the top of the equivalent of the lower Hartshorne Sandstone. If the upper coal bed in well 6 is the lateral equivalent of the Upper Hartshorne coal of well 7 then the interval, approximately 47 feet thick, between the upper coal bed and the Hartshorne Sandstone in well 6, is equivalent to some part of the interval occupied by the middle shale and the upper sandstone of the Hartshorne in section 7. Hendricks (1937, p. 11) stated that in the McAlester district south of wells 6 and 7 the upper sandstone of the Hartshorne grades laterally into sandy shale.

The contact between the Hartshorne Sandstone and the underlying Atoka Formation is generally gradational, but locally the contact is sharp and probably unconformable (Hendricks, 1939, p. 264). The locally unconformable relations between the two formations resulted from the deposition of the basal Hartshorne Sandstone in channels in the Atoka. In one area in eastern-central Sebastian County, Arkansas, the contact between the Hartshorne and the Atoka is an angular unconformity (B. R. Haley, oral communication, June 11, 1959; illustrated in Kansas Geological Society, 1956, p. 19).

ATOKA GROUP

Atoka Formation

The Atoka Formation was named by Taff and Adams (1900) for the town of Atoka in Atoka County, Oklahoma. The formation, which is the only unit of the Atoka Group, was initially described as a sequence of alternating sandstone and shale beds, 7,000 feet thick, which is overlain by the Hartshorne Sandstone and underlain by the Wapanucka Limestone.

The Atoka Formation is present at the surface or in the subsurface throughout the Arkoma basin in Oklahoma and Arkansas. The formation is exposed at the locations of five wells of this report and is present in the subsurface in the other 12 wells. Samples of the entire formation were available from 10 wells. In these, the thickness of the formation ranges from 663 feet (section 4) to 3,213 feet (section 2), but its greatest thickness is in well 16 drilled on the Atoka outcrop. There, 5,325 feet of the formation is preserved in a nearly complete section.

The Atoka Formation is composed predominantly of sandstone, shale, and siltstone. The sandstone of the Atoka generally is composed of fine to medium quartz grains and ranges in color from white to dark gray; some of the sandstone has scattered coarse quartz grains. Mica is a common accessory in the sandstone and some of the sandstone is glauconitic. Sandstone beds of the formation commonly are slightly calcareous; in sections 1 to 8 sandstone beds are almost invariably calcareous but in wells 9 to 16 calcareous sandstone beds are the exception rather than the rule. The shale of the Atoka Formation is gray to black and generally has fine mica flakes, silt, and in many places includes very fine quartz sand. Some shale is pyritic. In well 2 grayish-red shale is present in the upper 50 feet of the formation. Shale in wells at the west end of the cross section generally is calcareous, and calcareous shale is present in the formation in decreasing amounts as far east as section 12. In most wells siltstone beds comprise a minor part of the total thickness of the formation but in well 10 siltstone beds comprise about 30 percent of the thickness. Siltstone in the formation is light to dark gray and generally is calcareous. Some siltstone contains very fine to fine-grained sand and glauconite is present in some of the siltstone.

Coal and limestone beds are present in the Atoka Formation in sections of this report, but they are neither thick nor persistent. Coal beds are present in wells 1, 5, 7, and 9. Limestone beds are more numerous in well sections 1 to 3 than they are in wells north and east of section 3. These limestones generally are very light to dark gray and granular to medium crystalline. Most limestones are silty and clayey and some contain very fine to medium sand grains.

In some of the well sections the basal part of the Atoka Formation contains thin beds of shale that are markedly different in appearance from the other shale in the formation. The color of this shale is much lighter than the other shale in the Atoka; it is very light gray, light gray, olive gray, and yellowish gray. Characteristically it is extremely soft and can be easily broken into small flakes. The luster has been variously described as "waxy," or "pearly." Some of this shale contains clear, brown or black mica, and some contains minute dolomite rhombs.

The thickness of the individual thin shale beds is not determinable from cuttings but the shale is not abundant in any of the samples, so the beds probably are less than a foot thick. The thickness has been exaggerated in the well sections where the shale beds are indicated by an inverted Y outside the columns. One shale bed is present in wells 5, 8, and 14, two beds are present in wells 9, 10, 11, 12, and 15, and three beds are present in well 13.

Although no attempt is made in this report to correlate these shale beds, the author believes that they may be persistent for long distances. Shale beds similar to these described above are known to occur in the Atoka in wells as far as 120 miles east of sections 16 and 17. Additional mineralogical and stratigraphic data are needed to determine the significance of these beds.*

The Atoka Formation unconformably overlies the Wapanucka Limestone and its equivalent, the Bloyd Formation.

MORROW GROUP

Wapanucka Limestone

Taff (1901), who named the Wapanucka Limestone for the town of Wapanucka in Johnston County, Oklahoma, included in the formation all the rocks in the stratigraphic interval between the base of the Atoka Formation and the top of the unit then called the Caney Shale. Wallis (1915) apparently extended the lower limits of the formation downward to the top of the ironstone concretion zone that is currently placed in either the base of the Springer Formation (Barker, 1951, p. 183) or at the top of the Caney Shale (Kuhleman, 1951, p. 196). Ulrich (1927) proposed that the part of the Caney Shale that is Pennsylvanian in age (Morgan, 1924; see discussion of Springer Formation) be included in the Wapanucka Limestone. Hollingsworth (1934, an unpublished M.S. thesis) followed the proposals of Wallis and Ulrich and included a lower shale member in the Wapanucka below the sandstone that Taff (1901) defined as the basal unit of the formation. This lower shale member is now regarded as a separate formation.

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*Studies made after the writing of this report indicate that these thin beds are possible bentonites (Frezon and Schultz, 1961).

The Wapanucka Limestone and equivalent rocks of Morrowan age are present in all wells of this report. The thickness of these rocks ranges from 212 feet in well 12 to 940 feet in well 1.

The Wapanucka Limestone in most of the wells can be divided into three lithologic units which correspond to the three upper units of the formation as defined by Hollingsworth (1934). The unnamed upper limestone and the middle shale units are approximately equivalent to the Bloyd Formation, and the Union Valley Sandstone Member is equivalent in part to the upper member (Prairie Grove) of the Hale Formation. The upper limestone and the middle shale units are not differentiated on plate I. The top of the Union Valley Sandstone Member is differentiated on the cross section as far east as well 14.

The upper limestone of the Wapanucka ranges in thickness from 40 feet (well 11) to 200 feet (well 1). In all wells except 9 and 10 this unit is a comparatively massive limestone sequence. This is the youngest massive limestone in the Paleozoic section and is a distinctive marker bed. The limestone generally is medium gray to very light gray, but some is light olive gray or yellowish gray. It generally is granular to finely crystalline but some is medium or coarsely crystalline. Some limestone contains medium quartz grains, glauconite, and in some wells gray or dusky blue chert. Approximately 50 percent of the limestone in this unit is oölitic. In all sections the upper unit has interbeds of dark gray to black shale, some of which are calcareous.

The middle unit of the Wapanucka Limestone has a maximum thickness of 650 feet in section 1 and a minimum thickness of 60 feet in section 14. It is predominantly dark-gray to black shale that is commonly silty and calcareous. Limestones occur in the unit and are light gray to dark gray or shades of olive gray and are granular to finely crystalline. Gray micaceous calcareous siltstone is present in well 11. In sections 9 and 10 it was not possible to determine where the division between the upper limestone and the middle shale should be placed in the sequence of limestone and shale above the Union Valley Sandstone Member of the formation. In section 15 the interval between the Union Valley and the Atoka Formation is predominantly limestone and it is not known whether the middle unit is represented in this section.

The lower unit of the Wapanucka Limestone, the Union Valley Sandstone Member, was named by Hollingsworth (1934) for the Union Valley schoolhouse in Pontotoc County, Oklahoma. Numerous authors, including Hyatt (1936), Barker (1951), and Mann (1958), have given the Union Valley formational status. The Union Valley has a diagnostic lithology and is a well-defined unit along the cross section (plate I) but it is here regarded informally as the basal member of the Wapanucka Limestone. The Union Valley Sandstone is approximately equivalent to the Prairie Grove Member of the Hale Formation and to the Brentwood Limestone Member of the Bloyd Formation of northeastern Oklahoma and western Arkansas. The thickness of the member ranges from 30 feet in well 13 to 269 feet in section 3.

The Union Valley was mapped on the surface in east-central Pontotoc County by Barker (1951). In southeastern Pontotoc and Coal Counties, however, Kuhleman (1951) included the Union Valley in the Springer Formation. In this area the Union Valley apparently is mostly shale and is difficult to differentiate from the underlying Springer. Kuhleman (1951) and Barker (1951) stated that the Springer grades upward into the Union Valley. In well 1 of this report the Union Valley resembles the shaly phase of the Union Valley described by Kuhleman (1951, p. 201-202). North of section 1, however, the Union Valley is an easily differentiated sequence of sandstone, limestone, and shale.

The sandstone in the Union Valley consists mainly of fine to medium quartz grains which commonly are cemented with calcite. Most of the sandstone is white to dark gray, but some is yellowish gray. Glauconite is a common accessory mineral. The limestone of the Union Valley ranges from light to dark gray and generally is finely granular to medium crystalline. Glauconite and fine to medium sand grains are common accessories in the limestone, and at a few places the limestone is oölitic and contains gray chert. Interbeds of dark-gray to black noncalcareous shale are present in both the limestone and the sandstone.

The Union Valley Member conformably overlies the Springer Formation. In northeastern Oklahoma and western Arkansas rocks equivalent to the lower part of the Union Valley (the Prairie Grove Member of the Hale Formation) unconformably overlie the Cane Hill Member of the Hale Formation. Where the Cane Hill Member is absent in northeastern Oklahoma, the Prairie Grove Member unconformably overlies rocks of Mississippian age.

ROCKS OF PENNSYLVANIAN AND MISSISSIPPIAN AGE

Springer Formation

The Springer Formation, which was named by Goldston (1922) for the town of Springer in Carter County, Oklahoma, crops out in Pontotoc, Coal, and Atoka Counties. The formation was mapped by Morgan (1924) in the area of Stonewall, Pontotoc County, Oklahoma, as part of the Caney Shale. Morgan recognized that his Caney Shale included rocks of both Pennsylvanian and Mississippian ages and suggested "... that it would be desirable to restrict the term Caney to the Mississippian part of the formation and to describe as a new formation the upper or Pennsylvanian part" (Morgan, 1924, p. 58). Apparently as the result of this suggestion the informal name "Pennsylvanian" Caney shale came into use for the shale sequence of Pennsylvanian age which lies below the Union Valley Sandstone and above the Caney Shale of Mississippian age.

Miser (1934) described the Springer Formation in the Ouachita Mountains and pointed out that it is overlain by the Wapanucka Limestone of Pennsylvanian age and underlain by the Caney Shale of Mississippian age. The so-called "Pennsylvanian" Caney shale occupies the same stratigraphic position as the Springer as defined by Miser and the name Springer has since come into general usage for the informally named unit.

Barker (1951, p. 178-180) defined the "Springer" shale in Pontotoc County, Oklahoma, to include only the "Pennsylvanian" Caney, which is overlain by the unit he mapped as Union Valley Formation and underlain by the Caney Shale. Kuhleman (1951, p. 201), who mapped the Springer Formation in southwestern Pontotoc and western Coal Counties, included the Union Valley of Barker in the Springer Formation but placed the base of the Springer at the same stratigraphic horizon used by Barker.

The "Springer" shale of Barker, which is the Springer Formation of this report, was divided into the Rhoda Creek Formation and an overlying unnamed shale by Elias (1956). On the basis of the goniatite fauna in the Rhoda Creek, Elias (1956, p. 94 and table 2) assigned Barker's "Springer" shale to his Springer "series," which is considered to be older than the Union Valley Sandstone of Morrowan (Pennsylvanian) age and younger than Chesterian (Mississippian) age. Recent studies of a goniatite fauna from the basal member of the Hale Formation (Cane Hill) in the type area of the Morrow Group in northwestern Arkansas indicates that the basal Morrow in that area contains a fauna younger than the Rhoda Creek fauna of Elias and older than the known faunas of Union Valley age (Mackenzie Gordon, Jr., U. S. Geol. Survey, oral communication, 1961). The fauna of the Rhoda Creek of Elias and rocks of post-Pitkin Mississippian age in north-central Arkansas (Frezon and Glick, 1959, p. 181) are similar, and Gordon (oral communication, 1961) believes that the age of these faunas is very late Mississippian. For this reason the lower part of the Springer of this report is placed in the upper part of the Mississippian System in the Chester Group. Because the Union Valley of Morrowan age grades into the underlying Springer without an apparent depositional break (see previous discussion of the Union Valley), the upper part of the Springer in this report is considered to be of earliest Morrowan age and is correlated with the Cane Hill Member of the Hale Formation although fossil evidence is not available to substantiate this correlation.

The Springer Formation or its equivalent is present in 16 wells of this report. The unit is thickest in well 3 (317 feet) and thinnest in well 17 (29 feet). Along the line of the cross section the formation is present but thin in wells 13 and 15 and is absent in well 14.

In general the Springer is shale, silty shale, and fine-grained sandstone, which contrasts by being more sandy and less limy than the shale, calcareous shale, and limestone of the underlying Caney. The shale of the Springer is typically dark gray to black and contains some silt and very fine mica flakes. Limestone makes up a small percentage of the formation at any one section, and is dark gray, medium gray, or olive gray, and ranges from finely granular to finely crystalline.

The sandstone of the Springer is very light to dark gray and is very fine to fine grained. It commonly is calcareous, as is the sandstone of the overlying Union Valley, but the smaller grain size and the absence of glauconite can be used to differentiate the sandstone units of the Springer from the Union Valley Sandstone Member of the Wapanucka Limestone.

In wells 1 and 2 in Coal and Pontotoc Counties the Springer does not contain sandstone; in these wells the formation is a shale and limestone sequence resting upon shale and limestone which comprises the underlying Caney Shale. The basal part of the Springer in these sections is considered by the author to be a bed of dark-gray to black, very finely sandy, glauconitic shale which was originally described by Boyd (1938, p. 1567) in his study of the Jesse pool in Pontotoc County. Boyd and other geologists who have worked in this area (Kuhleman, 1951; Dannenberg, 1952) regard this glauconitic zone as the upper unit of the Caney Shale, but because the lithology of the zone, and especially the grain size of the sand, is similar to Springer sediments, the author believes that the glauconitic unit should be placed at the base of the Springer.

In wells 1, 2, and 5, the glauconitic zone is dark-gray to black, glauconitic shale which contains scattered very fine to fine quartz grains. In these sections the zone is difficult to recognize because the dark color of the shale masks the dark-green color of the glauconite, and the sand grains are small and scattered in the clay matrix. In well 3, this zone is represented by dark-gray very fine- to fine-grained glauconitic sandstone, and the unit in well 4 is dark-gray to black, very finely sandy, glauconitic siltstone. In wells 1 and 2 this bed is at the base of a shale and limestone phase of the Springer, but in wells 3 to 5 it underlies the more typical shale and sandstone lithology of the Springer.

The Cane Hill Member of the Hale Formation, which was named and described by Henbest (1953), is regarded as the basal unit of Morrowan (Pennsylvanian) age in the type area of the Morrow Group in Washington County, Arkansas. In the type area the Cane Hill, which ranges in thickness from a thin edge to 65 feet (Henbest, 1953, p. 1938), is overlain by the Prairie Grove Member of the Hale Formation and is underlain by the Pitkin Limestone of Chesterian (Late Mississippian) age or by the Fayetteville Shale of Chesterian age where the Pitkin is absent. In the type area the Cane Hill is primarily a sequence of clastic sediments which do not exceed the size of fine-grained sand. The stratigraphic position and the lithology of the Cane Hill shown in wells 15 to 17 (plate I) are similar to the stratigraphic position and lithology of the member in the type area of Washington County, Arkansas.

The Cane Hill of wells 15 to 17 and the Springer of wells 1 to 13 are apparently parts of the same continuous body of clastic sediments and are therefore believed to be correlative. Well 14 is apparently north of this continuous body of sediments; rocks equivalent to the Springer (or Cane Hill) are not present in this well. In the area of outcrop in northeastern Oklahoma, north of well 14, the Cane Hill is generally absent; where it is present, it apparently occurs as thin outliers north of the continuous body of rocks in the subsurface.

Rocks of Mississippian Age

CHESTER AND MERAMEC GROUPS

Caney Shale

The Caney Shale in the northern and northeastern parts of the Arbuckle Mountains includes rocks of Chesterian and Meramecian age and is equivalent to four formations in northeastern Oklahoma and five formations in northern Arkansas. In northeastern Oklahoma three formations, in descending order the Pitkin Limestone, Fayetteville Shale, and Hindsville Limestone, are included in the Chester Group, and the underlying Moorefield Formation is placed in the Meramec Group. In western Arkansas the Chester Group includes, in descending order, the Pitkin Limestone, Fayetteville Shale, and the Batesville Sandstone (with the Hindsville Limestone Member at the base), and the Meramec Group includes the probable lateral equivalent of the Moorefield Formation.

The Caney Shale and equivalent rock units of Chesterian and Meramecian age are present in all the wells on plate I. The Caney and equivalent rocks range in thickness from 626 feet in well 4 to 123 feet in well 14.

The Caney Shale is a sequence of dark shale, siltstone, and limestone. The shale generally is dark gray to black and commonly is silty and limy. The siltstone is medium gray to dark gray and generally is micaceous and limy. The limestone is medium gray to dark gray and olive gray, finely granular to finely crystalline, and silty. Some of the limestone is oölitic, and some cherty limestone is present in well 14.

In sections 15 and 17 the formations of Chester and Meramec age typical of the Ozark region can be partially differentiated. Three units in these sections, the Pitkin Limestone, the Fayetteville Shale, and the undifferentiated Batesville Sandstone (or its equivalent, the Hindsville Limestone), and Moorefield Formation, are recognized. The Pitkin Limestone is mainly light-gray to dark-gray or brownish-gray finely granular to medium-crystalline silty limestone which is oölitic in part. The underlying Fayetteville Shale is a dark-gray very limy finely micaceous siltstone in section 15 and is a black micaceous slightly limy silty shale in section 17. In section 15 the unit designated as the Hindsville Limestone, and Moorefield Formation, undifferentiated, consists of light- to medium-gray finely granular to finely crystalline silty micaceous limestone.

The criteria used to determine the contact of the Caney with the overlying Springer Formation were discussed previously. The base of the Caney is placed below a glauconitic bed that varies laterally from sandy shale to sandstone in outcrops in the northeastern part of the Arbuckle Mountains (Kuhleman, 1951, p. 194; Barker, 1951, p. 174). This glauconitic bed is present in wells 1 to 7, 10, and 12. In the wells where the glauconitic bed is absent (wells 8, 9, 13, 14, and 17), the difference between micaceous limy silty shale of the lower part of the Caney and dark-gray to black noncalcareous shale of the underlying Woodford (or Chattanooga) is easily determined from the samples. In section 15 rocks equivalent to the Caney Shale rest upon the Boone Formation. No samples were available from the basal Caney-upper Woodford interval in section 11.

The Caney Shale and equivalent strata unconformably overlie older rocks. The Boone Formation, which is 44 feet thick in well 15, is truncated and missing beneath the Caney and equivalent rocks in other wells. In well 2 the Welden (?) Limestone is present beneath the Caney but is absent in adjoining wells.

OSAGE AND KINDERHOOK GROUPS

Boone Formation

The Boone Formation was named by Branner (Branner and Simonds, 1891) for exposures in Boone County in north-central Arkansas. The outcrop of the Boone extends across northern Arkansas westward into northeastern Oklahoma. In this report the Boone Formation includes the rocks between the base of the Meramec Group (Moorefield Formation) and the top of the Chattanooga Shale. Rocks referred to the Boone in this report are probably equivalent to the Reeds Spring Formation as mapped by Huffman (1958, pls. IV and V).

The Boone is present in only one well (15) of this report, where it is 44 feet thick. In this section the formation is composed of light-colored limestone and chert which is the typical lithology of the formation in most surface and subsurface sections. The limestone is light gray and finely granular to medium crystalline, and the chert is yellowish gray and light olive gray and translucent. The limestone also has thin interbeds or stringers of light olive-gray finely crystalline dolomite.

Maher and Lantz (1953) and Frezon and Glick (1959) reported 150 feet of silty micaceous limestone in section 17 as equivalent to the Boone Formation. The author does not now regard these interpretations as correct. Instead, he believes that there are no great lithologic changes in the Boone Formation, and that the thinning of the Boone from north to south in western Arkansas and eastern Oklahoma (Frezon and Glick, 1959, pl. 27; and Huffman, 1958, fig. 4) occurs beneath the unconformity at the base of rocks of Meramecian age. The Boone Formation unconformably overlies the Chattanooga Shale in section 15.

Welden(?) Limestone

The term Welden Limestone was first used on a map of the Arbuckle Mountains published as a part of Bulletin 55 of the Oklahoma Geological Survey (Decker and Merritt, 1931). Rocks of Mississippian age were mapped by C. L. Cooper, who apparently named the thin Welden Limestone for Welden Creek in Pontotoc County, Oklahoma. Barker (1951) mapped the Welden Limestone in central Pontotoc County, but Kuhleman's (1951) report indicates that the unit is absent on the surface in southeastern Pontotoc County. In the subsurface north of the Arbuckle Mountains the Welden has an erratic distribution. Boyd (1938, p. 1566) and Hyatt (1936, p. 957) have reported on its distribution in the Jesse pool in Pontotoc and Coal Counties and in the Fitts pool in Pontotoc County.

The Welden(?) Limestone is present in well 2 where it is only 10 feet thick. The formation is light-gray to very light-gray slightly pyritic finely granular limestone.

Because the Welden(?) Limestone is present in only well 2, it cannot be traced eastward along the line of sections and correlated with possible equivalent units in northeastern Oklahoma or northern Arkansas.

The relation between the Welden(?) Limestone and the underlying Woodford Shale is not evident from the data gathered for this report. Barker (1951, p. 172) stated "The Woodford, pre-Welden shale, and the Welden limestone are believed to represent continuous deposition." The Welden(?), therefore, apparently conformably overlies the Woodford.

ROCKS OF MISSISSIPPIAN AND DEVONIAN AGE

Woodford Shale

J. A. Taff (1902) assigned the name Woodford Chert to a sequence of chert and black fissile shale that underlies the Caney Shale and overlies the Hunton Group in the vicinity of Woodford in Carter County, Oklahoma.

The Woodford Shale and its correlative, the Chattanooga Shale of northeastern Oklahoma and northern Arkansas, is present in 16 wells of this report. Well 16 was not drilled deep enough to encounter the Chattanooga Shale. The thickness of this unit along the line of cross section ranges from 10 feet in well 15 to 216 feet in well 4.

The Woodford and Chattanooga consist largely of dark-gray to black shale which contains scattered fine grains of pyrite. In sections 1 to 5 on the west end of the cross section some silicified shale has been logged as black granular chert. The silicified shale is more abundant in well 1 than in well 5.

The basal sandstone of the Woodford and Chattanooga is present in all wells except well 6. This sandstone, which is as much as 10 feet thick, is very light gray to medium gray and consists of fine to medium quartz grains which commonly are cemented with calcite. Grains of glauconite generally are present in this sandstone. Where the sandstone is not calcareous the sand grains are angular to subangular as a result of secondary quartz enlargement; where the sand is calcareous the grains are subrounded or rounded. Rounded grains of phosphatic material which have the same size as the quartz grains are present in the basal sandstone unit.

The Woodford unconformably overlies rocks of Silurian or Devonian age assigned to the Hunton Group. In the wells in eastern Oklahoma the Chattanooga unconformably overlies the Sallisaw Formation (Devonian) or, where the Sallisaw is absent, the St. Clair Limestone of Silurian age. In wells 4 to 6, where the Woodford has overlapped the rocks of the Hunton Group, the Woodford unconformably overlies the Sylvan Shale of Ordovician age.

ROCKS OF DEVONIAN AGE

Sallisaw Formation

Cram (1930, p. 550-551) named a sandstone of Devonian age the Sallisaw Sandstone from exposures along Sallisaw Creek in Sequoyah County, Oklahoma. Schuchert (1922, p. 668) reported that brachiopods found in the basal five feet of the Sylamore Sandstone Member of the Chattanooga Shale in the Marble City area in northern Sequoyah County were characteristic of forms found in the Camden Chert (Devonian) of Tennessee. On this basis Schuchert correlated the Sylamore with the Camden Chert. Cram (1930, p. 550-551) believed that the Sylamore Sandstone in northern Sequoyah County was Mississippian in age and that the sandstone containing the Devonian fauna probably was unconformably overlain by the Sylamore. The most extensive exposures of the unit, which is now known as the Sallisaw Formation, occur in northern Sequoyah County in T. 13 N., R. 23 E. (Huffman, 1958, p. 36); north of the area only scattered, isolated outcrops occur in southern Adair and Cherokee Counties.

The Sallisaw and its equivalent in Arkansas, the Penters Chert, is present in five wells on plate I; it was completely penetrated in wells 12, 13, and 14 and partly penetrated in wells 15 and 17. The maximum thickness of the formation is 57 feet (section 14), and the minimum thickness is 5 feet (section 12).

Limestone and chert, which are the predominant rock types of the Sallisaw Formation, are easily differentiated from the underlying limestone of Silurian age. The limestone is light gray and granular to finely crystalline. In all the sections the limestone contains scattered rounded fine grains of quartz sand, scattered fine "rhombic" crystals of dolomite, and chert. The chert is white to light gray and dense; it contains scattered sand grains and dolomite rhombs similar to those found in the limestone.

The Sallisaw Formation unconformably overlies the St. Clair Limestone of Silurian age. Along the line of the cross section the Sallisaw is overlapped by the Chattanooga between wells 11 and 12; southwest of well 12 rocks equivalent to the Sallisaw are not present. The Penters Chert in Arkansas is Camden in age and is the correlative of the Sallisaw Formation of Oklahoma (Kinney, 1946, p. 611-612). Previous subsurface studies (Frezon and Glick, 1959) show that the Penters is present in western Arkansas and that the formation is sandy in that area.

Rocks of Devonian and Silurian Age

HUNTON GROUP

Rocks of Silurian and Devonian age that crop out in the Arbuckle Mountains were described and named the Hunton Limestone by Taff (1902). In a subsequent publication Taff (1903) divided the Hunton Limestone into three unnamed lithologic units. Reeds (1911, p. 258) later divided the Hunton into four named formations, in descending order, the Bois d'Arc Limestone and Haragan Shale of Helderbergian age (Devonian), the Henryhouse Shale of Niagaran age (Silurian), and the Chimneyhill Limestone of Alexandrian age (Silurian). In a later publication Reeds (1926) stated that the upper part of the Bois d'Arc contains a fauna of Oriskanian age (Devonian), and he named those rocks the Frisco Formation. Reeds also assigned all of the formations of Devonian and Silurian age to the Hunton Group. Maxwell's studies of the Hunton Group (1936), which were published in abstract form, resulted in the introduction of a new formation (the Cravatt Limestone) between the Bois d'Arc and the Haragan and a division of the Chimneyhill into four formally named members. Ham (1955) published lithologic descriptions and a cross section that show the stratigraphic relations of the various units of the Hunton Group. Amsden's (1957) stratigraphic classification of the Hunton Group retained the five formational divisions proposed by Reeds (1911, 1926). Of the five names proposed by Maxwell, Amsden retained three, renamed two, and proposed a sixth, all as members. This stratigraphic classification is shown in column 1 of table 1.

Recent stratigraphic studies of the Hunton Group by Amsden (1960) have been used by the author to determine which formations of the Hunton are present in wells 1 and 2 (plate II). Amsden (1957, 1960) has emphasized that the lithologic differences between some formations of the Hunton Group are inadequate for separating the formations and that the faunas are the identifying features. The Frisco and Bois d'Arc are lithologically similar (Amsden, 1960, p. 134), the basal member of the Bois d'Arc (Cravatt) and the Haragan are similar in lithology and contain chert (Amsden, 1957, p. 43) and the Haragan and Henryhouse Limestones are lithologically inseparable (Amsden, 1957, p. 30). In view of these lithologic similarities it is necessary to know something about the distribution of these formations in nearby outcrops before identifying the formations in subsurface sections.

Amsden's (1960, figs. 27, 32, 35, and 42) thickness and distribution studies of the above-mentioned formations in T. 1 S., R. 8 E., approximately three miles southwest of well 1, have led to the following conclusions: 1) the Frisco Limestone is questionably present in wells 1 and 2, 2) the Bois d'Arc and Haragan Limestones are probably present in wells 1 and 2, and 3) the Henryhouse Limestone is not present in well 1 but probably is present in well 2.

Frisco Limestone

The Frisco Limestone, which overlies the Bois d'Arc Limestone, is 60 feet thick in outcrops in T. 2 N., R. 6 E., and is less than 20 feet thick in outcrops approximately three miles southwest of well 1 in T. 1 S., R. 8 E. Northeast of these outcrops the extent of the formation in the subsurface is unknown (Amsden, 1960, fig. 42) and the formation probably could not be differentiated from the Bois d'Arc if it were present (Amsden, 1960, p. 134). If the Frisco is present in sections 1 and 2, it is included with the Bois d'Arc Limestone.

Bois d'Arc Limestone

The Bois d'Arc Limestone in exposures along the eastern side of the Arbuckle Mountains was divided into two members by Amsden (1957). Amsden described the upper member (Fittstown) as a calcarenite whereas the lower member (Cravatt) is a calcilutite, although both types of rock are present in each member (Amsden, 1957, p. 41 and 45). In the area of outcrop, chert is irregularly distributed in the upper member but is consistently present in the lower member. Inasmuch as the two members of the Bois d'Arc can be similar in lithology it is not practicable to attempt to differentiate these units by means of lithologic criteria in wells 1 and 2.

The Bois d'Arc Limestone is 66 feet thick in well 1 and 63 feet thick in well 2. The upper unit of the formation in these sections is a bed of white to very light-gray chert; the remainder of the formation is white to medium light-gray finely granular to coarsely crystalline limestone. Pale-orange and pinkish-gray calcite crystals are present in the upper 20 feet of the limestone, and the upper 18 feet of the limestone in well 1 is glauconitic.

In this report the contact between the Bois d'Arc and the underlying Haragan Limestone is determined on the basis of limestone crystallinity. The finely to coarsely crystalline limestone is placed in the Bois d'Arc and the granular and finely crystalline limestone is considered to be equivalent to the Haragan. The Bois d'Arc in wells 1 and 2 is coarsely crystalline and has no chert and therefore is lithologically similar to the upper (Fittstown) member of the formation as described by Amsden (1957) nearby to the southwest.

Haragan Limestone and Henryhouse Limestone, Undifferentiated

Amsden's (1960, figs. 32 and 27) thickness and distribution studies of the Haragan and Henryhouse Limestones are useful for determining whether these formations are possibly present in wells 1 and 2. Amsden's studies projected eastward to the localities of these wells indicate to the author that the Haragan is probably present in both wells and that the Henryhouse is probably present only in well 2. There are, however, no adequate lithologic criteria which can be used to differentiate the two formations (Amsden, 1957, p. 30). For this reason these formations are discussed as a single undifferentiated unit in this report.

The undifferentiated Haragan-Henryhouse unit is 183 feet thick in well 1 and 216 feet thick in well 2. The unit is not present in any other section of rocks of Hunton age in wells on the cross section. The unit consists largely of granular to very finely crystalline limestone, which is mainly medium gray and olive gray. In each instance where dolomitic limestone is indicated in the unit in wells 1 and 2 the dolomite is in the form of very fine rhombs scattered in the limestone. The upper part of the unit in well 2 has a sequence of dolomite beds that are olive gray and are granular to finely crystalline.

The Haragan Limestone in normal sequence unconformably overlies the Henryhouse, which in turn unconformably overlies the Chimneyhill Limestone.

Chimneyhill Limestone

Reeds (1911) divided the Chimneyhill Limestone of Silurian age into three informal units which, in descending order he called the "pink crinoidal," the "glauconitic," and the "oölitic" members. Maxwell (1936) divided the Chimneyhill into four formally named units; formal names were proposed for the "pink crinoidal" and "glauconitic" members of Reeds, and the "oölitic" member of Reeds was divided into two members. Amsden

(1957) followed Maxwell's four-part division of the Chimneyhill but substituted new names for two of Maxwell's members because the names were preoccupied. The members of the Chimneyhill proposed by Amsden are, in descending order, the Clarita ("pink crinoidal"), Cochrane ("glauconitic"), Keel ("oölitic"), and Ideal Quarry. These units are not differentiated on cross section C-D, but they are recognizable in the subsurface.

The Chimneyhill Limestone is present in sections 1, 2, and 3 of plate II. The formation has a maximum thickness of 119 feet in section 3 and a minimum thickness of 42 feet in section 1.

The upper three members of the Chimneyhill are present in wells 1 to 3 and the lithology of the members is comparable to that of correlative units on the surface. Pink, red, and orange coarsely crystalline limestone in the "pink crinoidal" member, glauconite in light-gray granular limestone of the "glauconitic" member, and the oölitic texture of the "oölitic" member are readily recognizable in well samples. The Chimneyhill Limestone unconformably overlies the Sylvan Shale.

The St. Clair Limestone of Silurian age, which was originally described from outcrops in Independence County, northern Arkansas, was first recognized in northern Sequoyah County, Oklahoma, by Drake (1897). The formation dips southward and westward from the area of outcrop and is present in wells 7 to 14. The St. Clair is considered to be correlative with the "pink crinoidal" (Clarita) member of the Chimneyhill Limestone because of faunal (Amsden, 1957, p. 24-25; 1960, p. 64) and lithologic similarity. The formation ranges in thickness from 48 feet in section 11 to 211 feet in section 13.

The lower part of the St. Clair Limestone in sections 7 to 13 includes cherty and glauconitic limestone. This lithology is characteristic of the "glauconitic" member of the Chimneyhill in the Arbuckle Mountains, and these sections may include rocks equivalent to the "glauconitic" member. The St. Clair Limestone unconformably overlies the Sylvan Shale in eastern Oklahoma and the equivalent of the Sylvan, the Cason Shale, in Arkansas.

Rocks of Ordovician Age

ROCKS OF POST-SIMPSON AGE

In the Arbuckle Mountains the three formations of post-Simpson Ordovician age are, in descending order, the Sylvan Shale, the Fernvale Limestone, and the Viola Limestone. Each formation is characterized by a uniform and relatively distinctive lithology over the area in which it occurs, and the distinctive features permit ready identification of the units in well samples. Post-Simpson rocks of Ordovician age were completely penetrated in wells 1 to 14; wells 15 to 17 were not drilled deeply enough to encounter rocks of Ordovician age.

Sylvan Shale

The Sylvan Shale, the youngest formation of Ordovician age, was first described by Taff (1902) and named for exposures near the former village of Sylvan in Johnston County, Oklahoma.

The Sylvan Shale is present in sections 1 to 14 of plate I. The formation consists mainly of medium dark-gray, dark-gray, and greenish-gray dolomitic shale which is locally finely pyritic. Much of the shale is silty. One bed of dolomitic fine-grained sandstone also is present in well 4. No marked lithologic changes in the formation are apparent along the cross section. The maximum thickness of the Sylvan is 151 feet in section 1; the minimum thickness is 18 feet in section 14. The Sylvan unconformably overlies the Fernvale Limestone.

The Cason Shale of Arkansas is the correlative of the Sylvan Shale. The Cason is similar in lithology to the Sylvan and occupies the same stratigraphic interval (overlain by rocks of Silurian age and underlain by the Fernvale Limestone). The Sylvan is present in the subsurface east of section 4, in Sequoyah and northern Le Flore Counties, Oklahoma. The Cason is present in the subsurface in Crawford and Sebastian Counties, Arkansas, and eastward in the Arkoma basin.

Fernvale Limestone

The Fernvale Limestone of Oklahoma and Arkansas is equivalent to the unit that was originally described and named for exposures in the vicinity of Fernvale, Tennessee.

The Fernvale Limestone, present in sections 1 to 14, consists uniformly of light-gray to medium-gray finely granular to coarsely crystalline limestone which characteristically contains coarse pink or orange calcite crystals. Pyrite and glauconite are present locally in the limestone, and some of the limestone beds are thinly interbedded with dark-gray shale. The thickness ranges from 70 feet in section 2 to 23 feet in section 14.

In all sections of the Fernvale Limestone in the subsurface west of Sequoyah County, Oklahoma, the lower 10 to 40 feet of the formation contains rounded, very fine to medium grains of quartz sand. The quantity of sand in the lower 5 to 10 feet of the formation is variable. In some sections the limestone contains only scattered sand grains, and in other sections (1 and 6) the basal part of the formation is calcareous sandstone. The Fernvale Limestone unconformably overlies the Viola Limestone (sections 1 and 2), or the Corbin Ranch Formation and its correlatives where the Viola is absent.

Viola Limestone

J. A. Taff (1903) described the Viola Limestone from exposures near the village of Viola in Johnston County, Oklahoma. The Viola, as originally defined, included both the Fernvale and Viola Limestones of present usage. The name Viola was restricted as a result of subsurface stratigraphic work and the recognition of faunal differences between the upper and lower parts of the original Viola (Wengerd, 1948, p. 2187-91).

The Viola Limestone is present in sections 1 and 2. In these sections, as in outcrops in the northern part of the Arbuckle Mountains, the formation is composed of very light-gray to medium-gray finely granular to finely crystalline limestone that locally contains gray or brownish-gray opaque or translucent chert. The formation is 211 feet thick in section 1, 188 feet thick in section 2, and absent in all other sections. The Viola Limestone unconformably overlies the Corbin Ranch Formation.

SIMPSON GROUP

The stratigraphy of the Simpson Group has been the subject of a voluminous literature since the rocks of the group were originally described as the Simpson Formation by Taff (1903). Because the sandstone beds within the group are excellent oil reservoirs, a large part of this literature concerns the informal nomenclature used to identify these beds and the correlation of the sandstone beds from one area to another. The reader is referred to a paper by Harris (1957) for a synthesis of the paleontology and stratigraphy of the Simpson Group.

In the northeastern part of the Arbuckle Mountains the rocks of the Simpson Group are divided into five formations. These formations, in descending order, are the Corbin Ranch of Trentonian age, Bromide (restricted), Tulip Creek, McLish of Blackriveran age, and Oil Creek of Chazyan age (Harris, 1957). Only four of the formations can be identified in the well sections north of the Arbuckle Mountains; the Tulip Creek, if present, cannot be differentiated from the overlying Bromide Formation. The Bromide, McLish, and Oil Creek Formations in wells 1, 2, and 3 have basal units that are either sandy limestone or sandstone; the basal part of the Corbin Ranch Formation is essentially non-sandy.

Wells 1 to 14 were drilled deep enough to reach the rocks of the Simpson Group, which undoubtedly underlie all of the McAlester basin; nine of the wells were drilled through the group. The maximum thickness of the Simpson Group was encountered in section 1 (1,158 feet), and the minimum thickness in section 8 (360 feet).

Several changes in the thickness and lithologic character of the Simpson Group are apparent along cross section C-D. A general northeastward thinning of the group is largely accounted for by the truncation of the Bromide and McLish Formations beneath the Corbin Ranch Formation and its equivalent, the Fite Limestone. Available evidence indicates that limestone, which is the predominant rock type of the Bromide and McLish in section 1, is replaced by dolomite northeastward along the line of the cross section and that the ratio of sandstone to carbonate rock in the Bromide and McLish increases northeastward. These changes are discussed more completely in the following description of the formations.

Corbin Ranch Formation

A limestone unit at the top of the Bromide Formation, informally called the "Bromide dense," has long been recognized as a persistent lithologic unit in exposures in the northern part of the Arbuckle Mountains and in the subsurface north of the mountains. Harris (1957, p. 94-101) found that this unit contains a diagnostic ostracod fauna and that it is separated from overlying and underlying units by unconformities. As a result, Harris removed the so-called "Bromide dense" from the Bromide Formation and established it as a new formation, the Corbin

Ranch Formation. The type locality of the Corbin Ranch is a roadcut exposure in sec. 12, T. 1 N., R. 6 E.,* in Pontotoc County, Oklahoma. This locality is about 12 miles northwest of well 1.

In surface exposures Harris (1957, p. 87) included all limestone with lithographic or "birdseye" lithology in the Corbin Ranch Formation. This criterion is used here to identify the Corbin Ranch. Limestone of the Corbin Ranch along the cross section varies from very light gray to medium gray and ranges from very finely crystalline to dense. Dense gray limestone, which constitutes most of the formation in both the surface and subsurface, generally contains blebs of clear crystalline calcite which may be as large as 5 mm in diameter. This rock is the so-called "birdseye" limestone described in the type section of the formation (Harris, 1957, p. 96). In most sections the Corbin Ranch includes dolomite and dolomitic limestone. The dolomite is light gray to shades of olive gray and is granular to finely crystalline. Some of the basal beds of the formation contain fine to coarse quartz sand grains.

Most of the dense limestone of the Corbin Ranch Formation and equivalent units contains scattered minute rhombohedral crystals of dolomite few of which exceed ¼ mm in their longest dimension; some of the limestone contains scattered slender doubly-terminated euhedral quartz crystals which are less than ½ mm long. Both types of inclusions can be seen at magnifications of 6x after the fragments of limestone are slightly etched with 6N hydrochloric acid.

The Corbin Ranch Formation or its apparent equivalent, the Fite Limestone, is present in sections 1 to 14. The unit ranges in thickness from 18 feet in section 9 to 85 feet in section 3.

The Fite Limestone of northeastern Oklahoma and Plattin Limestone of northern Arkansas are apparently equivalent to the Corbin Ranch Formation. The Fite and Plattin are similar in lithology to the Corbin Ranch and occupy the same stratigraphic interval; both are overlain by the Fernvale Limestone and underlain by correlative units of the Simpson Group (Tyner-Burgen in Oklahoma and Everton in northwestern Arkansas).

The Corbin Ranch Formation and its equivalents overlap progressively older rocks of the Simpson Group in a northeast

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*Harris (1957, p. 95) designated the type section of this formation as the section described by Decker (1941, p. 663). Decker gave a location of sec. 12, T. 1 N., R. 6 E., on State Highway 48 for this section. This highway is now numbered State 99. On chart 3, Harris (1957, facing p. 74) incorrectly lists the location of this section as sec. 11, T. 1 S., R. 3 E., and the page reference to Decker as page 662.

direction along the line of the cross section. Available data indicate that in the McAlester basin the unconformity at the base of the Corbin Ranch has a rather large magnitude. In section 1 the Corbin Ranch overlies the Bromide Formation, and the base of the Corbin Ranch is 723 feet above the top of the Oil Creek Formation. In section 6 this interval is only 266 feet, and the Corbin Ranch lies upon the McLish Formation. In section 14 the Fite Limestone overlies sandstone beds considered to be equivalent to the basal part of the McLish Formation, and in exposures 13 miles north of Sequoyah County, Oklahoma, in sec. 36, T. 16 N., R. 22 E., the Fite rests upon the Tyner Formation, which is here correlated with the upper part of the Oil Creek Formation. It is not possible to determine, with present data, whether the progressive northeastward overlap of the Bromide and Tulip Creek beneath the Corbin Ranch-Fite is due to erosion prior to deposition of rocks of Corbin Ranch age or to nondeposition of the Tulip Creek and Bromide or to a combination of both.

Bromide Formation

In its typical development in the Arbuckle Mountains, the Bromide Formation, as redefined by Harris (1957, p. 85-94), is divisible into two units. The upper unit is finely to coarsely crystalline limestone which has thin shale interbeds; the lower unit is fine- to coarse-grained quartz sandstone. Lithographic limestone commonly found at the top of the Simpson Group is no longer included in the Bromide Formation (see discussion of Corbin Ranch Formation).

A section of the Bromide Formation, as restricted by Harris, is present at the type section of the Corbin Ranch Formation in sec. 12, T. 1 N., R. 6 E., Pontotoc County, Oklahoma. Harris' reconstruction of this section (1957, chart 3), based on Decker's lithologic description (1941, p. 663), indicates that the basal sandstone of the formation is absent in this section.

The Bromide Formation is present in sections 1 to 5; it is truncated by the Corbin Ranch between wells 5 and 6. The maximum thickness of the formation (273 feet) occurs in section 1, and the minimum thickness (110 feet) occurs in section 5.

The lithology of the carbonate rocks in the Bromide Formation is variable. In section 1 the formation is chiefly light- to medium-gray granular to finely crystalline limestone. Dolomitic limestone found in the upper part of the Bromide in section 1 contains very fine dolomite rhombs. In sections 3 to 5 the carbonate rock consists almost entirely of dolomite which is very light to light gray, olive gray, and brownish gray and is finely crystalline to granular. The carbonate rock in section 2 is a sequence of both limestone and dolomite; the limestone is similar to that in section 1, and the dolomite is similar to that in section 3.

The Bromide Formation includes two units of sandstone and sandy carbonates that are generally called the "First and Second Bromide sands" or the "First and Second Wilcox sands" (Jordan, 1957, p. 26). These two units, which are zones of prolific oil production in the subsurface north of the Arbuckle Mountains, are represented in wells 1 to 3 of this report (plate II). The upper interval in these three sections is a single sandstone bed; the lower interval consists of three sandstone beds in wells 1 and 2 and four sandstone beds in well 3 (plate II). The two units cannot be differentiated in well 5.

The Bromide Formation is 273 feet thick in well 1 and 195 feet thick in well 3. This northeastward thinning is accompanied by a thinning of the interval between the upper and lower sandstone units of the formation; in wells 1 and 2 the sandstone units are separated by approximately 170 feet of limestone, dolomite, and shale, and the two units in well 3 are separated by approximately 85 feet of dolomite and shale. It thus appears that depositional thinning accounts in part at least for the northeastward thinning of the Bromide.

The Bromide Formation unconformably overlies the McLish Formation.

McLish Formation

The section of the McLish Formation exposed on the P. A. Norris Ranch (sec. 2, T. 1 N., R. 6 E., Pontotoc County, Oklahoma), about 13 miles northwest of section 1, was described by Decker and Merritt (1931, p. 78-80). This section is similar in lithology and has nearly the same thickness as the formation in section 1. North and east of section 1 the formation becomes thinner, and limestone, characteristic of the formation in surface exposures and in section 1, is replaced by dolomite.

Complete thicknesses of the McLish Formation are present in 11 sections. Incomplete thicknesses are present in sections 2 and 7, and 4, 15, 16, and 17 were not drilled deep enough to encounter the McLish. The maximum thickness of the formation is 450 feet (section 1); the minimum thickness is 65 feet (section 14).

In section 1 the upper 235 feet of the McLish Formation consists predominantly of light- to medium-gray dense to finely granular and finely crystalline limestone and greenish-gray shale. The lower part of this limestone sequence contains reddish-brown and pale-orange calcite crystals; Decker and Merritt (1931, p. 80, bed No. 37) described "numerous blood-red spots" in the lower limestone of the McLish Formation in the Norris Ranch section (sec. 2, T. 1 N., R. 6 E.). The lower unit of the McLish in section 1, about 215 feet thick, is chiefly fine- to medium-grained white to very light-gray dolomitic or calcareous sandstone. A sequence of greenish-gray and yellowish-gray finely crystalline dolomite and greenish-gray shale is present just above the middle of this sandstone unit. The sandstone below this dolomite unit contains beds of light-gray granular to coarsely crystalline limestone.

Limestone in the McLish is replaced by dolomite to the north and east of section 1 and the amount of sand in the formation increases east of section 2. The upper 208 feet of the McLish in section 2 contains many beds of the dolomite and limestone. In section 3 and sections to the east the carbonate beds of the McLish are almost all dolomite that is very light gray, yellowish gray, olive gray, and greenish gray, and ranges from finely granular to finely crystalline. The sandstone in the formation is very light gray, yellowish gray, medium gray, and greenish gray and is composed of fine to coarse grains of quartz. The shale in wells 3 to 14 is dark gray and greenish gray.

In the 11 complete sections of the McLish Formation in this report, the formation apparently conformably overlies the Oil Creek Formation or equivalent rocks. Shale interbedded with sandstone in the lower part of the McLish Formation is similar to shale in the upper part of the Oil Creek Formation.

In the southernmost exposure of rocks of Simpson age in sec. 35, T. 15 N., R. 21 E., Cherokee County, Oklahoma, lithologic equivalents of the McLish Formation in wells 13 and 14 are not present. In this locality Huffman (1958, p. 171) reported that the rocks underlying the Fite Limestone assigned to the Tyner Formation are, in descending order, 12 feet of dolomite, 1.5 feet of sandstone, and 66 feet of shale. Huffman and Starke (1960) reported that the upper part of the Tyner contains a faunule of Blackriveran age. Because the McLish is the basal unit of Blackriveran age in the Arbuckle Mountains (Harris, 1957), it appears possible that the McLish of wells 13 and 14 may grade northward into a sequence of shale and dolomite equivalent to the upper part of the Tyner. In this report, however, the sequence of sandstone and shale of the McLish is lithologically different from rocks believed to be equivalent to the Tyner, and the McLish is differentiated as a separate formation.

In the subsurface in Sequoyah County, Oklahoma, rocks equivalent to the McLish are overlain by the Fite Limestone and underlain by the Tyner Formation. In eastern Crawford County, Arkansas, the St. Peter Sandstone occupies the same stratigraphic interval as the McLish in Sequoyah County, Oklahoma, and is overlain by rocks equivalent to the Fite (Plattin Limestone) and is underlain by rocks older than the McLish (Everton Formation). It is not possible with data available to determine whether the McLish correlates with the St. Peter Sandstone or the sandy phase of the Everton Formation in Crawford County, Arkansas.

Oil Creek Formation

The Oil Creek Formation, which is composed of limestone, shale, and a basal sandstone, thins northeastward within the area of outcrop in the Arbuckle Mountains. A regional cross section by Ham (1955, p. 30) shows that the thickness of the formation ranges from 803 feet in exposures in the south-central part of the mountains to 235 feet in the northeast. This trend of northeastward thinning is evident along the line of cross section (pl. II). The Oil Creek, which was completely penetrated in nine wells, ranges in thickness from 358 feet in well 1 to 182 feet in well 8.

The Oil Creek can be divided into an upper and lower unit in the west. In the east the two units are separate formations. On plate II this division is shown by a dotted line where the Oil Creek is recognized as a single formation.

The upper unit of the Oil Creek is an easily recognized sequence of shale and carbonate rocks which ranges in thickness from 30 feet in sections 11 and 14 to 62 feet in section 5. In sections 1 and 3 the upper unit consists of light- to medium-gray dense and granular to finely crystalline limestone and dark-gray shale. In section 1, limestone, which is glauconitic and in part shaly, is the dominant rock type in the unit. In section 3 dark-gray shale is dominant. In wells 5 to 10 the unit with some exceptions consists of shale and dolomite; the shale is dark gray, medium gray, and greenish gray, and the dolomite is light to dark gray and greenish gray, and is finely granular to finely crystalline. In wells 8 to 12 some blackish-red and dusky-red shale is present in the unit. One bed of very light-gray, fine- to medium-grained sandstone is present in the unit in well 14, and greenish-gray and dusky-red siltstone is present in well 10.

The lower unit of the Oil Creek Formation is composed largely of sandstone, shale, and dolomite. The unit has a maximum thickness of 304 feet (well 1) and a minimum thickness in well 8 (137 feet). The sandstone is white to very light gray and fine to medium grained. The grain size in the upper 50 feet of the lower unit generally is finer than the grain size in the lower part. Some medium grains are present locally in the upper 50 feet of the unit, but medium grains are more abundant in the lower part. Shale and dolomite comprise less than half of the lower unit of the Oil Creek. The shale, which generally is dark gray or greenish gray, is dolomitic and contains fine to medium sand. The dolomite in the lower unit of the Oil Creek is very light gray to medium gray, brownish gray, and greenish gray, and finely granular to finely crystalline; much of the dolomite also contains fine to medium sand.

The Oil Creek unconformably overlies rocks of the Arbuckle Group. The contact between the Oil Creek and the Arbuckle is determined by a change in gross lithology; the lower part of the Oil Creek is mainly sandstone and the upper part of the Arbuckle Group is largely dolomite. In sections 1 and 3 the upper part of the Arbuckle contains sandstone and the lower part of the Oil Creek includes dolomite. The Arbuckle Group east of section 3 has little or no sandstone.

In outcrops in the southern and western parts of the Arbuckle Mountains, the Joins Formation occupies the stratigraphic interval between the base of the Oil Creek and the top of the Arbuckle Group. Ham's surface studies of the Simpson Group indicate that the Joins decreases in thickness and is overlapped by the Oil Creek in a northeastward direction in the Arbuckle Mountains and is absent in the northeastern part of the area of outcrop of the Simpson Group (Ham, 1955, p. 29 and fig. 10). Harris (1957, p. 57) pointed out that there is a tendency of the Joins to become increasingly dolomitic in the subsurface and that dolomite in the Joins is practically indistinguishable from dolomite of the underlying Arbuckle Group. The Joins Formation was not recognized in the wells of this report.

In this report, rocks lithologically similar to the upper and lower units of the Oil Creek are correlated, respectively, with the Tyner Formation and the Burgen Sandstone of northeastern Oklahoma. Huffman and Starke (1960, p. 271) stated that "The faunule collected by Starke from the lower part of the Tyner formation suggests a Chazyan age for the lower Tyner and for the underlying Burgen sandstone, and establishes their equivalency to the Oil Creek formation of the Simpson group of south-central Oklahoma".

The Tyner Formation is less distinct in wells 13 and 14 than equivalent rocks in wells to the west. In these two sections the unit is thin and contains more sand (sandy shale in both sections and sandstone in section 14) than in other wells on the cross section. The Tyner probably grades into and becomes a part of the sandy phase of the Everton Formation in Crawford County, Arkansas. In two wells in Crawford County, Arkansas (Cities Service No. 1 W. R. Bruce, sec. 4, T. 11 N., R. 32 W., and Trumbo et al. No. 1 Craddock, sec. 3, T. 11 N., R. 30 W.), the uppermost part of the sandstone of the Everton Formation of that area contains one or two thin gray to greenish-gray shale beds similar to shale in the Tyner in sections 13 and 14.

The Tyner is a thicker and more distinct unit at the surface north of sections 13 and 14 in northeastern Oklahoma and in the subsurface in western Arkansas north of Crawford County. In the previous discussion of the McLish Formation it has been pointed out that the Tyner in that area may include rocks equivalent to the McLish Formation of this report. In sec. 35, T. 15 N., R. 21 E., Cherokee County, Oklahoma, the Tyner is 79 feet thick and is predominantly greenish-gray shale (Huffman, 1958, p. 171). In two wells drilled in southwestern Washington County, Arkansas, north of Crawford County, the Tyner, which was included in the upper part of the Everton Formation by Frezon and Glick (1959), is composed of dolomite and greenish-gray shale, and is as much as 50 feet thick.

The Burgen Sandstone in northeastern Oklahoma is equivalent to the lower unit of the Oil Creek Formation and apparently equivalent to part of the sandy phase of the Everton Formation of northwestern Arkansas (Frezon and Glick, 1959, pl. 21).

The sandy phase of the Everton Formation in northwestern Arkansas has been traced eastward along the outcrop in northern Arkansas and is known to correlate with beds in the middle of the lower part of the Everton Formation of north-central Arkansas.

UPPER PART OF THE ARBUCKLE GROUP

In the Arbuckle Mountains the two upper formations of the Arbuckle Group are, in descending order, the West Spring Creek and Kindblade Formations. In the Ozark uplift, in northeastern Oklahoma and northwestern Arkansas, rocks equivalent to the upper part of the Arbuckle Group are divided, in descending order, into the Powell Dolomite, Cotter Dolomite, and Jefferson City Dolomite.

Nine wells of this report (1, 3, 5, 6, 8, 9, 12, 13, and 14) penetrated rocks of the Arbuckle Group. None of these wells was drilled deep enough to completely penetrate the group; the maximum penetration of Arbuckle (451 feet) was in well 1. The Arbuckle consists of very light-gray to medium-gray granular to finely crystalline dolomite which contains varying amounts of chert, shale, and fine to medium sand. Some thin beds of fine- to medium-grained sandstone occur within the Arbuckle in some sections.

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APPENDIX

LIST OF WELLS ON CROSS SECTIONS (PLS. I, II) OF THIS REPORT

WELL NUMBER	NAME AND LOCATION	FORMATION AT TOTAL DEPTH	TOTAL DEPTH (FEET)
1	Rockhill Oil Co. No. 1 A. J. Fanning NE¼ NE¼ SW¼ sec. 35, T. 1 N., R. 8 E. Coal County, Oklahoma	Arbuckle Group	5,709
2	Magnolia Petroleum Co. No. 1 Hockett NE¼ SE¼ NE¼ sec. 10, T. 2 N., R. 8 E. Coal County, Oklahoma	McLish Formation	7,768
3	W. H. Pine No. 1 O. Busby SW¼ SE¼ NW¼ sec. 12, T. 4 N., R. 8 E. Pontotoc County, Oklahoma	Arbuckle Group	6,200
4	Amerada Petroleum Co. No. 1 T. J. Carder SW¼ NW¼ SW¼ sec. 12, T. 5 N., R. 9 E. Hughes County, Oklahoma	Bromide Formation	5,686
5	Phillips Petroleum Co. No. 1 C. W. Mandler SE¼ SW¼ SW¼ sec. 1, T. 6 N., R. 10 E. Hughes County, Oklahoma	Arbuckle Group	6,153
6	Pure Oil Co. No. 1 W. G. Rogers SE¼ SE¼ NE¼ sec. 18, T. 8 N., R. 12 E. Hughes County, Oklahoma	Arbuckle Group	5,051
7	Midcontinent Petroleum Corp. No. 1 K. Dorsey C SW¼ NE¼ sec. 12, T. 9 N., R. 13 E. McIntosh County, Oklahoma	McLish Formation	4,365
8	Carter Oil Co. No. 1 C. L. Follansbee SW¼ NW¼ SW¼ sec. 18, T. 9 N., R. 15 E. McIntosh County, Oklahoma	Arbuckle Group	5,461
9	Phillips Petroleum Co. No. 1 Ruby C NW¼ SW¼ sec. 30, T. 10 N., R. 16 E. McIntosh County, Oklahoma	Arbuckle Group	4,982
10	Carter Oil Co. No. 1 Graham C-309 NW¼ SE¼ NE¼ sec. 3, T. 9 N., R. 16 E. McIntosh County, Oklahoma	Oil Creek Formation (Burgen Sandstone)	5,259
11	Edwin D. Pauley No. 1 D. Bennett C SE¼ NE¼ sec. 18, T. 10 N., R. 18 E. McIntosh County, Oklahoma	Oil Creek Formation (Burgen Sandstone)	4,461
12	Midco Oil Co. No. 1 M. Dunagan SE¼ SE¼ NE¼ sec. 31, T. 11 N., R. 19 E. Muskogee County, Oklahoma	Arbuckle Group	3,024

WELL NUMBER	NAME AND LOCATION	FORMATION AT TOTAL DEPTH	TOTAL DEPTH (FEET)
13	Indian Territory Illuminating Oil Co. No. 1 J. J. Blake C SW¼ NW¼ sec. 3, T. 10 N., R. 21 E. Haskell County, Oklahoma	Arbuckle Group	3,007
14	Diamond Drilling Co. No. 1 J. Mullen C NW¼ sec. 5, T. 11 N., R. 23 E. Sequoyah County, Oklahoma	Arbuckle Group	1,956
15	Arkansas-Oklahoma Gas Co. No. 1 B. Berry C N½ SW¼ NE¼ sec. 23, T. 11 N., R. 25 E. Sequoyah County, Oklahoma	Penters Chert	3,241
16	Arkansas-Oklahoma Gas Co. No. 1 George Bieker C NW¼ SE¼ sec. 2, T. 7 N., R. 32 W. Sebastian County, Arkansas	Pitkin Limestone	5,812
17	Athletic Mining and Smelting Co. No. 1 W. Ayers C NW¼ SE¼ sec. 11, T. 7 N., R. 32 W. Sebastian County, Arkansas	Penters Chert	6,385