STATE OF ARKANSAS

Arkansas Geological and Conservation Commission

Norman F. Williams, Geologist-Director

INFORMATION CIRCULAR 21

SUBSURFACE GEOLOGY OF PRE-EVERTON ROCKS IN NORTHERN ARKANSAS

By

William M. Caplan

Little Rock, Ark.

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SUBSURFACE GEOLOGY OF PRE-EVERTON ROCKS IN NORTHERN ARKANSAS

By William M. Caplan

ABSTRACT

All or a major part of the Cambro-Ordovician sediments studied are Arbuckle-Ellenburger-Knox group equivalents. They lie on the south and southwest flanks of the Ozark dome.

Precambrian igneous rocks have been reported from six wells in northern Arkansas. Northerly trending structures mapped are attributed largely to draping over Precambrian highs.

Most faulting in the region is post-Arbuckle and probably occurred between mid-Mississippian and the end of Pennsylvanian time.

The pre-Everton Ordovician rocks are more prospective for fresh water than for petroleum in the report area. The water is introduced through outcrops in southern Missouri. Roubidoux and Gunter beds are the most prospective of these sediments for fresh water. Where water is present regionally downdip in the pre-Everton section, evidence suggests it will be brackish or saline rather than fresh. Cambrian potentialities for petroleum or fresh water are virtually unexplored.

Prospects for petroleum from the pre-Everton column are thought to be more promising southward and southeastward because of thicker sections, facies changes, and the presence of more source beds in those directions. Asphaltic-type material is fairly common in pre-Powell sediments in northern Arkansas.

INTRODUCTION

This study was initiated to examine the petroleum possibilities of the pre-Everton Cambro-Ordovician sediments in northern Arkansas. They have been non-productive to date.

All or a major part of the sediments studied are Arbuckle-Ellenburger-Knox group correlatives. Poorly understood stratigraphic relationships in the upper and lowermost parts of the Cambro-Ordovician column in the report area preclude closer definition.

The petroleum production histories of the correlative groups in nearby areas lent significance to the study.

Subsurface information for this report was derived chiefly from the examination of well cuttings by the writer. Limited insoluble residue studies were required for several wells. The quality of cuttings was generally good, as the area concerned has been drilled almost exclusively with cable tools. Fossils were too scarce in the cuttings to be of value.

The contour maps included in this report are intended for use on a regional rather than a local basis because of the limitations of subsurface control. The particular uncertainties of mapping across the Gulf Coastal Plain boundary precluded the use of Coastal Plain wells for control purposes. Formation tops used throughout the report must be regarded as tentative.

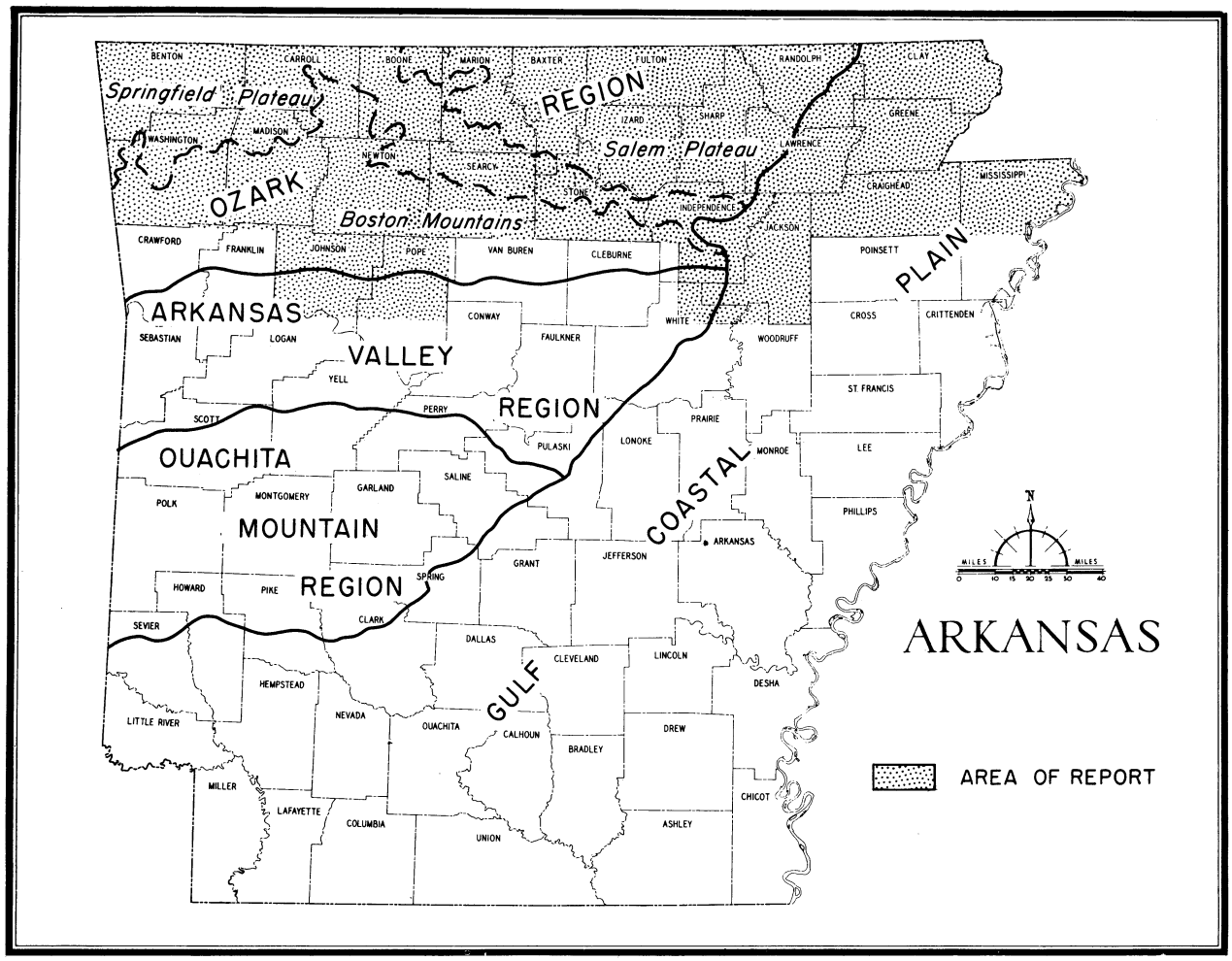

Figure 1.

Index map showing area of report and physiographic provinces.

ACKNOWLEDGMENTS

Acknowledgment is due the officials of the following cities in northern Arkansas for providing well cuttings or data pertinent to this study: Berryville, Cotter, Eureka Springs, Flippin, Gravette, Green Forest, Mammoth Spring, Marshall, Mountain Home, Rogers, Salem, and Tontitown.

In addition the writer wishes to thank the Arkansas Western Gas Company; the Magnolia Petroleum Company; the Millsap Oil and Gas Company of Siloam Springs, Arkansas; Thelma Poyner of Pocahontas, Arkansas; the U. S. Bureau of Mines, Rolla, Missouri; and the U. S. Geological Survey, Ground Water Branch, Little Rock, Arkansas, for furnishing well cuttings or data.

Acknowledgment is also due the Missouri Geological Survey for providing subsurface information from various wells drilled in southern Missouri and an insoluble residue log (No. 5406, by McCracken) for the Benedum-Trees No. 1 Mack well, Mississippi County, Arkansas.

Tentative formation tops for the Carnation Milk Company No. 1 water well, Benton County; the (Operator unknown) No. 1 Andrews well, Boone County; and the Baker Hospital water well, Carroll County (Table 3), were taken from Sheldon (1954).

STRATIGRAPHY

The area of report lies in the Ozark region of Arkansas on the south and southwest flanks of the Ozark dome. The Precambrian porphyry, felsite, and granite exposed in the St. Francois Mountains in southeastern Missouri represent the core of the dome.

In northern Arkansas progressively older formations outcrop northward and northeastward toward the exposed core. In the eastward extension of the Ozark region into the Arkansas Coastal Plain, progressively older Paleozoic beds are encountered at the base of the Upper Cretaceous column in the northerly directions.

The Ozark dome, also referred to in a broader sense as the Ozark uplift, did not achieve mountainous heights during its geologic history, but it stood as a landmark through much of Paleozoic time. Intermittent uplifts and subsidence created a number of unconformities within the pre-Everton section in northern Arkansas; however, these are considered to be of local significance only and probably are not in evidence downdip.

The pre-Everton interval, which consists mainly of dolomites and limestones in northern Arkansas, thickens and undergoes facies changes southward and southeastward. Correlatives outcropping in the Ouachita Mountain region are darker colored and predominantly clastics.

The Jefferson City is the oldest formation outcropping in the Arkansas Valley-Ozark regions of Arkansas. The exposures are limited to a few widely separated stream cuts in northern Marion, eastern Fulton, and northern Sharp Counties (Plate 1).

The Cotter dolomite is the principal pre-Everton outcrop in the area of this report. It is the surface rock over most of the Salem Plateau (Plate 1 and Figure 1).

The youngest pre-Everton formation exposed in northern Arkansas as shown in this report (Plate 1) is the Black Rock limestone. This interpretation is not necessarily accepted generally, as some geologists are of the opinion that the Black Rock limestone and the underlying Smithville limestone are facies of the Everton formation. A more detailed discussion of this controversy appears later in the report.

Pre-Jefferson City formations, encountered only in the subsurface within the area of report, have been identified and delimited by comparison with outcrop and subsurface sections in Missouri and subsurface correlatives in northeastern Oklahoma.

PRECAMBRIAN

Igneous rocks of Precambrian age have been reported from six wells in Arkansas. All of these wells were drilled in the area of this report. They are the Arkansas Publicity Bureau No. 1 Lay, Sec. 5, T. 19 N., R. 31 W., the Millsap Oil and Gas Company No. 1 Jones, Sec. 12, T. 19 N., R. 31 W., and the Ozark Production Company No. 1 Curry, Sec. 33, T. 18 N., R. 33 W., all in Benton County; the Independent Oil and Gas Company No. 1 Banks, Sec. 6, T. 16 N., R. 27 W., and the War Eagle Oil and Gas Company No. 1 Brener, Sec. 13, T. 15 N., R. 26 W., both in Madison County; and the Hulsey-Fletcher-Bailey Oil Corp. (Legion O & G Co.) No. 1 Baggett-Maupin, Sec. 30, T. 15 N., R. 31 W., Washington County.

The only record of the Lay well (T. D. 2,430 feet) is the driller's log, which reported "syenite" at 2,365 feet and an oil show from 2,400 to 2,425 feet. Croneis (1930, pp. 173-175) indicated that the latter show reported was "apparently well within the igneous basement," casting doubt on most of the other shows reported in the well.

The Jones well (T. D. 2,338 feet) was reported abandoned in granite with no reference to the depth at which the granite was encountered. Samples or other information are not available below 2,199 feet, at which depth the well was some 59 feet into the Lamotte sandstone. It is assumed that the well was abandoned upon encountering igneous rock or after penetrating a relatively small footage of igneous rock.

The Curry well (T. D. 2,236 feet) encountered light-gray to pink igneous rock, containing chiefly feldspar and quartz, between 2,205 feet and the total sample depth of 2,222 feet. The igneous rock has not been identified specifically but is either granite or rhyolite.

The Banks well (T. D. 2,515 feet), penetrated gray to red, very finely granular rhyolite between 2,397 feet and the total sample depth of 2,504 feet.

According to Miser and Ross (1925) the Brener well (T. D. 2,320 feet) encountered porphyritic rhyolite of Precambrian age from 2,286 feet to total depth.

The Baggett-Maupin well (T. D. 2,485+ feet) topped a "red sand" at 2,485 feet and drilled an unreported thickness of this rock. According to Croneis (1930, pp. 171-173) the "red sand" was red granitic arkose "basement" rock. However, he stated that the cuttings had not been examined and that the correlations below the St. Peter sandstone were guesses.

Skillman (1948) described a 1,245-foot section of pre-Upper Cambrian (pre-Lamotte) quartzites, siltstones, and shales from two wells in Vernon County, Missouri, and tentatively assigned these beds to the Precambrian. The drillers reported oil and gas shows from the section. No related beds have been identified in Arkansas.

CAMBRIAN

Lamotte sandstone: The Lamotte sandstone was encountered with assurance only in the above mentioned Curry and Jones wells. The thicknesses penetrated were 35 feet in the Curry well and about 59 feet, with a possible 150 feet plus, in the Jones well. In this latter well the 59-foot minimum is also arbitrary, as an 11-foot section of dolomite, chert, and sandstone just above the designated Lamotte top may be found later to be partially or entirely Lamotte rather than Bonneterre. If present in the Lay, Brener, and Baggett-Maupin wells, the Lamotte was not differentiated. If present in the Banks well, the Lamotte is dolomite rather than sandstone.

In the Ozark region of Missouri the Lamotte sandstone has achieved thicknesses up to 350 feet.

The Lamotte sandstone is fine to coarse-grained and white to yellow or red-stained. The sandstone is made up of subangular to rounded quartz grains, generally loosely cemented. Occasionally it is dolomitic. The Lamotte is often described as an arkosic sandstone because of the fragments of feldspar frequently present near the base of the formation, the feldspar having been derived from the underlying Precambrian igneous rocks.

The Lamotte is regarded as the oldest Cambrian formation in the area of this report. Generally it is correlated with the Reagan sandstone of Oklahoma.

Bonneterre dolomite: Rocks of Bonneterre age have been recognized only in the Curry and Jones wells, being about 60 feet thick in the former and 71 feet thick in the latter.

Bonneterre thicknesses range generally between 200 and 300 feet on the western flank of the St. Francois Mountains in Missouri, but the formation thickens rapidly and appreciably on the southeastern flank. In a well in Pemiscot County, Missouri, a Bonneterre section measuring some 1,580 feet was encountered, according to Grohskopf (1955).

The Bonneterre in northern Arkansas is principally a light-gray, finely granular to medium-crystalline, glauconitic, pyritic dolomite. Small amounts of white to light-gray, dense chert may be present. A few very fine fragments of dark-gray to black shale have been observed in well samples. Sandy phases are generally encountered near the base of the formation, where it is underlain by the Lamotte sandstone. McQueen (1931) considered an abundance of glauconite a distinguishing field characteristic of the formation.

The aforementioned Banks well in Madison County, Arkansas, may have a Bonneterre section present. If so, however, it is non-glauconitic dolomite.

The contact of the Lamotte and Bonneterre is reported to be disconformable or gradational.

Davis-Derby-Doerun formations: None of these formations has been identified in Arkansas. The Davis, in Missouri, is essentially a finely granular, shaly, sandy dolomite, becoming very sandy near the base. It contains glauconite, but less abundantly than the Bonneterre. It achieves thicknesses of several hundred feet in the Missouri Ozark region.

Derby-Doerun beds are generally finely granular, argillaceous dolomites which in part are also cherty, sandy, silty, glauconitic, or fossiliferous. The combined thickness of these formations ranges up to about 150 feet near their type localities in Missouri according to Grohskopf and McCracken (1949).

Some geologists arbitrarily consider the lower limit of Arbuckle correlatives in the southern Missouri-northern Arkansas region as coinciding with the top of the Cambrian clastic residues noted by McCracken (1955, p. 50) within the Derby-Doerun interval. However, this correlation is disputed by others who regard the entire post-Lamotte Upper Cambrian section as an Arbuckle group equivalent.

Potosi-Eminence dolomites: These formations are undifferentiated in northern Arkansas. The banded quartz druse often regarded as characteristic of the Potosi has not been observed in the area of report, although this is not in itself conclusive evidence that the Potosi is absent.

In western Missouri several wells reveal a break in the Upper Cambrian section resulting in Eminence beds resting directly on Bonneterre. Similar conditions have been encountered in the aforementioned Curry and Jones wells, and possibly the Banks well, in northern Arkansas, where the Davis-Derby-Doerun formations, and possibly the Potosi, are missing.

The Potosi-Eminence undifferentiated interval in northern Arkansas consists chiefly of light-colored, finely to coarsely crystalline dolomite with white to light gray, dense chert, sometimes containing siliceous oolites. Also, occasional traces of green shale and glauconite are present in the Potosi-Eminence sequence. The upper part of the Eminence may contain very thin sandstone or sandy dolomite lenses.

Thicknesses of the undifferentiated interval penetrated in the area of report range between 307 feet and 384 feet. The former thickness occurs in the Independent No. 1 Banks well and is valid only if the entire interval from Precambrian to Potosi-Eminence is absent. In southern Missouri the Potosi-Eminence section achieves thicknesses up to 900 feet.

The easternmost section of Arbuckle correlatives examined during this study was penetrated in the Benedum-Trees No. 1 Mack well, Sec. 3, T. 15 N., R. 12 E., Mississippi County, Arkansas, in the Gulf Coastal Plain, south of Pemiscot County, Missouri. No accurate thickness of Potosi-Eminence rocks could be obtained as the well was still in this interval at the total depth of 4,535 feet after having drilled some 215 feet of these beds.

The Eminence marks the top of the Cambrian section in northern Arkansas. All of the beds from the Eminence to the Precambrian are considered to be Upper Cambrian in age.

Gasconade-Van Buren formations: These units are undifferentiated in northern Arkansas. The Van Buren in parts of Missouri is mentioned in the literature variously as a formation (Grohskopf and McCracken, 1949; and McQueen, 1931) and as a member at the base of the Gasconade dolomite (Twenhofel et al, 1954). The Gasconade and Van Buren are treated arbitrarily in this report as undifferentiated formations to facilitate discussion.

The Gunter member at the base of the Gasconade-Van Buren interval represents the oldest Ordovician rock in the area of report. Generally the Gunter is described as a sandstone which may contain a few thin sandy or silty dolomite beds. However, the sections regarded as Gunter in the Ozark Production Company No. 1 Curry well and the City of Salem No. 1 water well are sandy dolomites, and the presumed Gunter in the City of Mountain Home No. 3 water well is a sandy dolomite with a thin basal sandstone. In the Millsap No. 1 Jones well the Gunter has been defined arbitrarily as a 16-foot sandstone (from 1,654 to 1,670 feet) with an underlying 15-foot section of dolomite and quartz sand grains. The lower 15 feet may be found ultimately to be part of the Potosi-Eminence instead.

The Gunter may be absent in the Benedum-Trees No. 1 Mack well as noted later in this section.

Knight (1954) pointed out two rock types in the southern Missouri subsurface representing the Gunter member, one being a sandstone and the other a sandy dolomite.

With one exception the Gunter thicknesses penetrated in the report area range upward to 40 feet, which compares with the thicknesses of the Gunter member observed in Missouri. The exception occurs in the Arkansas Western Gas Company No. 1 Bray well, Boone County, which contains approximately 100 feet of Gunter where 40 to 50 feet would be expected. Although faulting might explain it, the writer is of the opinion currently that the thickening represents a stream channel deposit or the filling of a solution cavity or slump structure.

The Gunter in the report area is mainly white to light-gray sandstone consisting of fine to coarse, subangular to rounded, frosted quartz grains. Near the Eminence contact it is very coarse grained locally. The sandstone is generally loosely cemented either by silica or by calcareous material. In the Curry well the Gunter is represented by light-gray, finely granular to finely crystalline, sandy to finely sandy dolomite. The Gunter in the Salem and Mountain Home water wells is mainly gray to buff, finely to medium-crystalline dolomite with fine to medium, rounded, frosted quartz grains.

In northern Arkansas the Gasconade-Van Buren formations, exclusive of the Gunter member, are essentially light-colored, finely granular to medium-crystalline, in part vuggy, dolomites containing white, light-gray, or blue-gray, dense cherts, which are sometimes oolitic. The cherts in the lower part of the section occasionally are slightly sandy or may contain dolomite rhombs.

The Gasconade-Van Buren interval appears to thicken and become more coarsely crystalline east-southeastward from Benton County, Arkansas.

The thickness of the Gasconade-Van Buren undifferentiated section penetrated in northern Arkansas ranges between 319 feet and 600 feet, excluding the Gunter member.

A possible maximum interval of 715 feet, consisting mainly of dark, dense limestone with subordinate dark cherts, was encountered in the Benedum-Trees No. 1 Mack well. No Gunter was identified in this well. It is either absent or is represented by a limestone aspect.

The Gasconade-Van Buren section rests unconformably on the Eminence formation.

Roubidoux formation: The Roubidoux in northern Arkansas consists of dolomite, sandstone, and subordinate chert. The dolomite is chiefly light-colored, finely granular to medium-crystalline, and sandy or cherty in part. An occasional trace of greenish-gray, pyritic shale or black shale is noted in the dolomite sections. The sandstones found throughout the formation consist of white to light-gray, fine to medium, angular to rounded, frosted quartz grains. They are loosely cemented to well-cemented by silica or by calcareous material and are sometimes cherty. The cherts in the formation are generally dense and light-colored, although blue-gray and black cherts have been noted. Occasionally dolomite rhombs are present in the cherts. Sandy and

quartzose, oolitic cherts may be present. An abundance of brown quartzose oolite is considered representative of the Roubidoux. In gross examinations of well cuttings sandstones or sandy dolomite beds are used to delimit both the top and base of the Roubidoux formation.

In the area of report the Roubidoux formation ranges in thickness between 132 feet and 455 feet. The 455-foot section tentatively identified as Roubidoux was encountered at 3,150 feet in the Benedum-Trees No. 1 Mack well. In this well the formation consists of dark-gray limestone to sandy limestone and dark chert which is oolitic in part.

Another well in the Gulf Coastal Plain of Arkansas, the Tennark No. 1 Martin, Sec. 35, T. 14 N., R. 3 E., Craighead County, also penetrated a section identified as Roubidoux at 4,819 feet. Some 273 feet of gray and brown limestones occupy the interval assigned to the Roubidoux. The well was still in this formation at the total depth of 5,092 feet.

The Roubidoux is reported to rest uncomfortably on the Gasconade.

Jefferson City dolomite: The Jefferson City beds in the subsurface consist chiefly of light-colored, finely granular to medium-crystalline, in part silty, dolomites. Light-colored, oolitic cherts are common to the formation. The top of the Jefferson City formation is sometimes delimited arbitrarily in well cuttings by the presence of abundant free, gray to brown, siliceous oolites. Minor beds of sandstone or sandy dolomite and grayish-green shale have also been encountered in the subsurface.

On the outcrop beds similar to those above are present as well as buff to gray, fine-grained, argillaceous, soft, chalky, weathered beds called "cotton rock."

The thickness range of Jefferson City beds penetrated in northern Arkansas wells is 100 feet to 496 feet. On the outcrop thicknesses in excess of 350 feet have been measured.

In the aforementioned wells in the Gulf Coastal Plain the No. 1 Mack well contains about 345 feet of dark-gray limestone and gray to tan, in part oolitic, chert correlated as Jefferson City. In the No. 1 Martin well about 420 feet of Jefferson City section has been delimited. It consists principally of gray limestone, sandy in part, and occasional gray to brown chert.

Two other wells drilled in the Gulf Coastal Plain of Arkansas also penetrated appreciable sections regarded as Jefferson City. These are the Arkansas Oil Ventures (Deardorf) No. 1 Doggett, Sec. 31, T. 10 N., R. 3 W., Jackson County, and the Magnolia Petroleum Company No. 1 Sturgis, Sec. 30, T. 9 N, R. 3 W., Woodruff County.

The Jefferson City in these wells is mainly gray to brown, medium-crystalline dolomite and dolomitic limestone, with traces of white to brown cherts and dolomitic sandstone. Actual thicknesses in both wells could not be determined, because drilling terminated in the Jefferson City. The thicknesses in each well are inferred to be between 350 and 550 feet.

The Jefferson City is reported to overlie the Roubidoux formation disconformably.

Cotter dolomite: The Cotter is generally undifferentiated from the underlying Jefferson City, both in the subsurface and on the surface in northern Arkansas, because of the lithologic similarities of the two formations. In some wells the base of the Cotter is marked by a thin bed of sandstone or sandy dolomite. An example of the basal sandy dolomite is found in the Camden Oil Company No. 1 Grissom well, Sec. 17, T. 15 N., R. 31 W., Washington County. The Poyner No. 1 Adams well, Sec. 13, T. 20 N., R. 1 E., Randolph County, offers a good example of the basal sandstone development. The Cotter in the Adams well has a maximum thickness of 285 feet. The initial samples available were from 40 feet, at which depth the well was in the Cotter; however, there may be a very thin section of Powell present.

Differentiation between Powell and Cotter beds is sometimes aided by the presence of roughly spherical oolites, pitted like golf balls, which are considered representative of the Cotter in such cases. In the City of Rogers water well oolites of this type were used, in conjunction with other evidence, to effect a Cotter-Powell separation. The presence of these oolites does not necessarily mark the top of the Cotter formation. Similar oolites, reported in Missouri by Grohskopf and McCracken (1949), were assigned by them to the middle unit of a three part differentiation of the Cotter.

The Arkansas Louisiana Gas Company No. 1 Hudson well, Sec. 15, T. 10 N., R. 24 W., Johnson County, is the southernmost well examined in the report area west of the Coastal Plain that contains Arbuckle correlatives as old as Cotter. A 145-foot section of gray to buff, finely crystalline, cherty dolomite,

encountered at 5,990 feet, was assigned to the Cotter formation. The well was still in the Cotter at the total depth of 6,135 feet.

In the Tennark No. 1 Martin well, the Cotter is not differentiated from the overlying Powell formation. Very little, if any, Cotter is present in the Benedum-Trees No. 1 Mack well because of the major truncation of Paleozoic beds immediately beneath the Upper Cretaceous section in the Gulf Coastal Plain. The Cretaceous-Paleozoic contact in the well was drilled at 2,805 feet.

In the Ginther No. 1 Gordon well, Sec. 22, T. 19 N., R. 7 E., Clay County, in the Coastal Plain, the Upper Cretaceous section is directly underlain by gray-brown dolomite presumed to be Cotter. In the Texas Piggott No. 1 Sallee well, Sec. 11, T. 20 N., R 8 E., Clay County, buff dolomite and gray to tan, in part tripolitic, chert of Cotter or Jefferson City age were encountered immediately under the Upper Cretaceous section. Both wells were terminated shortly below the Cretaceous-Paleozoic contact.

The Magnolia Petroleum No. 1 Sturgis well contains about 506 feet of Cotter. The Arkansas Oil Ventures No. 1 Doggett well has an estimated 527-foot Cotter section. However, the Jefferson City-Cotter contacts are poorly defined in both wells. The Cotter intervals in these wells, especially in the Doggett, contain more dolomitic limestone than they do in other wells examined to the northwest, outside the Coastal Plain area. Despite this, the Cotter and Jefferson City beds in the Sturgis and Doggett wells have greater apparent similarity under the microscope than the corresponding sections have in wells outside the Coastal Plain. The marked decrease in chert within the Cotter-Jefferson City intervals in the Sturgis and Doggett wells adds to the difficulty in separating the two formations.

These relationships suggest southeasterly facies changes within the interval of Arbuckle equivalents in northern Arkansas. The change from a dolomitic pre-Everton Ordovician section to a section that is essentially limestone between wells outside the Coastal Plain and the Mack and Martin wells supports this premise.

West of the Coastal Plain area, the Cotter includes abundant light-colored, pyritic chert, often containing dolomite rhombs, which serves to differentiate between the Cotter and the overlying Powell beds.

Among wells in which the Cotter has been delimited with some assurance, it has a thickness ranging up to 527 feet.

The Cotter-Jefferson City contact is generally regarded as disconformable.

Powell dolomite: The Powell is a light to dark-gray or brown to black, granular to medium-crystalline, silty, shaly, dolomite. Infrequently, thin-bedded sandy dolomites or dolomitic sandstones are present. The Powell sometimes contains thin, dolomitic limestone beds; thin layers of gray to brown, dense, in part oolitic chert; and thin, black to grayish-green, finely pyritic, dolomitic shale beds. Traces of lavender chert have been noted. Lavender chert was reported also in northeastern Oklahoma by Ireland (1946), who mentioned it as an unusually diagnostic Powell residue in most places within 35 miles of Tulsa, Oklahoma.

The Powell ranges up to 223 feet in thickness in the wells examined west of the Coastal Plain area. At 5,780 feet the Arkansas Louisiana Gas No. 1 Hudson well encountered a 210-foot interval of gray to buff, finely crystalline, in part silty, sandy, cherty dolomite regarded as Powell.

In the Cosden No. 1 Shackleford well, Pope County, an interval of gray to grayish-black, finely crystalline, finely sandy dolomite with traces of limestone and gray, fine-grained sandstone was drilled between 4,876 feet and total depth. This section is considered to be Powell.

A 223-foot section regarded as Powell was drilled between 4,850 feet and total depth in the Deep Rock No. 1 Sample well, White County. The Powell was tentatively delimited in this well on the basis of a change from light-gray, finely granular to finely crystalline, very finely to medium sandy limestone and dolomite to an interval consisting mainly of dark-gray, finely granular to finely crystalline, silty limestone and dolomite.

Locally, as in the Baker Hospital water well, Sec. 15, T. 20 N., R. 26 W., Carroll County, the Powell may be cut out by the unconformity at the base of the Devonian(?)-Mississippian Chattanooga shale.

In the Coastal Plain the Magnolia Petroleum No. 1 Sturgis and the Arkansas Oil Ventures No. 1 Doggett wells penetrated approximately 404 feet and 362 feet of Powell at 5,065 feet and 3,853 feet, respectively. The Powell sec-

tions in these wells include subordinate beds of dolomitic sandstone.

The Powell may be cut out in the Coastal Plain by the profound unconformity at the base of the Upper Cretaceous section.

The contact of Powell and underlying Cotter beds has been described both as conformable and as one of erosional unconformity. The contact between the Powell and the overlying Everton formation is reported as one of unconformity, although the Everton basal breccia sometimes present in outcrops has not been noted in well samples.

Smithville formation: The Smithville has been identified tentatively on the outcrop in northern Arkansas only in Lawrence, Randolph, and Sharp Counties. It is mainly a gray, finely granular, dolomitic limestone which may grade into dolomite locally. It weathers to white or drab colors. A small amount of sandstone has been noted in the unit. Lead and zinc minerals may be present, presumably being in greatest concentration near the base of the Smithville. Pink, mineral dolomite is also found in the ore zones.

In southeastern Missouri the Smithville-Powell interval contains brown, quartzose cherts, some dolomoldic chert, and bentonite.

Graptolites, gastropods, and cephalopods found in the Smithville in northern Arkansas were used to establish a Lower Ordovician age for the unit. McKnight (1935) suggests that the Smithville-Black Rock sequence may represent the eastward extension of at least part of the Everton formation. Contrary to that, unpublished work by Ulrich suggests that the Smithville-Black Rock interval is younger than Powell and older than Everton.

The Smithville outcrop may contain as little as 65 feet of section or as much as 200 feet. Both figures have been assigned to the unit as approximate maximum thicknesses at various times.

Only four wells in or near the Coastal Plain area in Arkansas have penetrated sections that may represent the Smithville or its equivalent. In these wells the possible Smithville interval is darker gray, more argillaceous, and appears to be less fossiliferous than in the outcrop area, although some silicified bryozoans have been noted. The wells are indicated in Table 3.

If the Smithville-Black Rock sequence extends into the subsurface of the Arkansas Valley, it is probably present mainly in the Independence-White County areas.

The Powell-Smithville stratigraphic relationships have not been defined adequately in Arkansas. Branner (1938) reported an unconformable contact at and around Smithville, Lawrence County, Arkansas.

Black Rock formation: The Black Rock outcrop tentatively identified in northern Arkansas parallels that of the Smithville. It is somewhat more extensive, having been identified in Independence County as well as in Lawrence, Randolph, and Sharp Counties.

The Black Rock is made up chiefly of the same type of gray, finely granular, dolomitic limestone as the Smithville. It may also contain dolomite beds and small amounts of sandstone. Lead and zinc minerals may be present but are thought to be in lesser concentrations than in the Smithville.

No Black Rock beds have yet been identified in southeastern Missouri.

Graptolites, brachiopods, sponges, and bryozoans found in the Black Rock establish it as Lower Ordovician in age. If the Black Rock is not simply an eastward aspect of the Everton formation, it may be the youngest Arbuckle group equivalent in northern Arkansas. At present the upper limit of Arbuckle equivalency can only be drawn arbitrarily somewhere between the base of the Everton and the top of the Powell.

The Black Rock on the outcrop has been assigned maximum thicknesses ranging between 55 feet and some 200 feet. A lack of good outcrops and base maps in the Smithville-Black Rock outcrop area precludes more accurate measurements at this time.

The four wells in or near the Coastal Plain containing possible Black Rock or equivalent beds are listed in Table 3.

In these wells the possible Black Rock interval is dark-gray, slightly sandy, in part fossiliferous, dolomitic limestone. Some tan to brown, translucent chert is present.

The Black Rock is reported to overlie the Smithville unconformably and to be overlain unconformably by the Everton formation.

Most pre-Everton beds in the area of report have an average regional dip to the south. Locally, southwestern or southeastern dips become predominant. The dips vary approximately between 20 and 50 feet per mile through the region.

The limitations of the Smithville-Black Rock outcrops and the presumed subsurface extensions of these beds suggest a Cambro-Ordovician basin developed chiefly in the Coastal Plain.

The presence of northerly trending structures in northwestern Arkansas is attributed initially to the draping of Paleozoic beds over Precambrian highs having those dominant trends, whether such highs were topographic or structural. Subsequent vertical movement along these trends established the structures in younger Arbuckle beds.

The magnitude of such uplifts was, for the most part, only in the hundreds of feet, with the folding generally becoming less apparent upward; therefore, only comprehensive examinations would reveal the surface expressions of many of the smaller structures in the area of report.

Croneis (1930, p. 186) discussed an Ordovician inception for the Osage anticline, whose surface axis trends between Sec. 16, T. 18 N., R. 23 W., and Sec. 9, T. 21 N., R 25 W., Carroll County, Arkansas. He based his contention on the fact that the Cotter outcrops have been somewhat more elevated than those of the Boone formation.

In the southern portions of the Ozark region, especially in the Boston Mountains, deformations occurring during Pennsylvanian time, with possible beginnings in mid-Mississippian time, are thought to have masked some of the older, northerly structural patterns by superimposing on them more pronounced east-west trending structures.

Some small anticlines and synclines in the report area probably owe their origins to solution and subsidence.

Most of the faulting in northern Arkansas is post-Arbuckle in age and probably occurred between mid-Mississippian time and the end of Pennsylvanian time.

The faults are generally high-angle, normal faults of small vertical displacement. A few faults have a small horizontal displacement only. Surface traces of faulting in this region range between east-west and approximately north-south, with the dominant trends varying from east-west to southeasterly. The downthrown sides of the faults trending essentially east-west are south of the fault traces for the most part; whereas, the downthrown sides of the faults trending north-south are chiefly east of the fault traces.

The Arkansas Western Gas Company No. 1 Bray well, NE NW SE Sec. 24, T. 18 N., R. 22 W., Boone County, Arkansas, may have cut a northerly trending, high-angle reverse fault. The surface trace of this possible fault would be east of the well. The fault would pass at depth between the Bray well and the King No. 1 Lee well, NE SW Sec. 24, same township and range. The downthrown side of the fault would be east of the trace. Estimated displacement would be 250-300 feet. The implication of faulting is based mainly on an increase in thickness of the Mississippian Boone section from about 372 feet in the Lee well to 640 feet in the Bray well. However, the repetition of section needed to support the fault premise is not clearly in evidence. The post-Boone Mississippian section in the Bray well is only about half as thick as the corresponding section in the Lee well. Assuming the fault to be present, the column in the Bray well might suggest a structure rising at least as far back as Batesville-Moorefield time with subsequent faulting during or at the end of Pennsylvanian time. Each of the pre-Boone beds mapped in the Bray well is somewhat higher structurally than the corresponding bed in the Lee well, but the thicknesses of the respective beds are comparable in the two wells.

The approximate doubling of thickness of the Ordovician Gunter member in the Bray well was mentioned elsewhere in this report as being suggestive of possible faulting. Following that premise a Pennsylvanian or younger fault could have developed along an Ordovician fault plane.

No fault has been shown between these wells on the accompanying maps, as its presence is too conjectural. The thickening of the Gunter member, as well as the respective thickening and thinning of the Boone and post-Boone Mississippian sections in the Bray well, can be justified by means other than faulting.

The Salem No. 1 well may have been drilled on the downthrown side of a fault, based on the thickness of the Gasconade-Van Buren interval in the well. If such a fault does exist, it has a probable displacement of about 150 feet.

The existence of the fault shown in T. 19 N., R. 23 W., on Plates III and V, is conjectural at the depths indicated. The fault, as mapped, occupies the approximate position of the Green Forest fault discussed by Croneis (1930, pp. 197-198).

OIL AND GAS POSSIBILITIES

The pre-Everton Ordovican column in most of the area of report is not considered very prospective for the accumulation of oil or gas in commercial quantities. The potential pre-Everton Ordovician reservoir beds of northern Arkansas are exposed on the surface in southern Missouri where they collect fresh water and become ground water aquifers downdip. This applies chiefly to the Roubidoux formation, the Gasconade-Van Buren vuggy dolomites, and the basal Gunter member of the Gasconade-Van Buren section.

The presence of fresh water would not, in itself, rule out the possibilities for petroleum production. However, coupled with the lack of shows and other prevailing conditions, it is the writer's opinion that the area in question will be more important in general as a source of fresh water than of petroleum from the beds mentioned above.

In the Arkansas Oil Ventures No. 1 Doggett well, Jackson County, an undetermined pre-Powell interval yielded water with a chloride ion concentration of 17,000 parts per million. A chemical analysis of water from the Benedum-Trees No. 1 Mack well, Mississippi County, indicated sulpho-saline water in the Jefferson City, Roubidoux, Gasconade, and Eminence formations and an increase in mineralization with depth (Grohskopf, 1955). Evidence of this nature suggests that fresh water is supplanted downdip regionally by brackish, saline, or sulpho-saline water. However, it is conjectural whether this would result from structural barriers, facies changes, or a change from one water system to another through a series of interfaces in a common aquifer.

Pre-Gunter beds in northern Arkansas are virtually unexplored; consequently, the prevalence and quality of hydrocarbons or water in them is unknown. Draping of the Cambrian beds over basement rock or wedging-out of the beds against basement rock could result in the presence of petroleum reservoir conditions. The Lamotte appears to be the most promising unit in those respects.

A pre-Everton test for oil or gas in the report area cannot readily be reconciled at this time unless it is a basement test.

Asphaltic-type material is fairly common throughout the pre-Powell column in northern Arkansas, frequently being found in conjunction with water. Abundant black viscous material of petroliferous nature was found through the Gasconade and Eminence sections, from approximately 3,700 feet to total depth, in the Benedum-Trees No. 1 Mack well.

Downdip from the report area petroleum possibilities from pre-Everton rocks are thought to be enhanced by formation thickening, facies changes, and an increase in potential source beds in the column.

FRESH WATER POSSIBILITIES

The most important natural resource derived from the pre-Everton section of northern Arkansas at this time is fresh water. A number of cities and individuals in that region already rely heavily upon these ground water supplies, especially in areas where surface waters are not readily available or necessitate unusual expenditures to utilize them.

Both the Cotter dolomite and the Powell-Everton contact supply water to springs. However, the only post-Eminence, pre-Everton beds that have yielded water to wells most consistently in useful quantities have been the Roubidoux and the Gunter member at the base of the Gasconade-Van Buren section. The vuggy dolomites in the latter section, frequently referred to by drillers as "rotten zones", also yield water, but it is generally

commingled with Roubidoux water and difficult to gauge.

Among the unevaluated pre-Gunter beds in the report area, the Potosi-Eminence and Lamotte sections may have fresh water potentials, although little to no water has been reported from the few wells that penetrated them. Since most of the deep water wells drilled to date in northern Arkansas have apparently satisfied the initial fresh water requirements from the Roubidoux or Gunter, the pre-Gunter section has not received much attention.

Water wells that commence drilling in beds as old as Cotter should be planned initially as Gunter tests. If the Roubidoux does not yield adequate quantities of water, the Gunter should then be investigated. Generally the combined water from the Roubidoux-Gasconade-Gunter beds will be adequate for ordinary needs. The Roubidoux and the Gunter may each yield up to 300 gallons per minute; however, it is generally necessary to drill both to get a total of 50 gallons per minute or more. Acidizing the section from the Roubidoux to the Eminence with commercial hydrochloric acid can be highly beneficial in increasing yields. The City of Rogers, Arkansas, has used this method with considerable success.

Some water wells in northern Arkansas commence drilling in the Mississippian Boone formation, or even younger beds, but are forced to try for Roubidoux or Gunter water because of inadequate local post-Powell potentials. In these wells the Boone may be underlain directly by the Chattanooga shale, the Sylamore sandstone, or progressively downward by both. This combination may furnish some water in the above wells, but it often contains hydrogen sulfide derived from pyrite in the Chattanooga or Sylamore beds. In that event such water muct be cased-off to prevent contamination of the fresh water derived from the older beds in the well.

Within the area of report where the pre-Everton section contains fresh water aquifers, the potentials from these beds are expected to become poorer toward the south and southeast. In the No. 3 city water well drilled in 1948, at Marshall, Searcy County, Arkansas, the Roubidoux section yielded little or no water. Unfortunately this well was not deep enough to test the Gunter, as only about 50 feet of Gasconade beds were penetrated. The well commenced drilling in Mississippian beds. The yield from the entire column, to the total well depth of 2,415 feet, was only about 75 gallons per minute. Most, if not all, of the water presumably was derived from the post-Everton Ordovician St. Peter sandstone.

MINERAL RESOURCES

A number of minerals have been found in the pre-Everton section outcropping in northern Arkansas, including lead, zinc, pyrite, limonite and hematite. Of these, only sphalerite (zinc sulfide) was noted in any concentration in the well cuttings studied. It constituted about ten percent of the cuttings between 50 and 55 feet in the city water well at Eureka Springs. The remainder of the sample, which was taken from the Cotter formation, consisted of dolomite and subordinate chert.

Dolomite common to the area has been used both as building stone and for agricultural purposes.

Geophysical prospecting, especially by magnetic, aeromagnetic, or gravimetric methods, should prove useful in the search for mineral deposits such as iron ores in parts of northern Arkansas.

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TABLE 1

Pre-Everton Geologic Column in Northern Arkansas Showing Thicknesses Penetrated in Reference Wells.

Ozark Region (Ulrich)	Mid-Continent Region		Formation	Thickness Penetrated (ft.)
Canadian	Lower Ordovician	Arbuckle	Black Rock formation	0 - 425
			Smithville formation	0 - 607
			Powell dolomite	0 - 404*
			Cotter dolomite	0 - 527*
			Jefferson City dolomite	100 - 496
			Roubidoux formation	132 - 455
Ozarkian			Gasconade-Van Buren formations	319 - 600**
			Gunter member	20 - 100***
	Upper Cambrian		Eminence dolomite	307 - 389
			Potosi dolomite	
Upper Cambrian			Derby-Doerun formations	not penetrated?
			Davis formation	
			Bonneterre dolomite	0 - 71
		Reagan ss.	Lamotte sandstone	0 - 59+
Precambrian			Igneous rocks	31± - 118±****

* These respective figures do not include the Tennark No. 1 Martin well, Sec. 35, T. 14N., R. 3E, Craighead County. In that well an undifferentiated Powell-Cotter interval contains some 1,124 feet of combined section encountered at approximately 3,275 feet.

** A possible maximum thickness of 715 feet may have been penetrated in the Benedum-Trees No. 1 Mack well, Sec. 3, T. 15N., R. 12E., Mississippi County, measured between the Gasconade and Potosi-Eminence tops. No Gunter has been delimited in the well. The 319-600 foot thickness range shown above excludes the Gunter member.

*** Excludes the Benedum-Trees No. 1 Mack well.

**** Excludes the Millsap No. 1 Jones well.

TABLE 2

List of Reference Wells

Ref. No.	County	Well	Location Sec.-Twp.-Rge.	T.D. (ft.)	Year Com-pleted	Formation at T.D.
1	Baxter	City of Cotter No. 1 water well	31-19N-14W	1090	Unknown	Gasconade
2	Baxter	City of Mountain Home No. 3 water well	9-19N-13W	1562½	1954	Eminence
3	Benton	Ark. Publicity Bureau No. 1 Lay	5-19N-31W	2430	1921	Precambrian (?)
4	Benton	Carnation Milk Company No. 1 water well	18-19N-29W	450	Unknown	Cotter
5	Benton	City of Gravette No. 3 water well	11-20N-33W	1603	1954	Eminence
6	Benton	City of Rogers water well	7-19N-29W	1662	1955	Eminence
7	Benton	Kaney & Butler No. 1 Butler	28-19N-29W	1212	1909	Roubidoux
8	Benton	Millsap Oil & Gas Company No. 1 Jones	12-19N-31W	2338	1956	Precambrian (?)
9	Benton	Ozark Production Company No. 1 Curry	33-18N-33W	2236	1948	Precambrian
10	Boone	Ark. Western Gas Company No. 1 Bray	24-18N-22W	2805	1958	Potosi-Eminence
11	Boone	King No. 1 Lee	24-18N-22W	1451	Unknown	Cotter
12	Boone	(Operator unknown) No. 1 Andrews	26-21N-21W	310	Unknown	Cotter
13	Carroll	Baker Hospital water well	15-20N-26W	555	Unknown	Cotter (?)
14	Carroll	City of Eureka Springs water well	16-20N-26W	1385	1954	Eminence
15	Carroll	City of Green Forest water well	4-19N-23W	1587	Unknown	Roubidoux (?)
16	Clay	Ginther No. 1 Gordon	22-19N- 7E	1309	1939	Cotter (?)
17	Clay	Texas Piggott Oil Company No. 1 Sallee	11-20N- 8E	1233	1926	Jefferson City (?)
18	Craighead	Tennark, Inc. No. 1 Martin	35-14N- 3E	5092	1940	Roubidoux
19	Fulton	Baker No. 1 Ramsdell	11-21N- 6W	350	1905	Roubidoux
20	Fulton	City of Mammoth Spring water well	8-21N- 5W	350	1937	Roubidoux
21	Fulton	City of Salem No. 1 water well	27-20N- 8W	1282	1956	Eminence
22	Jackson	Ark. Oil Ventures (Deardorf) No. 1 Doggett	31-10N- 3W	5004	1956	Jefferson City
23	Johnson	Ark. Louisiana Gas Company No. 1 Hudson	15-10N-24W	6135	1944	Cotter
24	Madison	Independent O&G Company No. 1 Banks	6-16N-27W	2515	1929	Precambrian
25	Madison	Service Drilling Company No. 1 Ledford	28-15N-27W	2100	1955	Jefferson City(?)
26	Madison	War Eagle O&G Company No. 1 Brener	13-15N-26W	2320	1925	Precambrian
27	Marion	City of Flippin No. 1 water well	19-19N-15W	760	1956	Roubidoux
28	Marion	U.S. Bureau of Mines Rush Creek Project No. 5	14-17N-15W	737	1942	Jefferson City
29	Mississippi	Benedum-Trees Oil Company No. 1 Mack	3-15N-12E	4535	1939	Eminence
30	Pope	Cosden Oil Company No. 1 Shackle-ford	13- 9N-19W	4910	1930	Powell (?)
31	Randolph	Thelma Poyner No. 1 Adams	13-20N- 1E	925	1957	Gasconade
32	Searcy	City of Marshall No. 3 water well	25-15N-16W	2415	1948	Gasconade
33	Washington	Camden Oil Company No. 1 Grissom	17-15N-31W	2097	1953	Eminence
34	Washington	City of Tontitown No. 1 water well	1-17N-31W	1416	Unknown	Gasconade
35	Washington	Greenspan No. 1 Walker	6-16N-31W	1525	1952	Gasconade
36	Washington	Hulsey-Fletcher-Bailey (Legion O&G Co.) No. 1 Baggett-Maupin	30-15N-31W	2585+	1921 (?)	Precambrian
37	White	Deep Rock Oil Company No. 1 Sample	4-10N- 6W	5073	1952	Powell (?)
38	Woodruff	Magnolia Petroleum Company No. 1 Sturgis	30- 9N- 3W	6002	1954	Jefferson City

TABLE 3

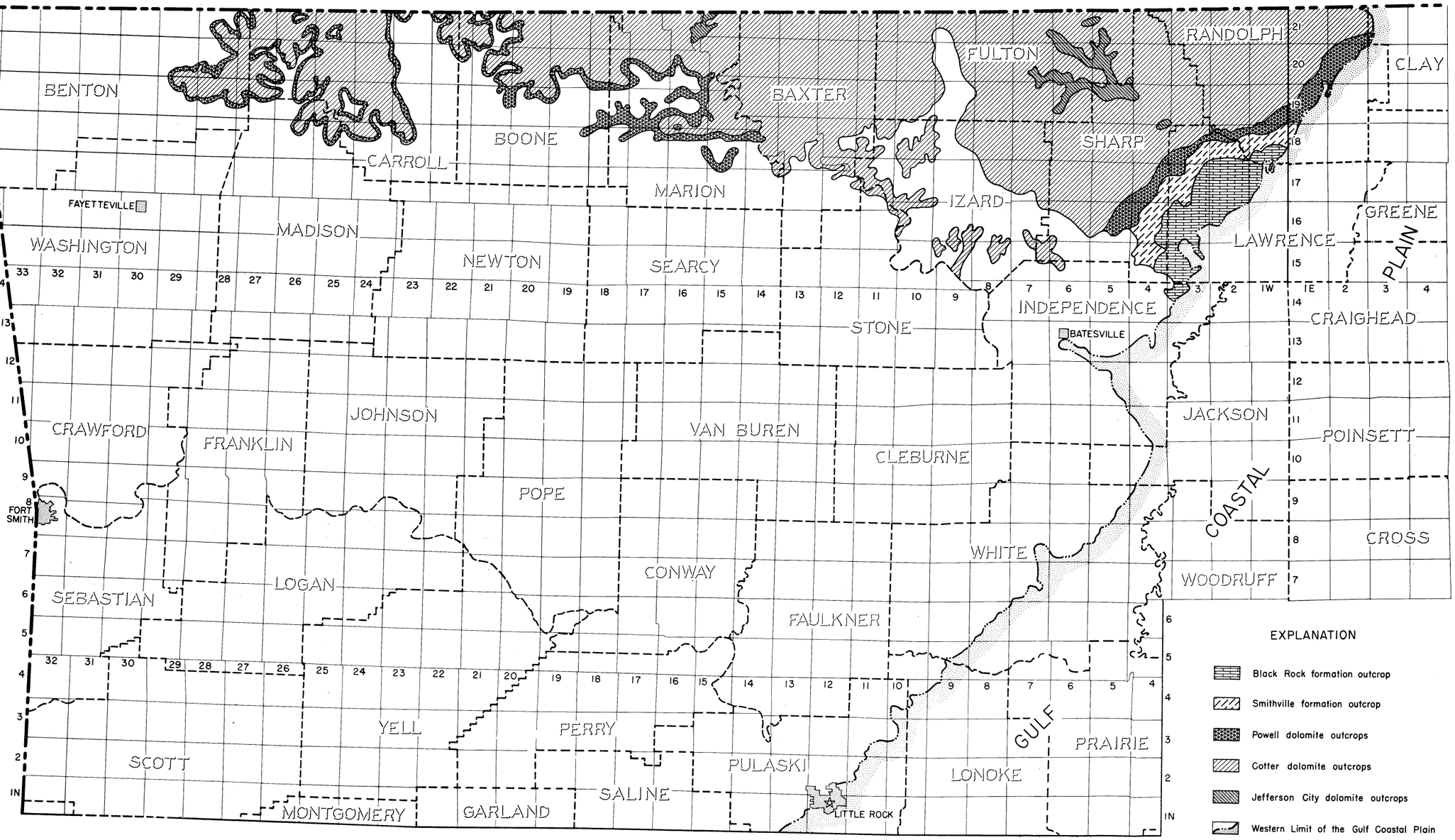
Tentative Pre-Everton Formation Tops in Reference Wells
(Depths are in feet below ground level)

Ref. No.	County	Well	Location Sec.-Twp.-Rge.	Elevation (ft.)	Black Rock	Smithville	Powell	Cotter	Jefferson City	Roubidoux	Gasconade-Van Buren	Gunter member	Potosi-Eminence	Bonneterre	Lamotte	Precambrian
1	Baxter	City of Cotter No. 1 water well	31-19N-14W	800 est.				surface fm.	490	720	940					
2	Baxter	City of Mountain Home No. 3 water well	9-19N-13W	809				surface fm.	480	770	945	1525	1550			
3	Benton	Arkansas Publicity Bureau No. 1 Lay	5-19N-31W	1099												2365
4	Benton	Carnation Milk Co. No. 1 water well	18-19N-29W	1350 est.			338	350								
5	Benton	City of Gravette No. 3 water well	11-20N-33W	1232 est.						995	1215	1560	1580			
6	Benton	City of Rogers water well	7-19N-29W	1225			252	330	620	1085	1270	1625	1655			
7	Benton	Kaney & Butler No. 1 Butler	28-19N-29W	1099			173	265	577	1073						
8	Benton	Millsap O & G Co. No. 1 Jones	12-19N-31W	1273			393	476		1181	1335	1654	1685	2069	2140	between 2199-2338
9	Benton	Ozark Production Co. No. 1 Curry	33-18N-33W	1190			380	446		1195	1400	1750	1775	2110	2170	2205
10	Boone	Ark. Western Gas Co. No. 1 Bray	24-18N-22W	2172			1265	1435		2130	2355	2700	2800			
11	Boone	King No. 1 Lee	24-18N-22W	2186			1257	1425								
12	Boone	(Operator unknown) No. 1 Andrews	26-21N-21W	1275 est.			228	250								
13	Carroll	Baker Hospital water well	15-20N-26W	1461 est.			not present?	160								
14	Carroll	City of Eureka Springs water well	16-20N-26W	1350 est.				surface fm.	435	815	995	1325	1365			
15	Carroll	City of Green Forest water well	4-19N-23W	1349			545	640	1040	1413						
16	Clay	Ginther No. 1 Gordon	22-19N- 7E	315				1267								
17	Clay	Texas Piggott Oil Co. No. 1 Sallee	11-20N- 8E	300			not present	1224								
18	Craighead	Tennark, Inc. No. 1 Martin	35-14N- 3E	350	2243	2668	3275		4399	4819						
19	Fulton	Baker No. 1 Ramsdell	11-21N- 6W	575 est.					surface fm.	250						
20	Fulton	City of Mammoth Spring water well	8-21N- 5W	573					surface fm.	115						
21	Fulton	City of Salem No. 1 water well	27-20N- 8W	660				surface fm.	295	395	630	1230	1255			
22	Jackson	Ark. Oil Ventures (Deardorf) No. 1 Doggett	31-10N- 3W	215	may be present		3853	4215	4742							
23	Johnson	Ark. Louisiana Gas Co. No. 1 Hudson	15-10N-24W	747			5780	5990								
24	Madison	Independent O & G Co. No. 1 Banks	6-16N-27W	1545			628	735	1110	1486	1665	2050	2090			2397
25	Madison	Service Drilling Co. No. 1 Ledford	28-15N-27W	1479			1353	1506								

TABLE 3 (Continued)

Ref. No.	County	Well	Location Sec.-Twp.-Rge.	Elevation (ft.)	Black Rock	Smithville	Powell	Cotter	Jefferson City	Roubidoux	Gasconade-Van Buren	Gunter member	Potosi-Eminence	Bonneterre	Lamotte	Precambrian
26	Madison	War Eagle O & G Co. No. 1 Brener	13-15N-26W	1406												2286
27	Marion	City of Flippin No. 1 water well	19-19N-15W	650-700 est.				surface fm.	420	760						
28	Marion	U.S. Bureau of Mines Rush Creek Project No. 5	14-17N-15W	490			205	382	708							
29	Mississippi	Benedum-Trees Oil Co. No. 1 Mack	3-15N-12E	263			not present		2805	3150	3605		4320			
30	Pope	Cosden Oil Co. No. 1 Shackleford	13- 9N-19W	765			4876									
31	Randolph	Thelma Poyner No. 1 Adams	13-20N- 1E	400 est.					285							
32	Searcy	City of Marshall No. 3 water well	25-15N-16W	1090 est.			1185	1400	1770	2135	2366					
33	Washington	Camden Oil Co. No. 1 Grissom	17-15N-31W	1140 est.			592	657	1056	1482	1625	2018	2040			
34	Washington	City of Tontitown No. 1 water well	1-17N-31W	1320 est.			383	460	840	1216	1350					
35	Washington	Greenspan No. 1 Walker	6-16N-31W	1220 est.			355	410	767	1200	1332					
36	Washington	Hulsey-Fletcher-Bailey (Legion O&G) No. 1 Baggett-Maupin	30-15N-31W	1175												2485
37	White	Deep Rock Oil Co. No. 1 Sample	4-10N- 6W	475 est.	may be present		4850									
38	Woodruff	Magnolia Pet. Co. No. 1 Sturgis	30- 9N- 3W	217	may be present		5065	5469	5975							

Plate I. PRE-EVERTON OUTCROPS



EXPLANATION

- Black Rock formation outcrop
- Smithville formation outcrop
- Powell dolomite outcrops
- Cotter dolomite outcrops
- Jefferson City dolomite outcrops
- Western Limit of the Gulf Coastal Plain

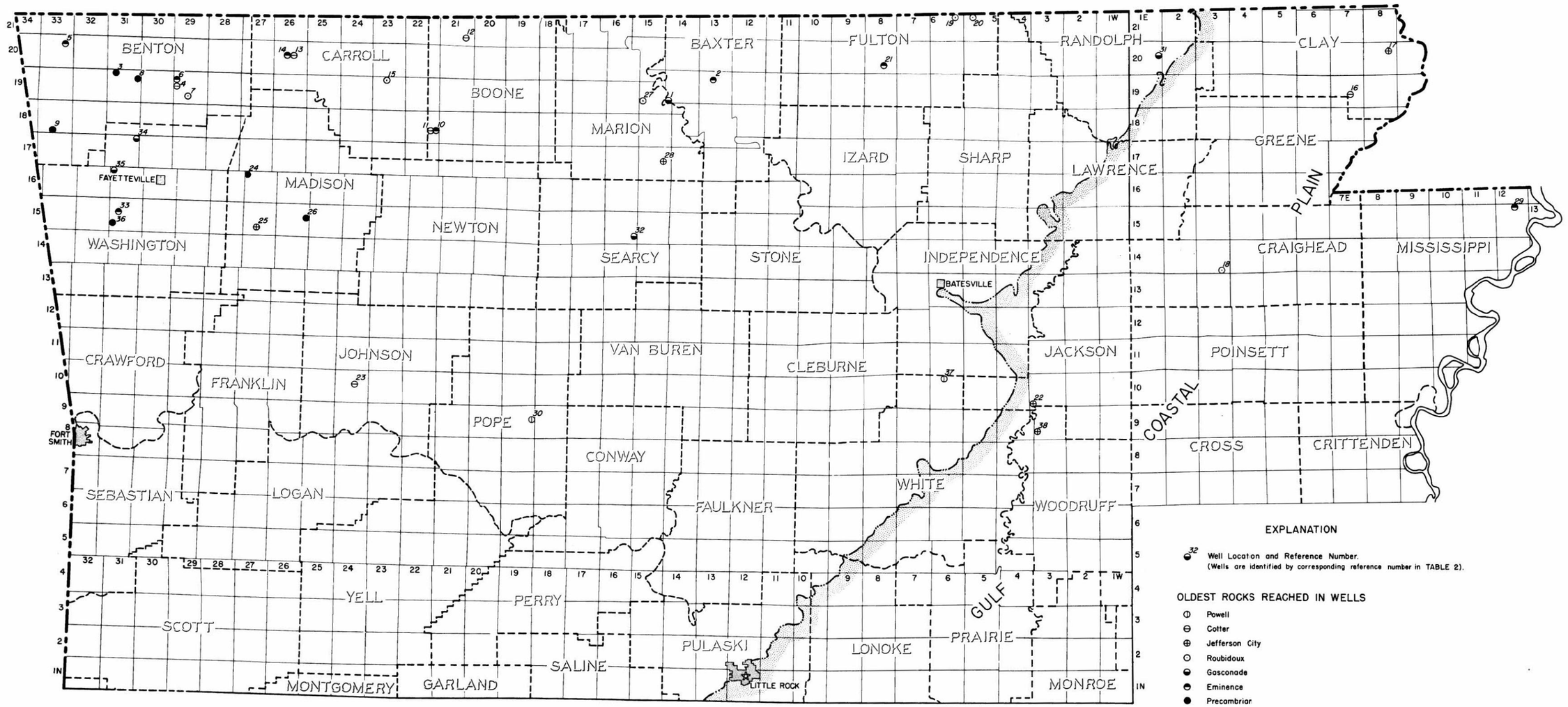
OUTCROP AREAS OF PRE-EVERTON ROCKS CURRENTLY MAPPED IN NORTHERN ARKANSAS

SCALE IN MILES

10 0 10 20 30 40

W. M. CAPLAN
1960

Plate II. REFERENCE WELL LOCATIONS



EXPLANATION

32 Well Location and Reference Number. (Wells are identified by corresponding reference number in TABLE 2).

OLDEST ROCKS REACHED IN WELLS

- Powell
- Cotter
- Jefferson City
- Roubidoux
- Gasconade
- Eminence
- Precambrian

MAP SHOWING LOCATION OF REFERENCE WELLS

SCALE IN MILES

10 0 10 20 30 40

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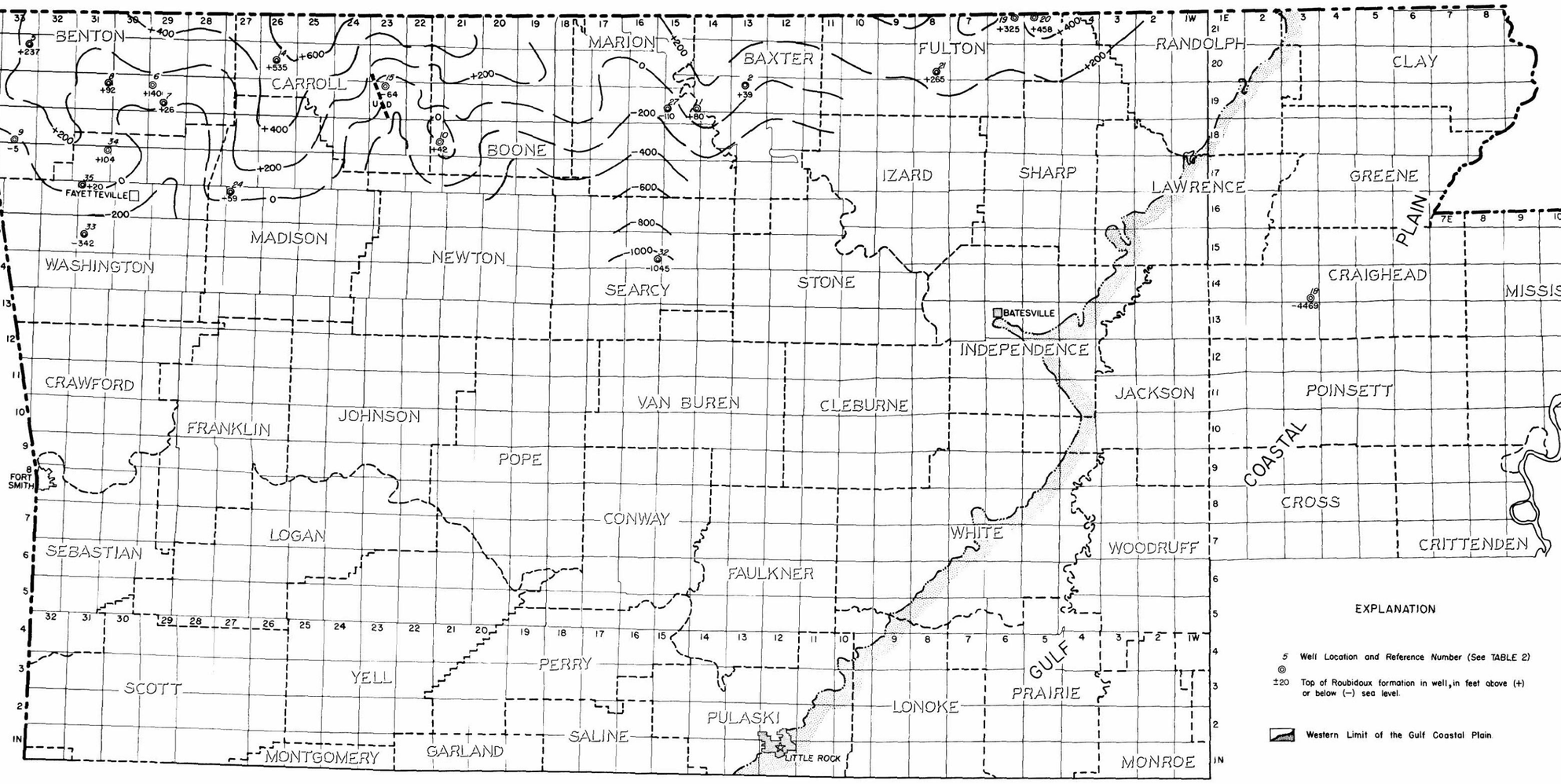
Plate III. ROUBIDOUX STRUCTURE



EXPLANATION

5 Well Location and Reference Number (See TABLE 2)

±20 Top of Roubidoux formation in well, in feet above (+) or below (−) sea level.

Western Limit of the Gulf Coastal Plain

GENERALIZED STRUCTURAL MAP CONTOURED ON TOP OF THE ROUBIDOUX FORMATION

SCALE IN MILES

10 0 10 20 30 40

CONTOUR INTERVAL: 200 FEET DATUM: MEAN SEA LEVEL

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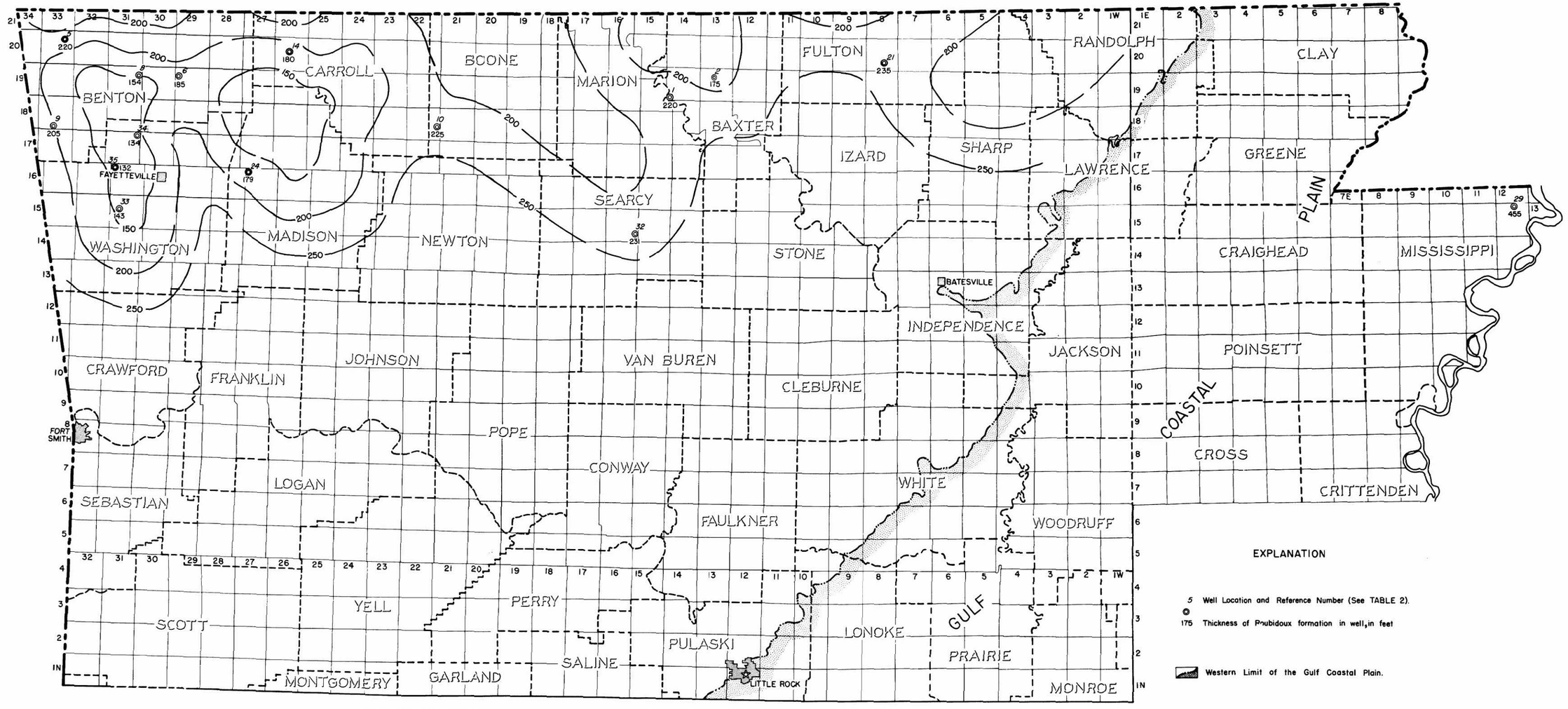
Plate IV. ROUBIDOUX ISOPACH



GENERALIZED ISOPACHOUS MAP OF THE ROUBIDOUX FORMATION

SCALE IN MILES

10 0 10 20 30 40

CONTOUR INTERVAL: 50 FEET

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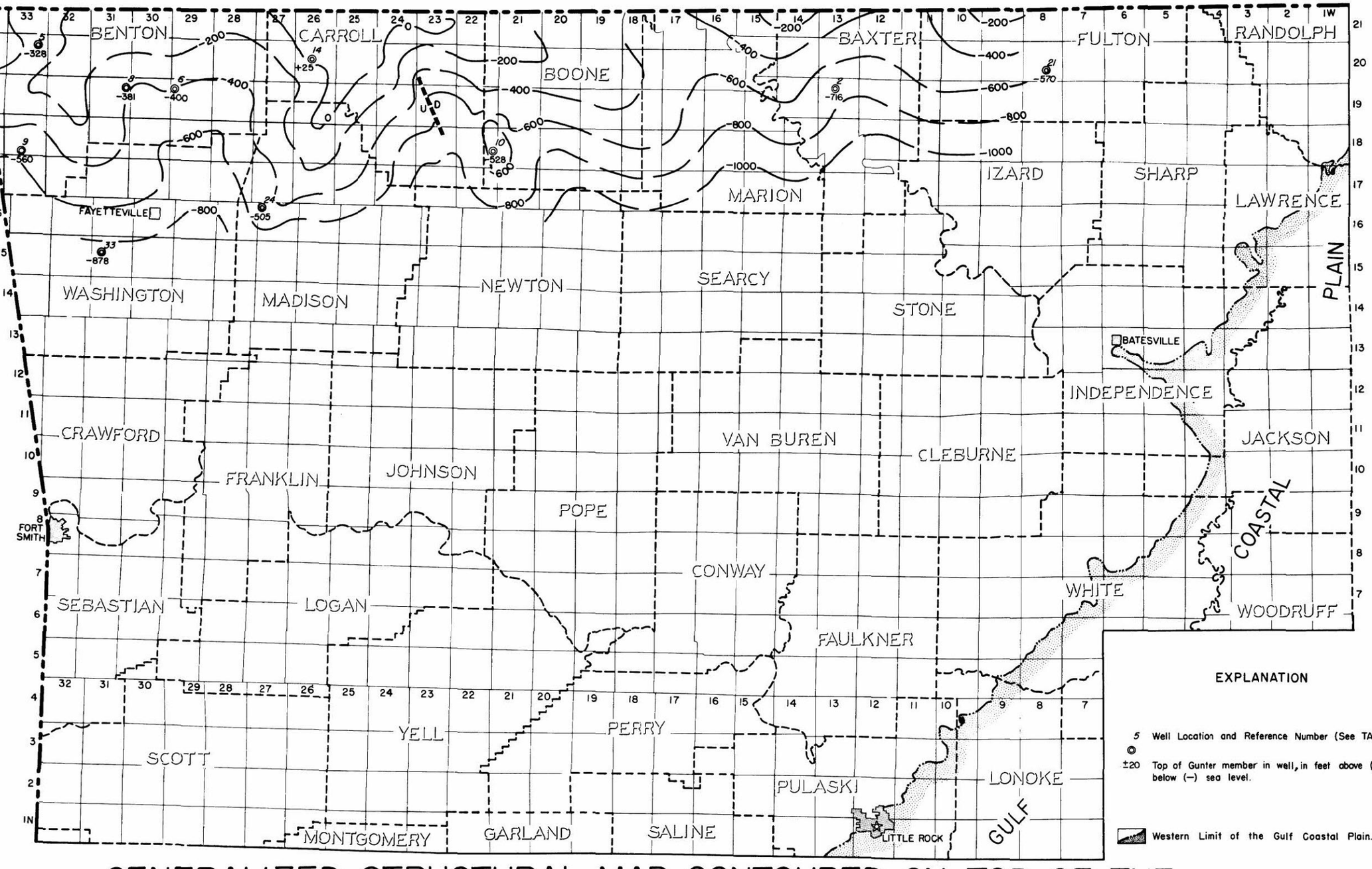
Plate V. GUNTER STRUCTURE



GENERALIZED STRUCTURAL MAP CONTOURED ON TOP OF THE GUNTER (BASAL GASCONADE-VAN BUREN) MEMBER

SCALE IN MILES

10 0 10 20 30 40

CONTOUR INTERVAL: 200 FEET

W. M. CAPLAN
1960

DATUM: MEAN SEA LEVEL