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SUBSURFACE GEOLOGY OF NORTHWESTERN ARKANSAS

By

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Little Rock, Ark.

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SUBSURFACE GEOLOGY OF NORTHWESTERN ARKANSAS

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ABSTRACT

Current subsurface mapping in northwestern Arkansas is feasible only on a regional basis, except in very localized areas.

Ozark-Arbuckle type rocks dip southward under Atoka and younger Pennsylvanian cover from outcrops in northwestern Arkansas. Southeastward they thicken and change facies.

During Everton time, or earlier, two shallow basins occupied the Arkansas Valley. Downwarping increased during Mississippian and Morrow times, at least in the eastern basin. Maximum development is thought to have occurred during Atoka time. A southwest trending nose along the Coastal Plain-Arkansas Valley boundary was uplifted as the eastern basin subsided.

Two major fault systems are thought to be present in the Valley, one trending northwest and the other northeast from the Pope County area. Major faulting along the Arkansas Valley-Coastal Plain boundary is not in evidence.

No oil has been produced throughout northern Arkansas. In northwestern Arkansas dry gas is obtained from Atoka and Morrow beds. The Atoka is regionally prospective for gas rather than oil. Post-Batesville Mississippian beds appear most prospective for oil or gas north and west of Pope County. Pre-Fayetteville Mississippian beds may produce from the areas south, southeast, and southwest of Independence County. Ordovician prospects are unknown. Saline waters have been found in Pre-Powell Ordovician and in Atoka beds.

Present gas producing structures merit deeper drilling. The nose along the Arkansas Valley-Coastal Plain margin warrants attention. Extensions of Atoka beds and Ozark type rocks under the Coastal Plain are possibly prospective for oil or gas.

INTRODUCTION

Comprehensive subsurface mapping in northwestern Arkansas is not feasible at this time, except in very localized areas, because of complex stratigraphy and inadequate well control. However, generalized regional structure and isopachous maps, such as those included in this paper, are useful for recognizing anomalous conditions. In view of the limitations stated, the attached maps are intended primarily for gross examinations.

Throughout this text the term "basin" is used arbitrarily to describe a number of structural configurations in the area of report. Additional subsurface information may reveal that the term "embayment" would better describe any or all of these features.

The data presented herein were derived essentially from well sample studies by the writer. The samples were generally fair to good, as many of the wells were drilled by cable tools.

Electrical logs were used in conjunction with sample examinations. Regionally, electrical log control alone is inadequate for correlations, as relatively few such logs have been made throughout the area of report. There are more electrical logs available from wells drilled in Franklin, Pope, and Sebastian Counties than from the other counties in the subject area.

The increasing use of air drilling in this region is causing a greater reliance on electrical logging, as samples from wells drilled by this method are difficult to interpret with assurance.

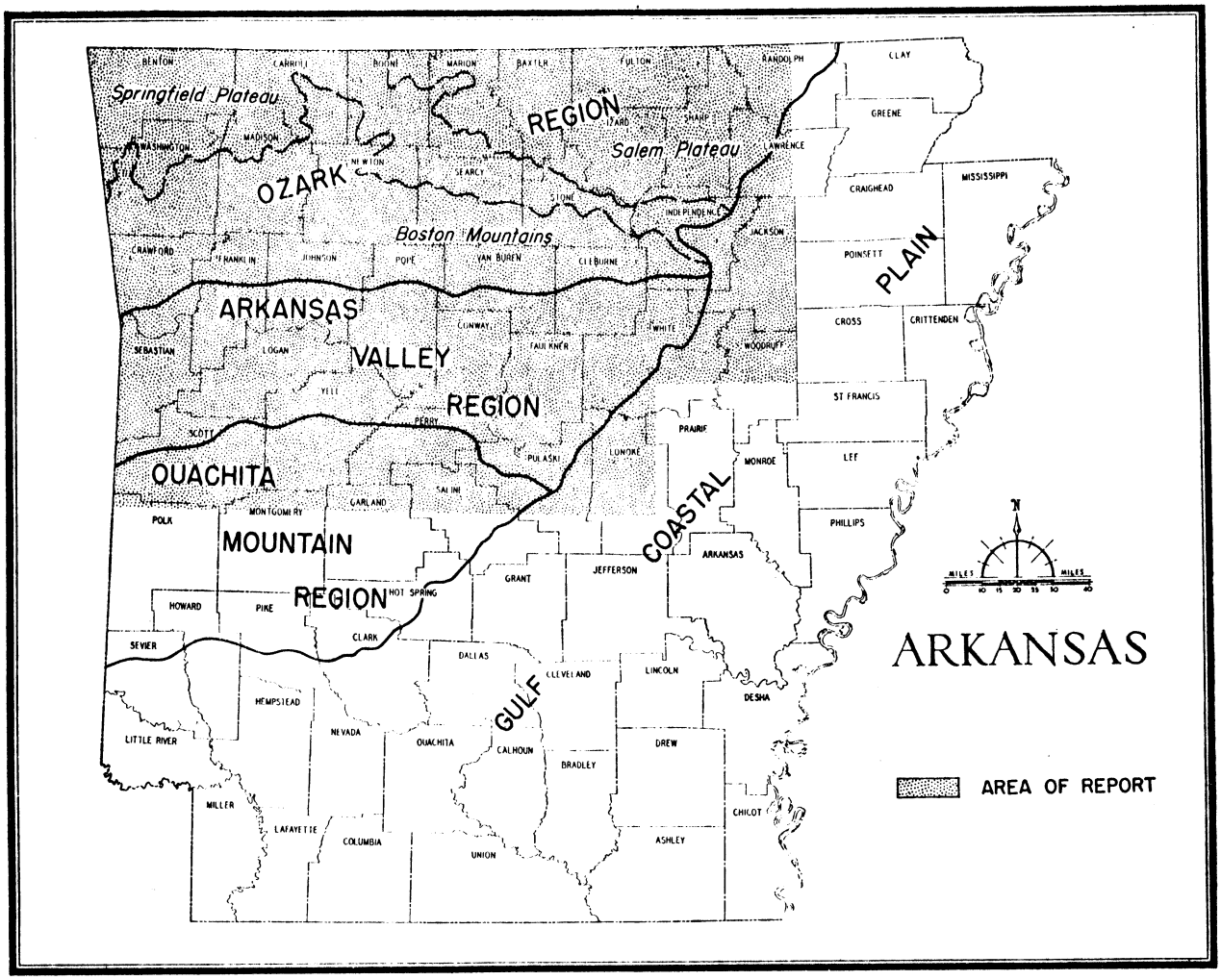

Figure 1.

Index map showing area of report and physiographic provinces.

ACKNOWLEDGMENTS

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Acknowledgment is also made to members of the Fuels Branch, U. S. Geological Survey, Tulsa, Oklahoma, for many courtesies extended in regard to this work.

Lithology and formations tops for the Industrial Oil and Gas No. 3 Williams well, Crawford County; the McAllister No. 1 Sisemore well, Madison County; and the Cosden Oil No. 1 Shackleford well, Pope County, were taken with some slight modifications from Maher and Lantz (1953b) and Sheldon (1954). Similar information for the Trumbo No. 1 Craddock well, Crawford County, was taken from Sheldon (1954).

STRATIGRAPHY

Ozark-Arbuckle type rocks, consisting mostly of limestone, dolomite and dark shale, outcrop in northwestern Arkansas. They dip generally southward under cover of Atoka and, in some parts of the region, younger Pennsylvanian beds.

Many of the stratigraphic problems in the region result from southeastward thickening and attendant facies changes in the pre-Atoka rock units, making correlations increasingly difficult downdip.

Ozark-Arbuckle correlatives outcrop in the Ouachita Mountains, along the southerly margins of the Arkansas Valley. They consist mainly of sandstones and dark shales.

Pre-Atoka rocks increase in thickness from 5,000 feet, or less, in the Ozark region to an estimated 20,000 feet, or more, in the Ouachita region.

Pre-Powell age rocks were not mapped for this paper since relatively few wells in the region have penetrated them. The Arkansas Oil Ventures No. 1 Doggett well in Jackson County and the Magnolia Petroleum No. 1 Sturgis well in Woodruff County, both in the Coastal Plain extension of the Arkansas Valley, drilled into dolomites thought to be of Jefferson City age or older.

Formation Descriptions

Powell dolomite: This unit is considered to be the youngest Arbuckle correlative in northern Arkansas. It consists of silty, shaly dolomite and subordinate sands and sandy dolomite.

Everton formation: The Everton is made up of sandy dolomite and friable to well-cemented sandstones containing sub-angular to rounded, frosted quartz grains. The Black Rock and Smithville limestones, as shown on the State Geologic Map, are considered by the writer to be facies of the Everton formation.

St. Peter sandstone: The friable to well-cemented sandstones of this formation are made up of sub-angular to rounded, frosted grains. Occasional limestone or dolomite beds are present. The St. Peter is often difficult to separate from the underlying Everton formation, especially where the almost indistinguishable sandstones of both formations are in contact.

Several wells in the extreme eastern parts of the Arkansas Valley, and several just inside the Coastal Plain, contain sandy limestones rather than sandstones in the St. Peter interval. These are thought to represent downdip St. Peter facies. The Lion Oil No. 1 Nalley and the Magnolia Petroleum No. 1 Sturgis wells are cited as examples.

Joachim dolomite: The Joachim has not been identified in enough wells to serve as a key formation.

Plattin-Kimmswick limestones: These beds are generally undifferentiated in wells, especially where the Plattin does not have the sublithographic texture often considered characteristic of it. An arbitrary separation of the formations was made for this paper, using the initial chert-free bed in the interval as the Plattin top. While this may be only a phantom top, it appears usable as a marker.

Fernvale limestone-Boone formation: Rocks through this range were not used for mapping. However, several of the formations are noteworthy regionally. The base of the Chattanooga shale marks an important unconformity. The

Boone formation may be used as an example of basinward facies changes in the Arkansas Valley, since its generally light-colored limestones and chert can be traced southeastward into darker, shaly units. The Cosden No. 1 Shackleford well, Pope County; the Deep Rock No. 1 Sample well, White County; and the Western Natural No. 1 Chapman well, Cleburne County, are cited in this regard.

Where both the Chattanooga shale and basal Sylamore sandstone are absent, Boone and Penters cherts may be in contact. An arbitrary separation can sometimes be made, if Chattanooga shale was once present, on the basis of a very dark chert zone at the former contact of the Penters chert and the shale.

Fayetteville shale: This unit is chiefly a carbonaceous, pyritic shale. In some cases it contains subordinate dark limestones and chert. Ironstone concretions are found frequently in the shale. In the western parts of the region the Wedington sandstone member is readily identifiable near the top of the formation.

Pitkin limestone: This limestone and associated dark shales have not been identified by the writer in wells southeastward from Johnson County. In this direction the Pitkin either was not deposited or has graded into shales which cannot be differentiated with assurance from the Fayetteville shale. The attached structure map contoured on top of the Fayetteville probably represents contours on an undifferentiated Pitkin-Fayetteville top east-southeast of Johnson County. These latter contours could have been placed on the Pitkin rather than on the Fayetteville structure map; however, the implication would be that the Pitkin was present as an identifiable unit regionally.

In view of the difficulties presented by separation of Mississippian formations southeast of Johnson County, the entire post-Boone Mississippian section was isopached as an undifferentiated unit over northwestern Arkansas.

Although closure is shown in the Pope-Johnson area, it might instead be an elongate nosing such as is shown on the Plattin isopachous map. By the same token the latter map might be contoured to show closure through the same general area rather than simply a nose. If the configuration on the Mississippian isopachous map does represent closure, present data would limit it to some 80 feet. The Morrow isopachous map does not reflect the closure nor does it indicate the nosing other than by inference.

Morrow group: Members of the Hale and Bloyd formations, which can be identified quite readily in northwestern Arkansas, exhibit facies changes eastward along the outcrop and southeastward in the subsurface. They become generally more silty and sandy in those directions. The Cane Hill and Prairie Grove members of the Hale, as designated by Henbest (1953), and the Kessler and Brentwood limestone members of the Bloyd, become increasingly difficult to trace southeastward from Johnson County.

In Conway County the Kessler appears to contain multiple sandy limestone beds. At present only the limestone initially encountered below the Atoka base is correlated by some geologists as Kessler, with successively deeper limestones, which may still be Kessler, then being assigned Brentwood, Hale and Pitkin ages.

Atoka formation: This formation consists mainly of dark shales and sandstones. A few dark-colored, fossiliferous, sandy limestones to limy sandstones have been placed in the Atoka in counties as widely separated as Crawford, Sebastian, Franklin, Pope and White.

The base of the Atoka is often difficult to pick in samples, especially where conglomeratic sands are not well developed or are absent. The Atoka base is frequently obtained arbitrarily by backing up-hole approximately one hundred feet from the first limestone encountered, with the assumption that the limestone is Kessler. Other than in local areas, such as in parts of Franklin County, this practice cannot be used with assurance. In White County, for example, in the States Oil No. 1 LaFerney well, the base of the Atoka is placed some 900 feet above the first limestone penetrated.

If facies changes are present within the Atoka, they are difficult to determine. Individual members of the formation have not been traced with assurance over more than very limited distances in the subsurface.

Croneis (1930) measured some 9,400 feet of Atoka on the outcrop near the town of Perryville in the Arkansas Valley. Consequently, more than 9,000 feet of Atoka have been lost between that area and the Atoka deposits in the Ozark region. The writer attributes this loss of formation units regionally more to northward overlap than to intensive erosion.

Post-Atoka Pennsylvanian: Formations in this category have been identified on the outcrop from the Oklahoma boundary eastward to Conway County. Of the several formations concerned, only the Hartshorne sandstone, immediately overlying the Atoka, was specifically identified in this study.

Stratigraphic Relationships

Certain inferences can be drawn regarding stratigraphic relationships of the formations mapped, at least in the updip areas. Basinward the evidences of unconformity tend to become obscured, as would be expected.

The Powell-Everton contact is probably disconformable generally, with slight angular unconformities being present locally.

Everton-St. Peter relationships may vary from disconformable, and possibly gradational, to locally angular contacts. Eastward from Izard County the State Geologic Map suggests a pronounced angular unconformity where undifferentiated Everton-St. Peter beds are shown intersecting Powell-Smithville-Black Rock beds at essentially right angles. Considering the Smithville-Black Rock as Everton facies, the attached isopachous maps indicate that these trends are not as diverse as implied above. The unconformity, whether the result of non-deposition or erosion of St. Peter beds, appears to be of local significance only.

St. Peter-Plattin contacts indicate locally unconformable relationships. As suggested by the Plattin isopachous map, a strip of the formation may be missing along a north-south line between Washington and Madison Counties into Franklin County.

Fayetteville-Pitkin and Pitkin-Morrow contacts appear to be generally conformable to disconformable. West and southwest of the Newton-Searcy County area local, slight, angular unconformities between the Pitkin and Morrow are indicated.

The Morrow-Atoka relationship suggests local, slight, angular unconformities.

STRUCTURE

Two shallow basins occupied the Arkansas Valley at least as early as Everton time, one being generally east and the other generally west of the Pope-Conway County area. These basins are thought to be considerably older than Everton, possibly dating back to pre-Cambrian time.

The basins were separated in effect by a nose trending southeastward through Pope, Conway, and Faulkner Counties. By Morrow, or possibly Pitkin, time, the boundary between the basins appeared to have migrated as far westward as Perry County. Possibly the Atoka outcrop mapped near Perryville by Croneis (1930) lies on a westerly rim of the eastern basin. The amount and direction of dip of the Atoka along that outcrop were reported by Croneis as 40 degrees and S 25° E, respectively.

Apparently the Ozark region was uplifted at the end of Powell time. The angle of uplift in the Fulton-Sharp County area need not have been more than a fraction of a degree to reconcile the rate of thickening southward in the Everton into the basin. The St. Peter in the same area thickens southward at a rate approximately one-third to one-fourth that of the Everton. Since the south dip is the steepest indicated, the eastern basin was shallow during these periods. It can only be inferred that some uplifting took place both near the close of Everton and St. Peter times, but the relative magnitudes are unknown.

The St. Peter appears to be absent on the outcrop generally westward from Marion County. The limitation of St. Peter updip could be accounted for either by erosion or non-deposition.

Both of the aforementioned basins persisted into Atoka time. During Mississippian time local downwarping was accentuated, at least in the eastern basin, as indicated by the marked increase in southward thickening shown on the post-Boone Mississippian isopachous map. The downwarping apparently continued in Morrow time but at a reduced rate. During Atoka deposition an acceleration of downwarping in the eastern basin implies maximum development of the basin during that period. It is conjectural whether faulting was contemporaneous with these adjustments.

The southwestward trending nose shown along the western boundary of the Coastal Plain probably was differentially uplifted as the eastern basin was depressed.

Little is known about the western basin regarding intensification of downwarping and pre-Atoka sedimentation. It is inferred that this basin also achieved its maximum development during Atoka time.

Other basins of a more localized nature existed in Franklin and Johnson Counties during St. Peter or pre-St. Peter time. Noticeable increases in development of these basins took place during or at the end of Pitkin time. The Morrow isopachous map shows increased activity in the areas concerned. Maximum development of these local

basins is also assumed to have taken place during Atoka time.

The number of faults encountered in this study, as best shown on the Morrow structure map, suggests more comprehensive faulting in the Arkansas Valley. Several fault systems are likely to be developed, one such system trending generally northwestward and the other generally northeastward from the vicinity of Pope County. The former probably is associated with east-west trending faults across Johnson County, which in turn, are thought to be related genetically to northeast trending faults in the Franklin County area. The State Geologic Map shows surface structures changing trends in similar manner. The structure maps in this paper reflect like changes in subsurface trends in the same areas. The old subsurface structural patterns probably influenced folding and faulting during the Ouachita orogeny.

None of the isopachous maps in this report, other than that of the Atoka, shows any thickening of consequence across the known major faults. The indicated thickening of Atoka beds on the downthrown sides of the faults could have resulted from deposition that kept pace with relatively low order fault displacements. However, the various data at hand suggest considerable removal of sediments by erosion from the upthrown sides of the faults. Therefore, the Atoka isopachous map may reveal only apparent thickening on the downthrown sides of the faults.

A few beds in the upper 1,000 feet of the Murphy Corporation No. 1 Barton and No. 1 McGuire wells, located in the Moreland Field of Pope County, are distinctive enough to be considered correlative. These beds are structurally higher in the McGuire well by some 60 to 105 feet. One of these, a partially conglomeratic sandstone containing crinoid fragments, is regarded as a fairly reliable marker in this case. It was penetrated at 780 feet in the McGuire and 885 feet in the Barton. From 1,000 feet, and down to about 2,150 feet in the Barton, the Atoka sections in the two wells are inferred to be generally correlative. Below the 2,150-foot level, the Barton correlates less closely with the McGuire than with the Carter Oil No. 1 Chronister. The latter well commenced drilling on the upthrown side of the fault, suggesting that the Barton crossed the fault at approximately 2,150 feet. Consequently both the Barton and McGuire wells would have commenced drilling on the downthrown, south side of the Moreland Field fault. The Barton would be structurally low to the McGuire, and would have encountered the base of the Atoka on the upthrown side of the fault, possibly 100 feet lower structurally than the Chronister.

With Atoka thicknesses slightly less than 4,200 feet in the Barton and Chronister wells and close to 5,500 feet in the McGuire well, a fault displacement of some 1,300 feet is indicated.

Fragments of coal were found in the uppermost beds in the Barton and McGuire wells, in a medium to coarse-grained sandstone. The sandstone, which is thickest in the Barton, is not present in the Chronister well. It is thought to be an Atoka stream channel deposit of the type described by Hendricks and Parks (1950) in the Fort Smith area. The absence of the sandstone in the Chronister could be accounted for either by non-deposition or erosion.

On the upthrown north side of the major fault in Township 10 North, Range 20 West, northnorthwest of the Moreland area, the Atoka is about 100 feet thick. It is 3,000 feet thick on the downthrown side. The control wells are some four miles apart across the fault. No correlative beds within the Atoka were identified between the wells. Although loss of beds by northward overlap, combined with a succession of low angle fault displacements, might account for the difference in thicknesses, it appears more likely that the considerable difference should be attributed essentially to erosion on the upthrown side of the fault.

Some geologists regard the Morrow section in the Carter Oil No. 1 Morrilton Lumber Company well, Conway County, as being indicative of faulting. A difference of opinion exists because of the questionable age of the formation at total depth in the well. If the unit penetrated from 3,302 feet to total depth is in the lower part of the Hale, a fault is suggested on comparison with the Carter Oil No. 1 Williams well in Conway County. The implication would be that the upper part of the Hale in the Morrilton Lumber Company well was thickened considerably as the result of a pre-Bloyd or a pre-Kessler fault.

If the unit encountered at 3,302 feet is Fayetteville or undifferentiated Pitkin-Fayetteville, no faulting would be required to reconcile the thickness of the Hale section in the Morrilton Lumber Company well. However, the lower part of the Hale would not correlate lithologically with the comparable interval in the Williams well, being predominantly sandstone in the former well and shale in the latter.

The relationship of the basal Atoka sandstone, containing the producing section, to the underlying Bloyd in the Morrilton Lumber Company

well is presumed to be one of slight angular unconformity.

Despite the amount of investigation by numerous geologists, dating of the major folding and faulting in the Arkansas Valley still cannot be done with assurance.

Regionally in northwestern Arkansas normal faults are downthrown to the south; however, normal faults downthrown to the north have been mapped in the subsurface of Franklin County and on the surface in Independence County.

Although not determinable from the maps, the axes of many of the anticlines in the Arkansas Valley probably migrate in southerly directions with depth. Closer to the Ouachita front, this relationship should be more pronounced. Differential forces applied from southerly directions during the Ouachita orogeny would be the likely cause of such axial shifting.

The nosing occurring along the western margin of the Coastal Plain is of interest, since local closures may be associated with it. The surface expression of one anticline on the State Geologic Map shows branching axes in this region. Several anticlines are aligned essentially parallel to the boundary between the Coastal Plain and the Arkansas Valley.

This study revealed no major faulting between the Arkansas Valley and the Coastal Plain. It is possible that the unusual straightness of the boundary between the provinces is more dependent upon intermittent uplifting along the same general axis, or system of axes, than on major faulting. If faulting at the end of Powell time is responsible for initiation of the eastern basin during Everton time, it is not revealed by present mapping.

The structure maps of Plattin and older beds do not reflect the faulting shown on post-Plattin maps in Franklin County because of inadequate control.

OIL AND GAS POSSIBILITIES

Few data are available for evaluating pre-Powell Cambro-Ordovician production possibilities throughout northern Arkansas. There is some historical basis for optimism, since these units, at least in part, are Arbuckle-Knox-Ellenburger correlatives. The Roubidoux and Gasconade formations may be the most prospective of the older Ordovician rocks. Sandstones and vuggy zones in these formations produce fresh water in the Ozark region; however, the water is introduced through the outcrop area in Missouri and does not necessarily influence downdip prospects of the units. Eastward in the Coastal Plain, in Mississippi County, Arkansas, these beds have graded into dense, dark-colored limestones. In Jackson and Woodruff Counties, just inside the Coastal Plain, beds as old as Jefferson City or possibly Roubidoux have been drilled. In these latter counties the pre-Powell rocks contain small quantities of milky chert but generally resemble the Everton formation. Floating sand grains and thin-bedded sands are also present. In the Arkansas Oil Ventures No. 1 Doggett well, Jackson County, an undetermined interval in the pre-Powell beds yielded water with a chloride content of 17,000 parts per million. Cotter and older beds in northern Arkansas wells frequently contain asphaltic material.

The Powell dolomite, which is generally thought to be too tight to act as a reservoir, produced considerable water of unknown chemical content from porous sands in the Doggett well.

Post-Powell formations such as the coarsely crystalline Fernvale and St. Clair limestones may provide stratigraphic traps where unconformably overlain by such units as the Chattanooga shale. The Kimmswick limestone recently yielded small quantities of oil in a La Clede Gas Company well near St. Louis, Missouri. Oil seeps have been reported from the Everton formation near Yellville, Marion County, Arkansas.

Numerous unconfirmed shows of oil or wet gas have been reported in northwestern Arkansas, especially in Madison County, but no commercial production of either exists in the Ozark or Arkansas Valley regions at this time.

Oil seeps and petroliferous residues are associated with a number of Pennsylvanian and Mississippian formations. Freshly fractured Moorefield, Batesville and Pitkin rocks give petroleum odors and small quantities of hydrocarbon distillation products. These Mississippian beds, as well as the Wedington sandstone member of the Fayetteville shale, are prospective for oil as well as gas. The more likely areas for accumulation appear to be generally northward and westward from Pope County for post-Batesville Mississippian rocks and in general southerly directions from Independence County for pre-Fayetteville Mississippian beds.

Fractured Boone and Penters chert are possible reservoir beds. Non-commercial quantities of dry gas have been produced from the Boone formation in northwestern Arkansas.

The southeastward gradation of Morrow formation members into siltstones and sandstones makes the Morrow prospective for oil and gas over a fairly large area. Differential cementation and lenticularity of sandstone members may be important factors in regard to downdip accumulation in the Morrow. Members of the Bloyd and Hale formations currently produce dry gas from limestones and sandstones in western portions of the Arkansas Valley.

Most of the present dry gas production in the Valley is from Atoka sands. Although production seems to be obtained essentially from structures, accumulation is not necessarily limited to structural traps. The lenticularity of some Atoka sands suggests the likelihood of stratigraphic trapping also. Drilling need not be concentrated on the upthrown sides of faults, since multiple sands in the Atoka may be productive indiscriminately. In Franklin and Pope Counties, Atoka gas is produced from sands on both sides of certain faults.

The Atoka formation is considered a more likely prospect for general dry gas production than for oil. In view of the recent successes in Pope and Conway Counties, especially the Carter Oil Company's 78.5 MMcf per day Chronister gas well in the former, it is not unlikely that drilling east-southeastward will be stimulated and will result in added gas production. Few regional limits can be imposed on Atoka gas prospects at this time. Eventually, production may also move southward toward the Ouachita front. Structure, differential cementation, and lenticularity are all likely to play important roles in controlling downdip Atoka accumulation.

Gas shows from the Atoka have been reported from scattered water wells and unsuccessful oil tests in White County. The States Oil No. 1 LaFerney, an abandoned production test drilled recently near McRae, just inside the Coastal Plain, found porosity and an ungauged amount of saline water in the basal Atoka sand. The water contained chlorides in excess of 26,000 parts per million.

The Stephens Production Company and Murphy Corporation No. 1 Ward well recently abandoned in Sec. 13, T. 8 N., R. 12 W., Faulkner County, reported a non-commercial 125 Mcf per day gas show between 2,010-18 feet, from an Atoka sand.

The structures that appear to control current Atoka and Morrow gas production merit deeper drilling. Traps are thought to have been created in pre-Pennsylvanian beds during several pre-Atoka periods of folding, such folding later being intensified by the tectonics of the Ouachita orogeny.

The region along the western margin of the Coastal Plain also warrants further investigation.

Eastward from the boundary between the Coastal Plain and the Arkansas Valley, Atoka and Ozark-Arbuckle type rocks have been penetrated beneath the Coastal Plain sediments. The generally southeastward extension of the Arkansas Valley across this region should be considered as unevaluated but possibly prospective.

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TABLE 1

Formations and Thicknesses Penetrated in Reference Wells

System		Formation	Member	Thickness in Feet
PENNSYLVANIAN		Hartshorne ss.		0–225
		Atoka fm.		0–8675
	Morrow Group	Bloyd sh.(undiff.)		0–1170±
			Kessler ls.	0–115
			Brentwood ls.	0–110
		Hale fm.(undiff.)		0–980
			Prairie Grove	0–150±
			Cane Hill	0–250±
MISSISSIPPIAN		Pitkin ls.		0–213
		Fayetteville sh.	Wedington ss.	0–1634±
		Batesville ss.	Hindsville ls.	
		Ruddell sh.		0–936
		Moorefield fm.		
		Boone fm.		0–370
		Chattanooga sh.	Sylamore ss.	0–60
DEVONIAN		Penters chert		0–265
SILURIAN		Lafferty ls.		
		St. Clair ls.		0–250
		Brassfield ls.		
ORDOVICIAN		Cason sh.		0–45
		Fernvale ls.		0–85
		Kimmswick ls.		0–180
		Plattin ls.		0–367
		Joachim dol.		0–96
		St. Peter ss.		0–160
		Everton fm.		0–1205*
		Powell dol.		0–420
		Cotter dol.		368–420
		Jefferson City dol.		112–470
		Roubidoux fm.		135–225
		Gasconade-Van Buren fm.(undiff.)	Gunter	380–510
CAMBRIAN		Eminence-Potosi fm.(undiff.)		300–350
		Pre-Potosi (undiff)		90**
PRE-CAMBRIAN				31**–107***

*Includes Black Rock-Smithville limestones.

**Ozark Production Co. No. 1 Curry, Sec. 33-18N-33W, Benton County, T.D. 2236 ft.

***Independent Oil & Gas Co. No. 1 Banks, Sec. 6-16N-27W, Madison County, T.D. 2515 ft.

TABLE 2

List of Reference Wells

Ref. No.	County	Well	Location Sec.-Twp.-Rge.	T.D. (ft.)	Elev. (ft.)	Formation at T.D.
1	Benton	Kaney & Butler (Monte Ne)	28-19N-29W	1212	1099	Eminence
2	Benton	Ozark Production Co. No. 1 Curry	33-18N-33W	2236	1190	pre-Cambrian
3	Boone	King No. 1 Lee	24-18N-22W	1451	2186	Cotter
4	Carroll	City of Green Forest water well	4-19N-23W	1587	1349	Roubidoux?
5	Cleburne	Cosden Oil No. 1 Donaphan Lumber Co.	19-9N-10W	4360	750	Fayetteville
6	Cleburne	Craver No. 1 Donaphan Lumber Co.	34-11N-9W	3750	765 est.	Plattin?
7	Cleburne	Western Natural Gas No. 1 Chapman	14-9N-12W	4919	688	St. Peter-Everton
8	Conway	Bergstrom Butler No. 1 Sadler	5-5N-17W	5122	350	Atoka
9	Conway	Blackwell O & G No. 1 Scroggins	14-7N-16W	4443	414	Morrow
10	Conway	Carter Oil Co. No. 1 Jones	8-6N-15W	5138	480	Atoka
11	Conway	Carter Oil Co. No. 1 Morrilton Lumber Co.	33-9N-17W	3502	618 est.	Fayetteville
12	Conway	Carter Oil Co. No. 1 Williams	1-9N-16W	3794	814	Everton
13	Crawford	Cities Service Oil Co. No. 1 Bruce	4-11N-32W	1760	800 est.	Everton
14	Crawford	Cities Service Oil Co. No. 1 Mo. Pacific	3-11N-32W	2305?	855	Everton
15	Crawford	Industrial O & G No. 3 Williams	6-8N-30W	6576	410 est.	Silurian?
16	Crawford	Stephens Production Co. No. 1 Huckleberry	11-10N-32W	2235	950	Pitkin
17	Crawford	Stephens Production Co. No. 1 Mo. Pacific	13-11N-32W	987	1070 est.	Pitkin
18	Crawford	Trumbo No. 1 Craddock	3-11N-30W	1893	775	Everton
19	Faulkner	Stephens Production Co. No. 1 Ward	13-8N-12W	4015	600 est.	Fayetteville?
20	Franklin	Ark. Louisiana Gas Co. No. 1 Barton	27-9N-28W	6650	815	Everton
21	Franklin	Ark. Louisiana Gas Co. No. 1 Stubblefield	36-9N-29W	5366	777	Hale
22	Franklin	Ark. Okla. Gas Co. No. 1 Morris	24-9N-29W	5008	776	Boone
23	Franklin	Ark. Western Gas Co. No. 1 Graf	29-10N-28W	4980	746	Fayetteville
24	Franklin	Ark. Western Gas Co. No. 1 Jenkins	22-10N-27W	4602	700 est.	Fayetteville
25	Franklin	Ark. Western Gas Co. No. 1 Mattox	5-10N-27W	4920	550	Fayetteville
26	Franklin	Ark. Western Gas Co. No. 1 McGehee	17-10N-28W	3715	456	Morrow
27	Franklin	Ark. Western Gas Co. No. 1 Parsley	15-10N-28W	3896	620 est.	Fayetteville
28	Franklin	Ark. Western Gas Co. No. 1 Peters	34-11N-29W	4160	830	Everton
29	Franklin	Ark. Western Gas Co. No. 1 White	20-11N-27W	2743	980 est.	Fayetteville
30	Franklin	Athletic Mining & Smelting No. 1 Mantooth	15-8N-27W	5700	538 est.	Morrow
31	Franklin	Ozark Natural Gas Co. No. 1 Self	31-10N-26W	5775	500 est.	St. Peter
32	Franklin	Stephens Production Co. No. 1 Carter	16-9N-27W	4865	757	Pitkin
33	Independence	Craft No. 1 Hinkle	23-11N-4W	1207	220 est.	Kimmswick?
34	Independence	Fitzpatrick No. 1 Pryor	32-13N-6W	1926	387	Everton
35	Independence	Jones (Tubular Service) No. 1 Norris	17-12N-4W	640	232 est.	Kimmswick
36	Jackson	Ark. Oil Ventures (Deardorf) No. 1 Doggett	31-10N-3W	5004	215	Roubidoux?
37	Johnson	Ark. Louisiana Gas Co. No. 1 Hudson	15-10N-24W	6135	747	Cotter
38	Johnson	Big Chief Drilling Co. No. 3 Low Gap Unit	30-11N-24W	1643	963	Pitkin
39	Johnson	Big Chief Drilling Co. No. 5 Low Gap Unit	19-11N-24W	1462	922	Pitkin
40	Johnson	LeFlore Co. Gas & Elec. No. 4-A Low Gap Unit	6-11N-23W	2539	1953	Pitkin
41	Johnson	Pure Oil Co. No. 1 Low Gap Unit	17-11N-24W	3945	2050	Everton
42	Johnson	Pure Oil Co. No. 2 Low Gap Unit	13-12N-24W	2015	1692	Pitkin
43	Johnson	Western Natural Gas No. 1 Bryant	19-9N-23W	5950	330	Morrow
44	Logan	Carter Oil Co. No. 1 Turner	15-6N-28W	5685	604	Atoka
45	Logan	Western Natural Gas No. 1 Gray	25-8N-24W	7874	380	Morrow
46	Madison	Independent O & G No. 1 Banks	6-16N-27W	2515	1545	pre-Cambrian
47	Madison	McAllister No. 1 J. Sisemore	10-15N-27W	710	1500 est.	Fayetteville
48	Madison	Service Drilling Co. No. 1 Ledford	23-15N-27W	1564	1479	Cotter?
49	Pope	Ark. Louisiana Gas Co. No. 1 Millsaps Unit	23-10N-21W	4120	800	Boone

TABLE 2 (Continued)

List of Reference Wells

Ref. No.	County	Well	Location Sec.-Twp.-Rge.	T.D. (ft.)	Elev. (ft.)	Formation at T.D.
50	Pope	Carter Oil Co. No. 1 Chronister	3-8N-19W	5211	818	Fayetteville
51	Pope	Cosden Oil No. 1 Shackleford	13-9N-19W	4910	765	Powell
52	Pope	Murphy Corp. No. 1 Ashmore	8-8N-19W	4678	661	Atoka?
53	Pope	Murphy Corp. No. 1 Barton	10-8N-19W	5508	776	Fayetteville
54	Pope	Murphy Corp. No. 1 Loveless	15-8N-19W	5207	656	Atoka
55	Pope	Murphy Corp. No. 1 McGuire	16-8N-19W	5464	790	Morrow
56	Pope	Murphy Corp. No. 1 Smith	10-8N-21W	6537	656	Hale
57	Pope	Stanolind O & G No. 1 Brinkman	6-10N-20W	2095	650 est.	Everton
58	Scott	Residue Co. No. 1 Mansfield	6-4N-30W	8675	680	Atoka
59	Searcy	Town of Marshall No. 3 water well	25-15N-16W	2415	1100 est.	Gasconade
60	Sebastian	Ark. Okla. Gas Co. No. 1. Bieker	2-7N-32W	5812	491	Pitkin
61	Sebastian	Ark. Okla. Gas Co. No. 1 Municipal Airport	36-8N-32W	5802	460	Pitkin
62	Sebastian	Athletic Mining & Smelting No. 1 Ayers	11-7N-32W	6385	500 est.	Penters
63	Sebastian	Gragg Pipeline & Reynolds Mining (Spencer Chemical) No. 1 Boyde	29-6N-30W	5115	571	Atoka
64	Sebastian	Reynolds Mining et al. No. 1 Turner	27-6N-30W	7520	666	Atoka
65	Sebastian	Western Natural Gas No. 1 Bergkamp	1-7N-30W	8325	437	St. Peter-Everton
66	Van Buren	Lion Oil No. 1 Griggs	23-10N-13W	4632	780	Everton
67	Washington	Ark. Western Gas Co. No. 1 Newlin	33-15N-30W	725	1400	Everton
68	Washington	Ark. Western Gas Co. No. 1 Ray	21-15N-30W	638	1310	Everton
69	Washington	City of Tontitown water well	1-17N-31W	1416	1300 est.	Gasconade
70	Washington	Eddington No. 1 McElroy	5-15N-32W	580	1100 est.	Everton
71	Washington	Greenspan No. 1 Walker	6-16N-31W	1525	1220 est.	Gasconade
72	Washington	Plymouth Oil No. 1 Spies	24-13N-30W	2121	1625 est.	Everton
73	Washington	Rakowsky No. 3 Area XDH	25-14N-33W	414	1060	Everton
74	Washington	Taylor No. 1 Rummy	1-13N-29W	1737	2000 est.	Silurian
75	White	Deep Rock Oil No. 1 Sample	4-10N-6W	4992	450 est.	Powell
76	White	Killam & McMillan No. 1 Curl	10-9N-5W	4772	448	Everton
77	White	Lion Oil No. 1 Nalley	33-8N-7W	6397	425	Everton
78	White	States Oil No. 1 LaFerney	25-6N-8W	4820	220 est.	Morrow
79	Woodruff	Magnolia Petroleum Co. No. 1 Sturgis	30-9N-3W	6002	217	Jefferson City
80	Yell	B & G Oil Co. and Carter Oil Co. No. 1 Mitchell	16-5N-24W	6011	?	Atoka

TABLE 3

Reference Wells Used in Preparation of Each Plate

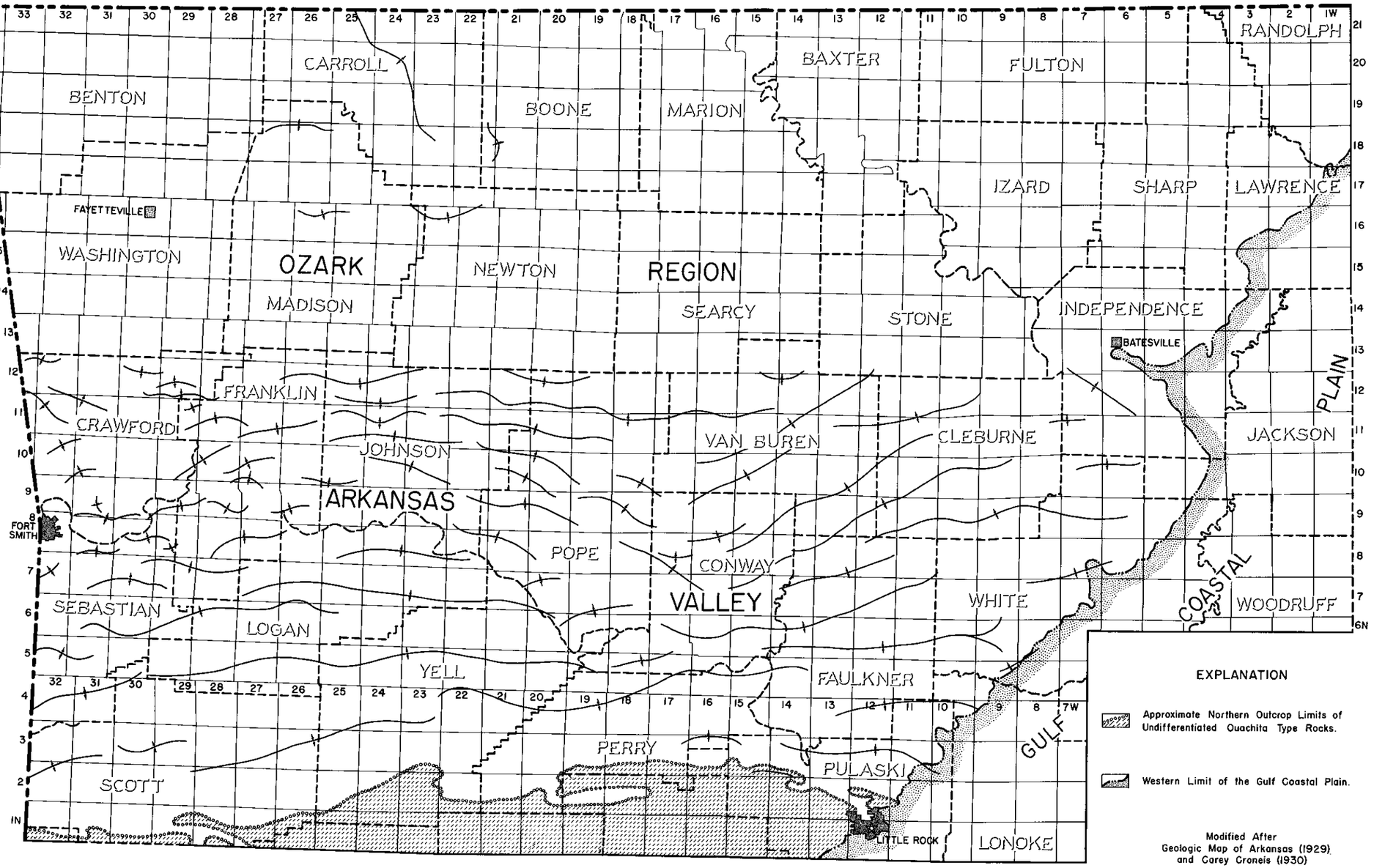
(Reference numbers correspond with reference numbers in Table 2. Numbers separated by dash are inclusive.)

Plate No.	Reference No.
I.	———
II.	1-80
III.	5-32, 36-45, 47, 49-58, 60-66, 74-80
IV.	5-7, 9, 11-33, 36-43, 45, 47, 49-51, 53, 55-57, 60-62, 65, 66, 74-79
V.	5-7, 11-18, 20, 22-25, 27-29, 31-33, 36-42, 47, 49-51, 53, 57, 60-62, 65-66, 74-77, 79
VI.	13-18, 20, 22-25, 27-29, 31, 32, 37-42, 47, 60-62, 65, 74
VII.	13-15, 18, 20, 22-25, 27-29, 31, 37, 41, 47, 62, 65, 74
VIII.	3, 5-7, 11-15, 18, 20, 22-25, 27-29, 31, 36, 37, 41, 47, 49, 51, 53, 57, 62, 65, 66, 74-77, 79
IX.	6, 7, 12-15, 18, 20, 22, 28, 31, 33-37, 41, 49, 51, 57, 62, 65, 66, 68, 74-77, 79
X.	7, 12, 31, 34, 36, 37, 41, 48, 51, 57, 59, 65, 66, 72, 73, 75-77, 79
XI.	6, 7, 12, 18, 20, 28, 31, 34, 36, 37, 41, 51, 57, 59, 65, 66, 72, 73, 75, 77, 79
XII.	6, 7, 12, 20, 28, 34, 36, 37, 41, 51, 57, 65, 66, 75-77, 79
XIII.	12, 20, 28, 31, 34, 36, 37, 41, 51, 57, 59, 66, 75-77, 79
XIV.	3, 4, 6, 12, 18, 20, 28, 31, 34, 36, 37, 41, 46, 48, 51, 57, 66-73, 75-77, 79
XV.	3, 4, 36, 46, 48, 51, 57, 59, 71, 75, 79
XVI.	1-4, 36, 37, 46, 48, 51, 57, 59, 69, 71, 75, 79
XVII.	2-4, 12, 15, 18, 20, 28, 31, 34, 36, 37, 41, 46, 51, 57, 59, 62, 66, 68-77, 79

TABLE 4
Gas Potentials of Reference Wells

County	Well	Year Completed	Potential (Mcf of gas per day)	Interval Yielding Gas (feet)	Formation	Remarks
Conway	Carter Oil Co. No. 1 Morrilton Lumber Co.	1956	5,205	1938-62	Atoka	Jerusalem Field discovery well.
Crawford	Industrial O & G No. 3 Williams	1941	25	1700, 2380, 2420, 4563	Atoka Atoka	Non-commercial.
Faulkner	Stephens Production Co. No. 1 Ward	1956	125	2010-18	Atoka	Non-commercial.
Franklin	Arkansas Louisiana Gas Co. No. 1 Barton	1949	7,000	4850-4930	Hale	Cecil Field discovery well. First Hale production in Arkansas.
Franklin	Arkansas Louisiana Gas Co. No. 1 Stubblefield	1955	1,800 2,100	2353-64 5260-72, 5278-94, 5305-20	Atoka Hale Hale Hale	Cecil Field.
Franklin	Arkansas Louisiana Gas Co. No. 1 Morris	1952	75,000 1,500	2162-2241 4008-26	Atoka Atoka	Cecil Field. Second largest gas well in Arkansas Valley.
Franklin	Arkansas Western Gas Co. No. 1 Jenkins	1946	2,500 2,500 1,500	2702-20 3118-14 3868-80	Atoka Atoka Morrow	White Oak Field.
Franklin	Arkansas Western Gas Co. No. 1 Mattox	1954	870	3774-84	Atoka	Watalula Field.
Franklin	Arkansas Western Gas Co. No. 1 Parsley	1951	6,000 2,000	3348-67 3782-3814	Atoka Atoka	Lone Elm Field.
Franklin	Arkansas Western Gas Co. No. 1 White	1955	1,250 1,000	1751-63 2170-85	Atoka Morrow	Jethro Field discovery well.
Franklin	Athletic Mining & Smelting No. 1 Mantooth	1956	4,500 4,000 5,500	4630-72 5348-67 5605-47	Atoka Atoka Hale	Old Aetna area.
Johnson	Arkansas Louisiana Gas Co. No. 1 Hudson	1944	3,500	3402-32 3560-90	Kessler Brentwood	Clarksville Field.
Johnson	Big Chief Drilling Co. No. 3 Low Gap Unit	1952	238 462	825-40 1311-26	Atoka Atoka	Linville Field discovery well.
Johnson	Big Chief Drilling Co. No. 5 Low Gap Unit	1953	140	1180-1220	Hale	Linville Field.
Johnson	LeFlore Co. Gas & Elec. No. 4-A Low Gap Unit	1952	1,086	2342-92	Hale	Ozone Field discovery well.
Johnson	Pure Oil Co. No. 2 Low Gap Unit	1951	434	1149-1327	Atoka	Low Gap Field discovery well.
Johnson	Western Natural Gas No. 1 Bryant	1954	176	4850-5690	Atoka & Hale	Spadra Field discovery well.
Logan	Western Natural Gas No. 1 Gray	1954	88	1379-1402	Atoka	Prairie View Field discovery well.
Madison	Independent O & G No. 1 Banks	1929	431	290-310	Boone	Non-commercial.
Pope	Carter Oil Co. No. 1 Chronister	1956	71,800 6,700	3918-4030 4469-4514	Atoka Morrow	Largest gas well in Arkansas Valley.
Pope	Murphy Corp. No. 1 Barton	1954	7,600	3993-4003	Atoka	Moreland Field discovery well.
Pope	Murphy Corp. No. 1 McGuire	1955	2,930	4422-66 4494-4509	Atoka Atoka	Production from downthrown side of Moreland Field fault.
Sebastian	Ark. Okla. Gas Co. No. 1 Bieker	1951	24,000	5268-88	Atoka	Massard Prairie Field deep production discovery well.
Sebastian	Ark. Okla. Gas Co. No. 1 Municipal Airport	1953	400	5343-51	Atoka	Massard Prairie Field.
Sebastian	Gragg Pipeline & Reynolds Mining No. 1 Boyde	1955	2,500	4112-23	Atoka	Gragg Field discovery well.
Sebastian	Reynolds Mining et al. No. 1 Turner	1956	5,200 3,000	2553-69 2774-92	Atoka Atoka	2¼ E. of Gragg Field discovery well.
Sebastian	Western Natural Gas No. 1 Bergkamp	1954	106	5986-6012	Atoka	Bloomer Field extension.
White	Deep Rock Oil No. 1 Sample	1952	ungauged shows	3512-74 4165-4205 4820-50	St. Peter-Everton Everton Everton	Drill stem tests.

Plate I. ANTICLINAL AXES



MAP SHOWING ANTICLINAL AXES IN THE OZARK REGION AND THE ARKANSAS VALLEY

SCALE IN MILES

0 5 10 20 30 40 50

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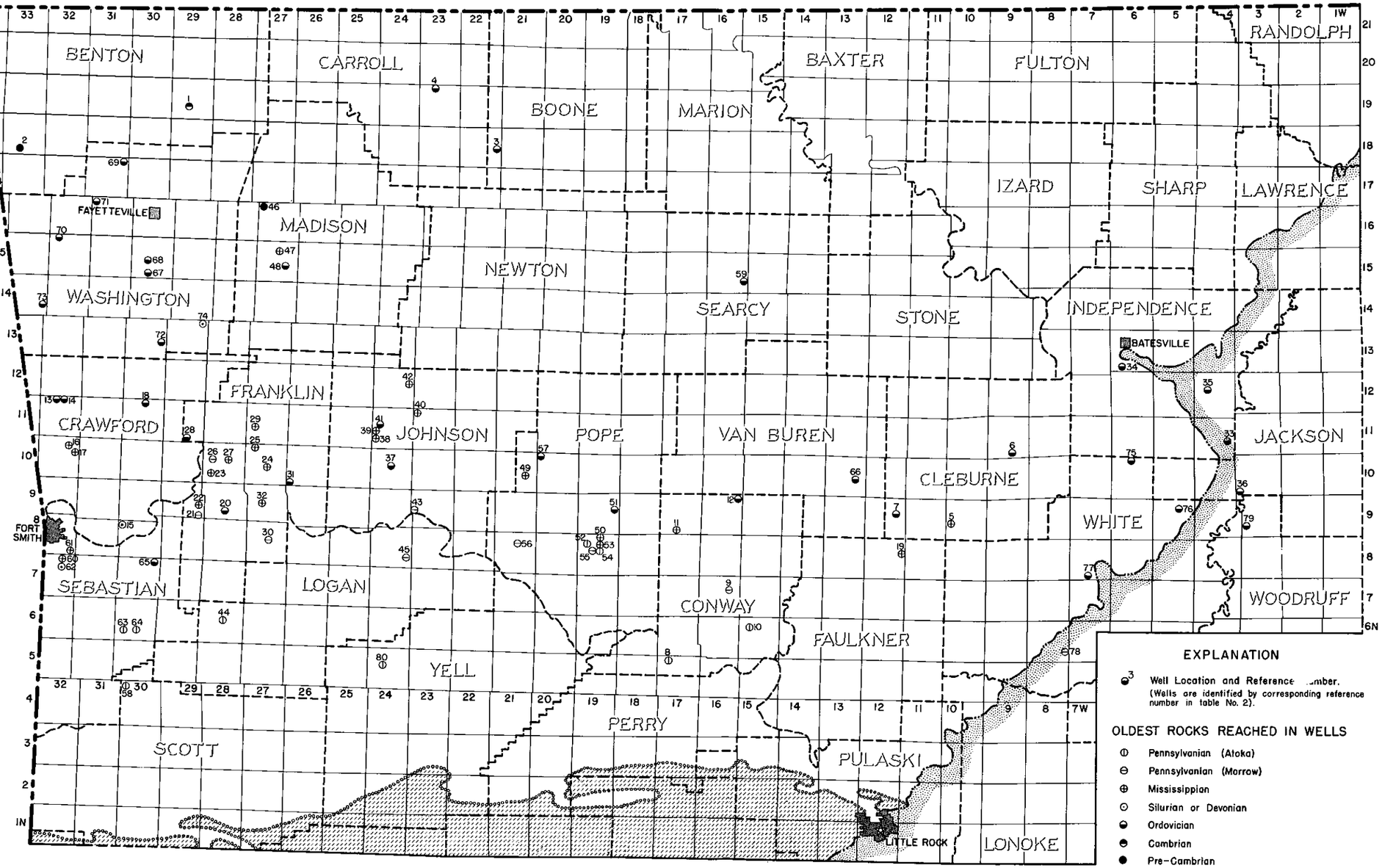
1957

Plate II. REFERENCE WELL LOCATIONS



MAP SHOWING LOCATION OF REFERENCE WELLS

SCALE IN MILES

0 5 10 20 30 40 50

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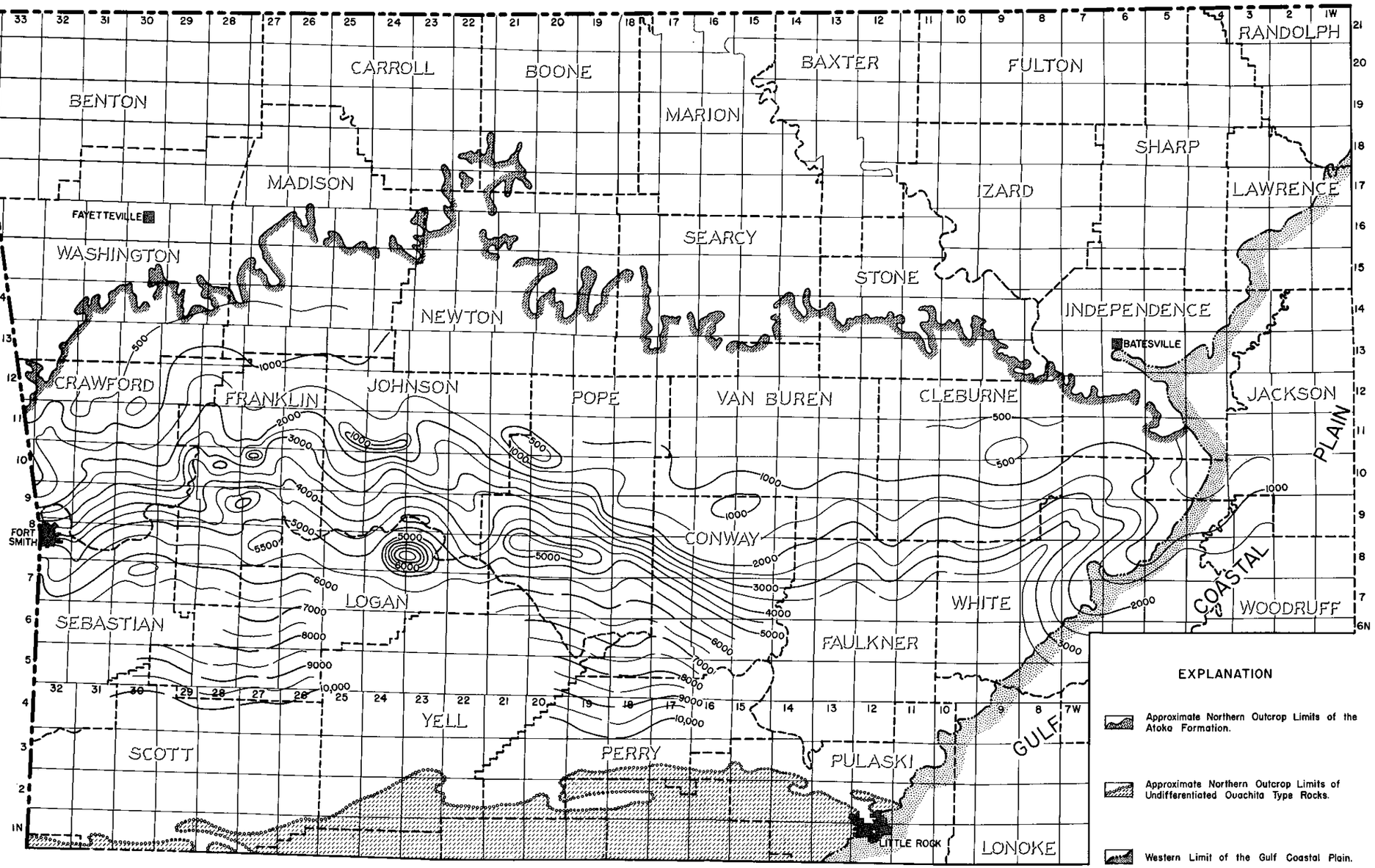
1957

Plate III. ATOKA ISOPACH



ISOPACHOUS MAP OF THE ATOKA FORMATION

SCALE IN MILES

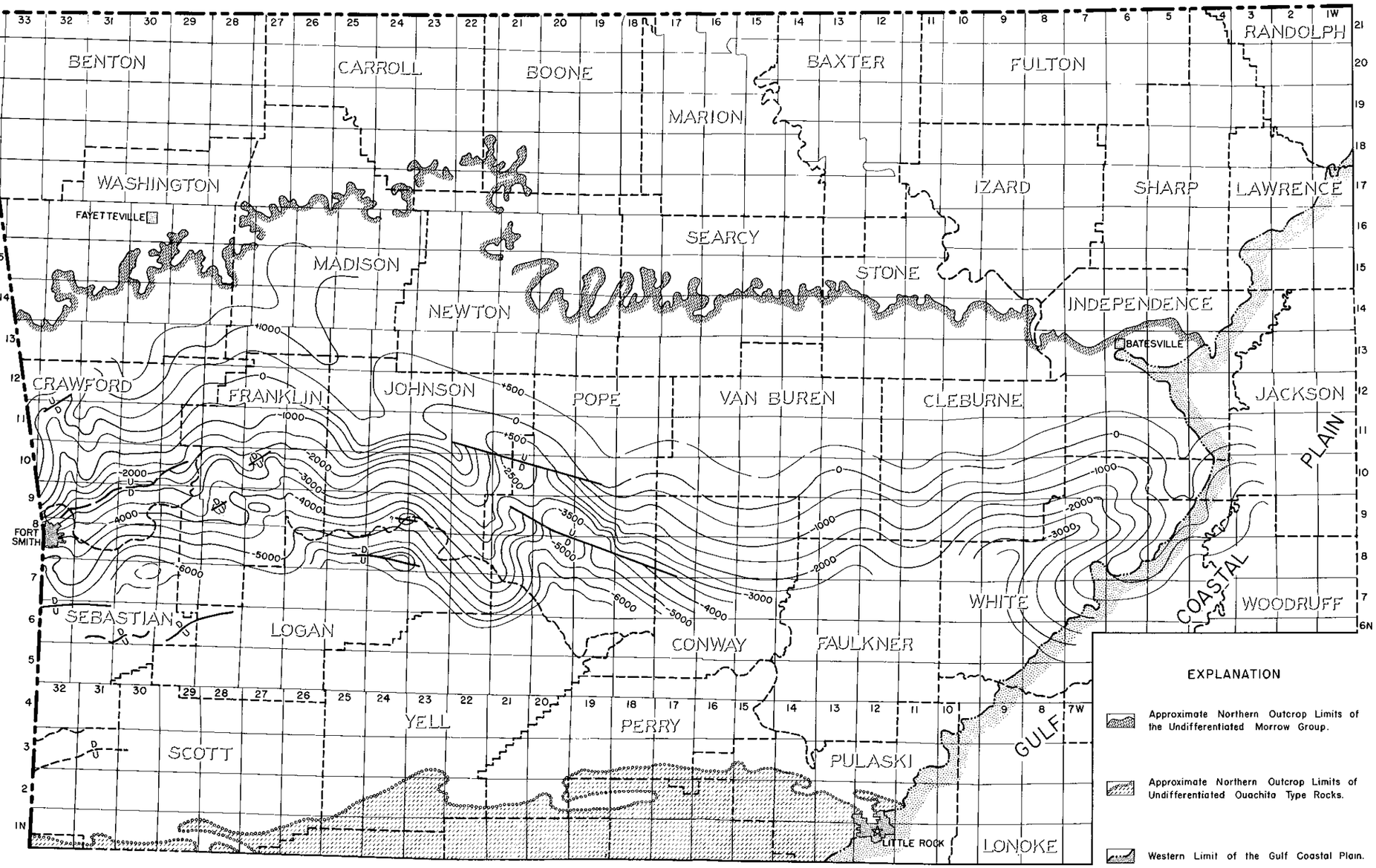
0 5 10 20 30 40 50

CONTOUR INTERVAL: 500 FEET DATUM: SEA LEVEL

W. M. CAPLAN

1957

Plate IV. MORROW STRUCTURE



STRUCTURAL MAP CONTOURED ON TOP OF THE UNDIFFERENTIATED MORROW GROUP

SCALE IN MILES

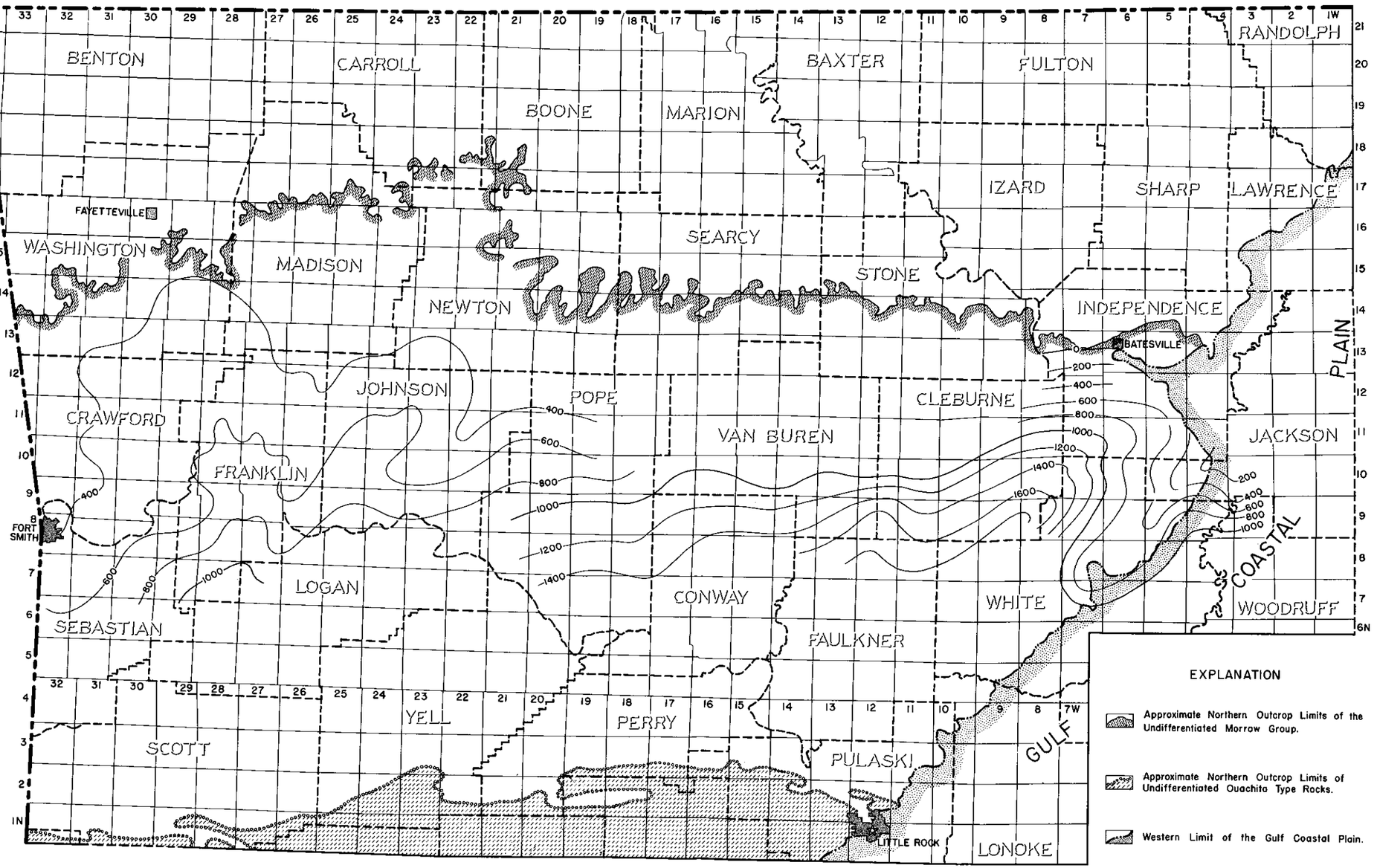
0 5 10 20 30 40 50

CONTOUR INTERVAL: 500 FEET

W. M. CAPLAN
1957

DATUM: SEA LEVEL

Plate V. MORROW ISOPACH



ISOPACHOUS MAP OF THE UNDIFFERENTIATED MORROW GROUP

SCALE IN MILES

0 5 10 20 30 40 50

CONTOUR INTERVAL: 200 FEET

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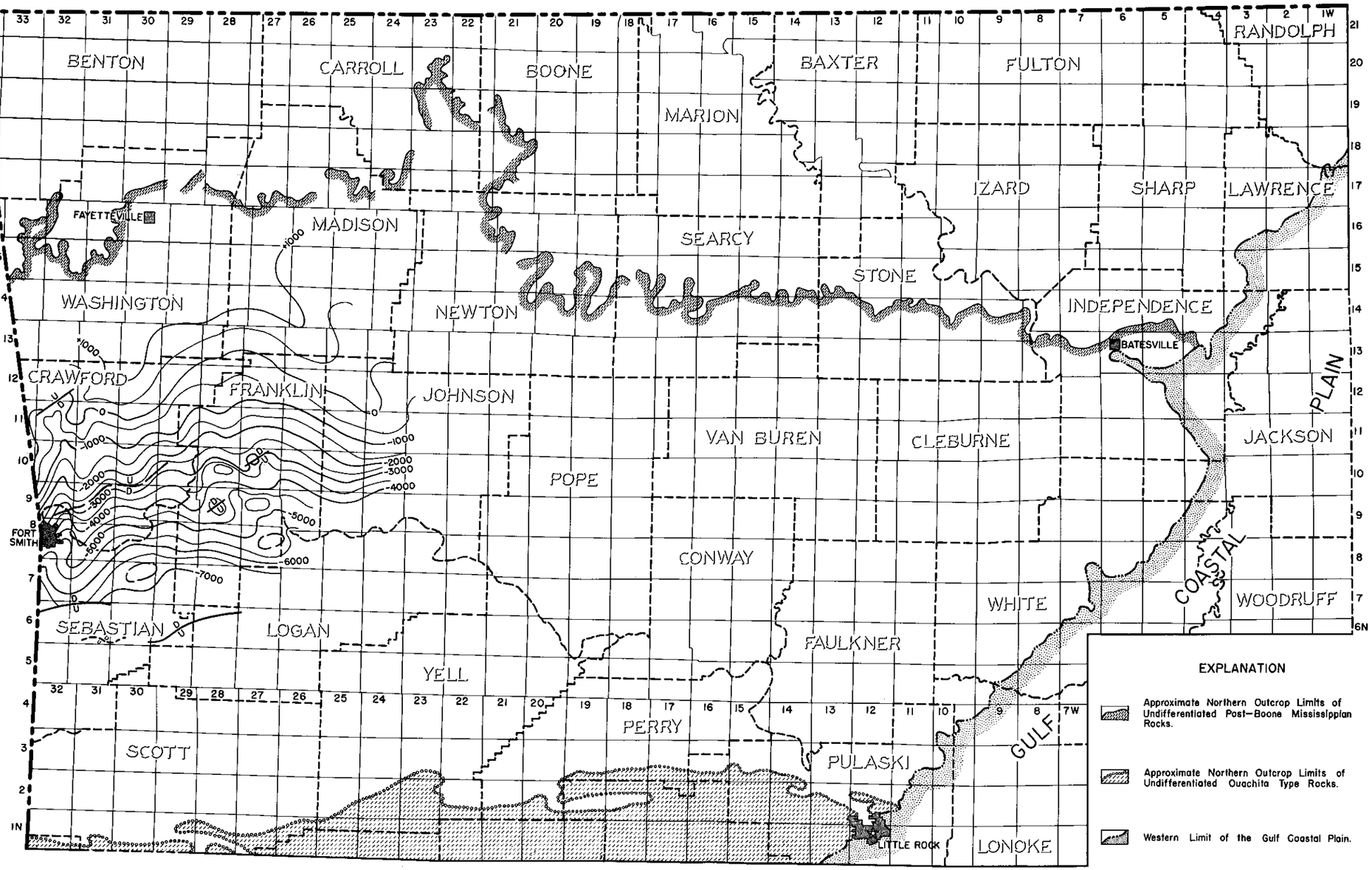
1957

Plate VI. PITKIN STRUCTURE



STRUCTURAL MAP CONTOURED ON TOP OF THE PITKIN LIMESTONE

SCALE IN MILES

0 5 10 20 30 40 50

CONTOUR INTERVAL: 500 FEET DATUM: SEA LEVEL

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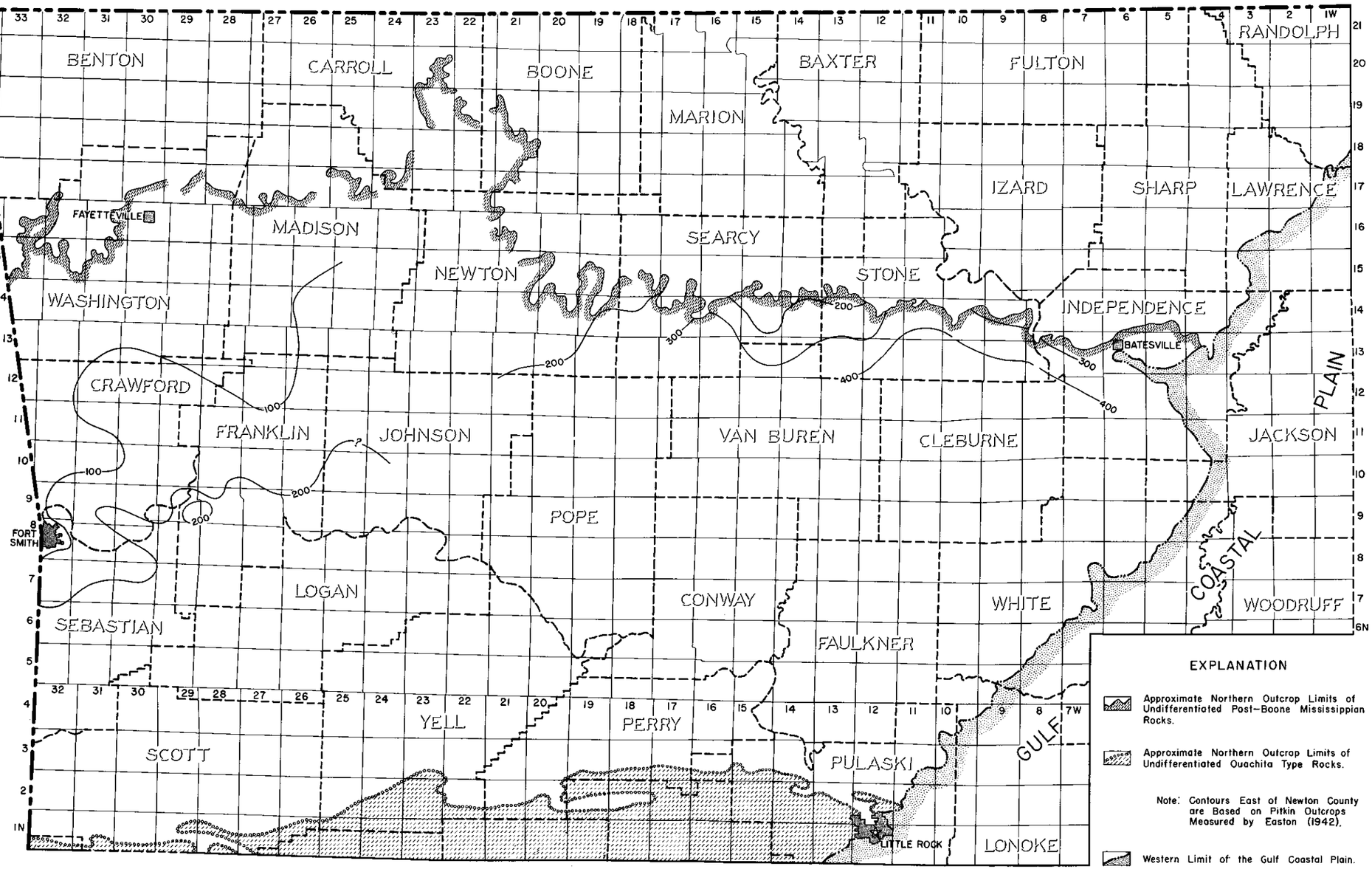
Plate VII. PITKIN ISOPACH



ISOPACHOUS MAP OF THE PITKIN LIMESTONE

SCALE IN MILES

0 5 10 20 30 40 50

CONTOUR INTERVAL: 100 FEET

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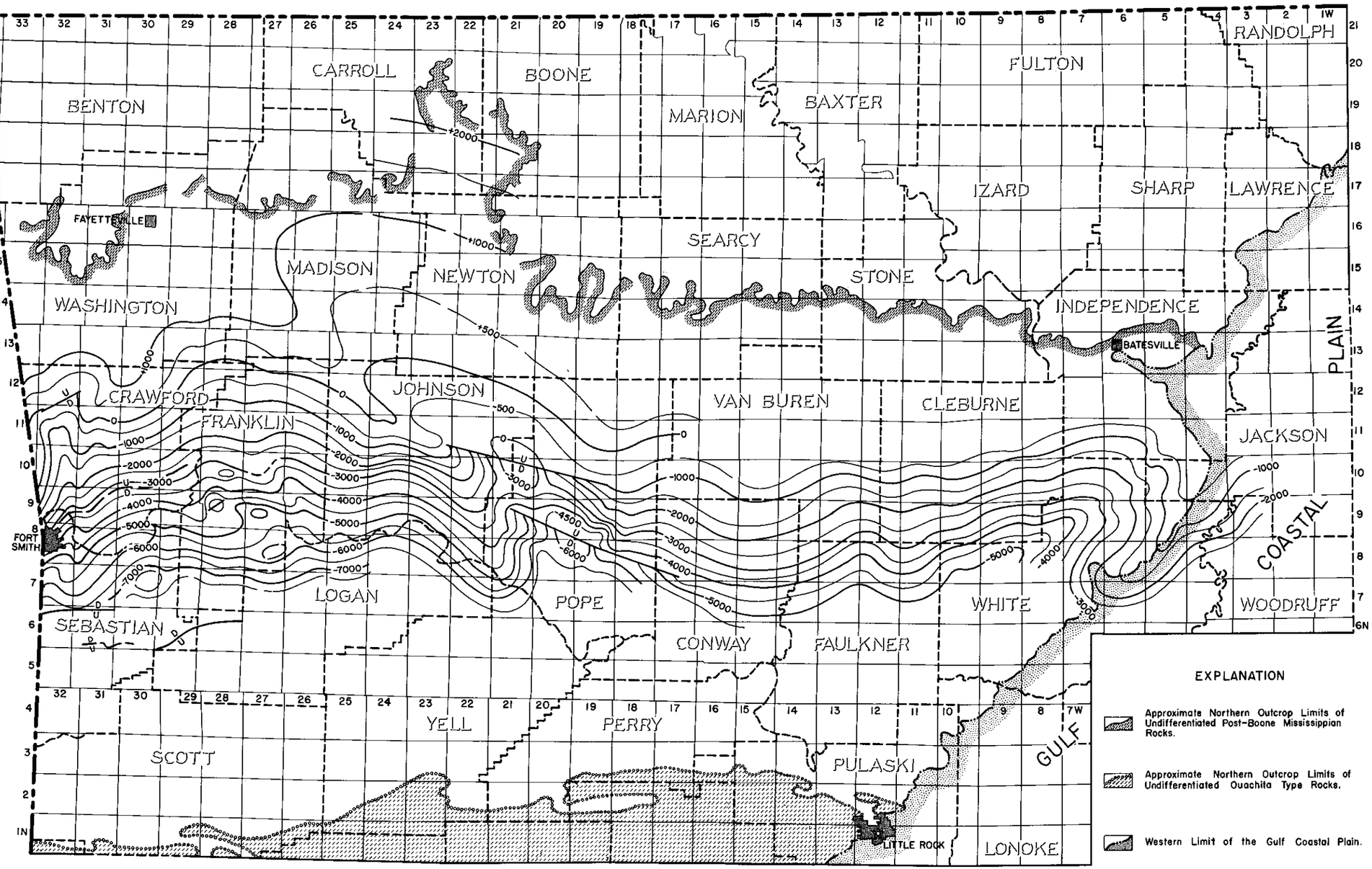
1957

Plate VIII. FAYETTEVILLE STRUCTURE



EXPLANATION

Approximate Northern Outcrop Limits of Undifferentiated Post-Boone Mississippian Rocks.

Approximate Northern Outcrop Limits of Undifferentiated Ouachita Type Rocks.

Western Limit of the Gulf Coastal Plain.

STRUCTURAL MAP CONTOURED ON TOP OF THE FAYETTEVILLE SHALE

SCALE IN MILES

0 5 10 20 30 40 50

CONTOUR INTERVAL: 500 FEET

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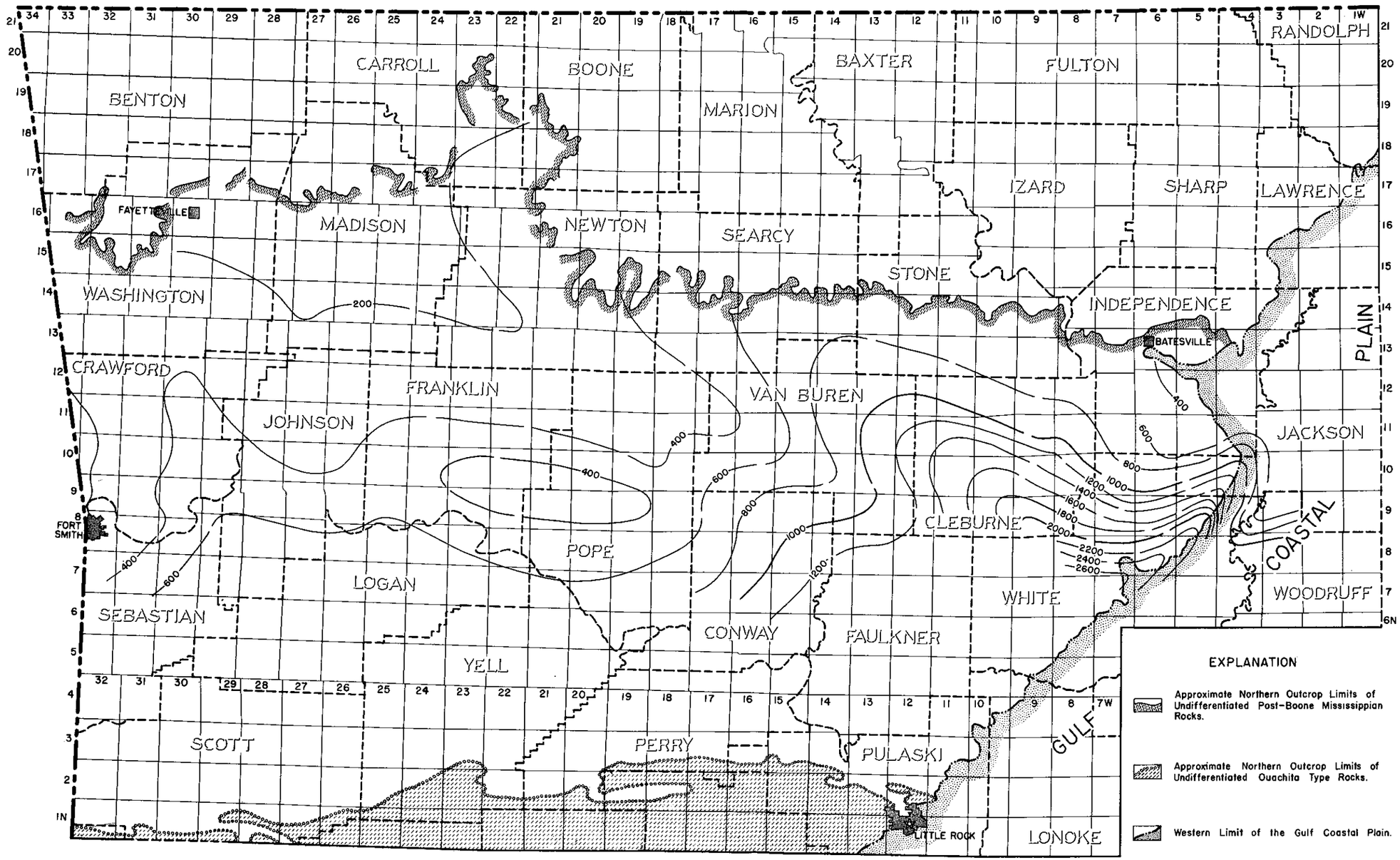
1957

Plate IX. POST-BOONE MISSISSIPPIAN ISOPACH



ISOPACHOUS MAP OF UNDIFFERENTIATED POST-BOONE MISSISSIPPIAN

SCALE IN MILES

0 5 10 20 30 40 50

CONTOUR INTERVAL: 200 FEET

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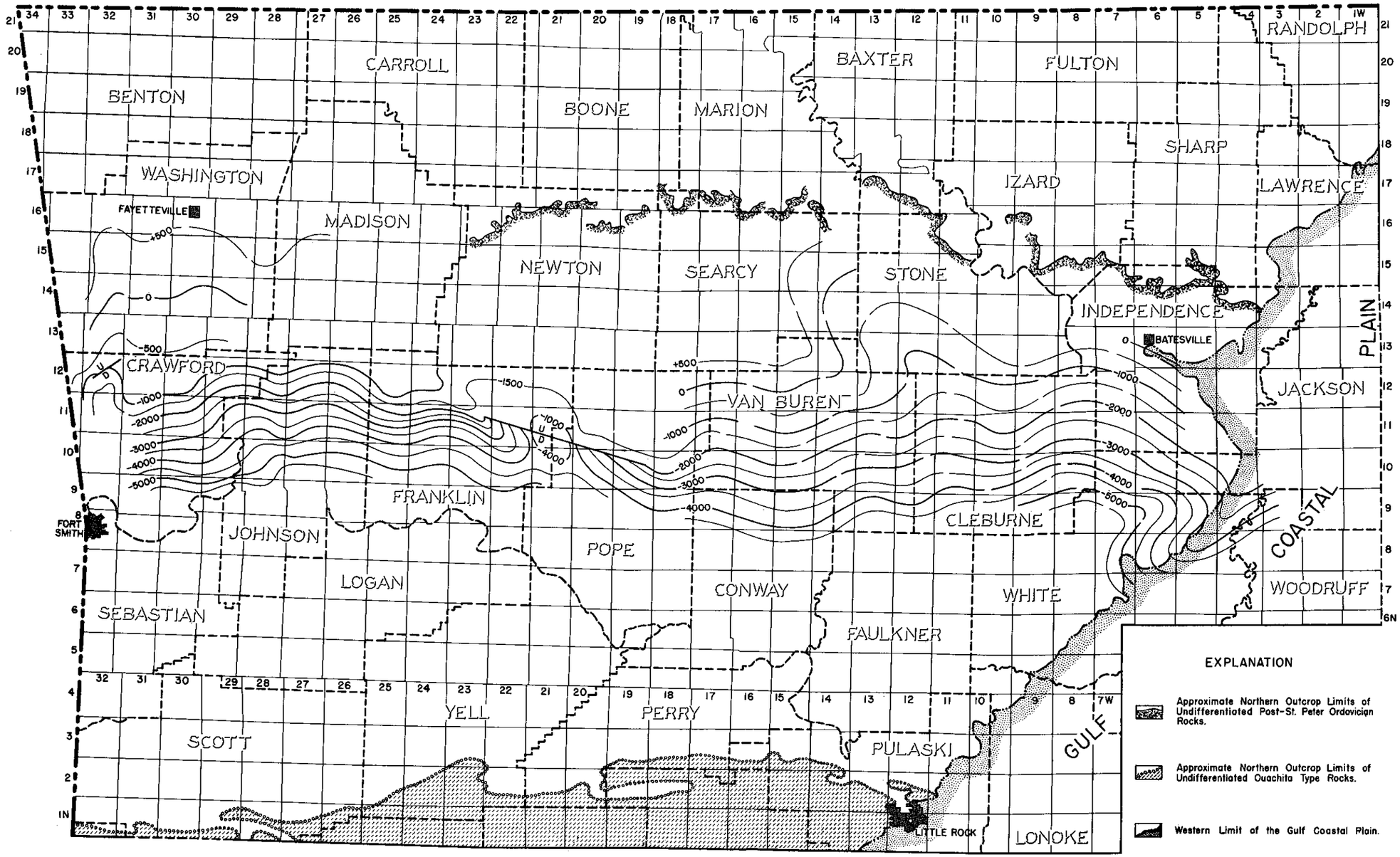
Plate X. PLATTIN STRUCTURE



STRUCTURAL MAP CONTOURED ON TOP OF THE PLATTIN LIMESTONE

SCALE IN MILES

0 5 10 20 30 40 50

CONTOUR INTERVAL: 500 FEET DATUM: SEA LEVEL

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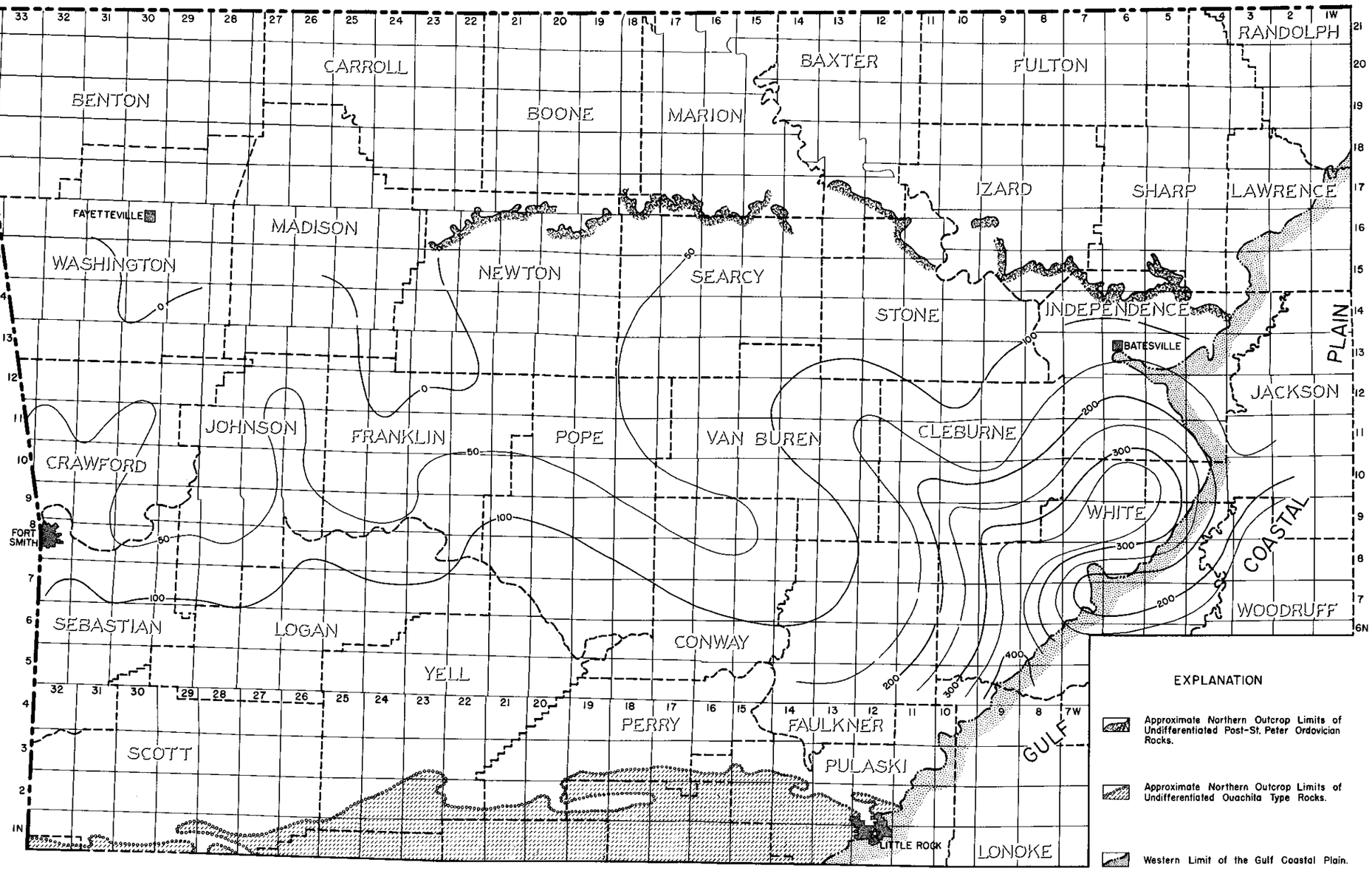
Plate XI. PLATTIN ISOPACH



ISOPACHOUS MAP OF THE PLATTIN LIMESTONE

SCALE IN MILES

0 5 10 20 30 40 50

CONTOUR INTERVAL: 50 FEET

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1957

Plate XII. ST. PETER STRUCTURE

BENTON
CARROLL
BOONE
MARION
BAXTER
FULTON
RANDOLPH
SHARP
IZARD
LAWRENCE
FAYETTEVILLE
MADISON
WASHINGTON
NEWTON
SEARCY
STONE
INDEPENDENCE
BATESVILLE
CRAWFORD
JOHNSON
VAN BUREN
JACKSON
FORT SMITH
FRANKLIN
POPE
CLEBURNE
WHITE
COASTAL PLAIN
LOGAN
CONWAY
FAULKNER
WOODRUFF
SEBASTIAN
YELL
PERRY
SCOTT
PULASKI
GULF
LITTLE ROCK
LONOKE

+500
0
-1000
-1500
-2000
-3000
-4000
-5000
U
D

EXPLANATION

Approximate Northern Outcrop Limits of Undifferentiated St. Peter – Everton Rocks.

Approximate Northern Outcrop Limits of Undifferentiated Ouachita Type Rocks.

Western Limit of the Gulf Coastal Plain.

STRUCTURAL MAP CONTOURED ON TOP OF THE ST. PETER SANDSTONE

SCALE IN MILES

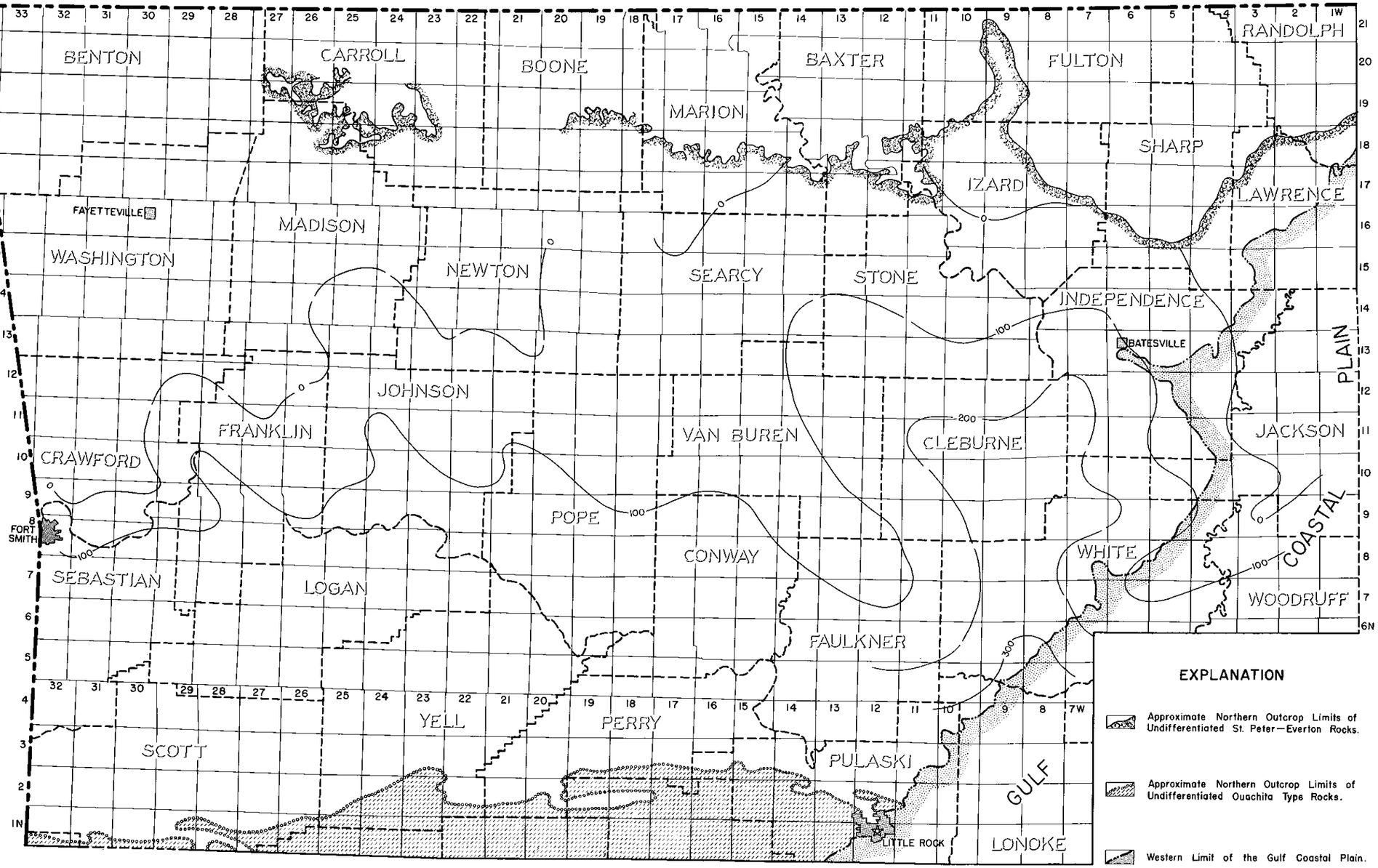
0 5 10 20 30 40 50

CONTOUR INTERVAL: 500 FEET DATUM: SEA LEVEL

W. M. CAPLAN

1957

Plate XIII. ST. PETER ISOPACH



EXPLANATION

Approximate Northern Outcrop Limits of Undifferentiated St. Peter—Everton Rocks.

Approximate Northern Outcrop Limits of Undifferentiated Ouachita Type Rocks.

Western Limit of the Gulf Coastal Plain.

ISOPACHOUS MAP OF THE ST. PETER SANDSTONE

SCALE IN MILES

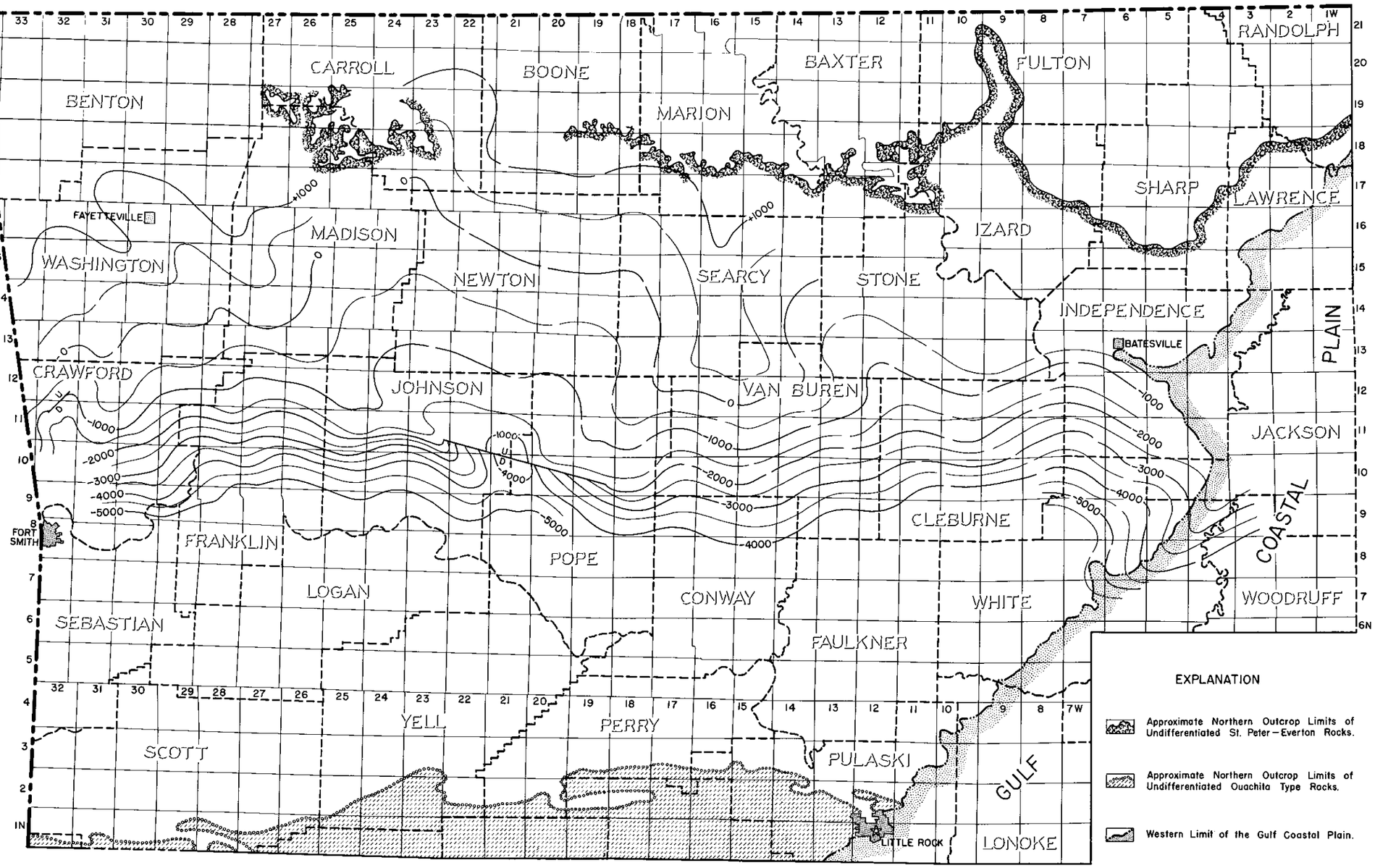
0 5 10 20 30 40 50

CONTOUR INTERVAL: 100 FEET

W. M. CAPLAN

1957

Plate XIV. EVERTON STRUCTURE



STRUCTURAL MAP CONTOURED ON TOP OF THE EVERTON FORMATION

SCALE IN MILES

0 5 10 20 30 40 50

CONTOUR INTERVAL: 500 FEET DATUM: SEA LEVEL

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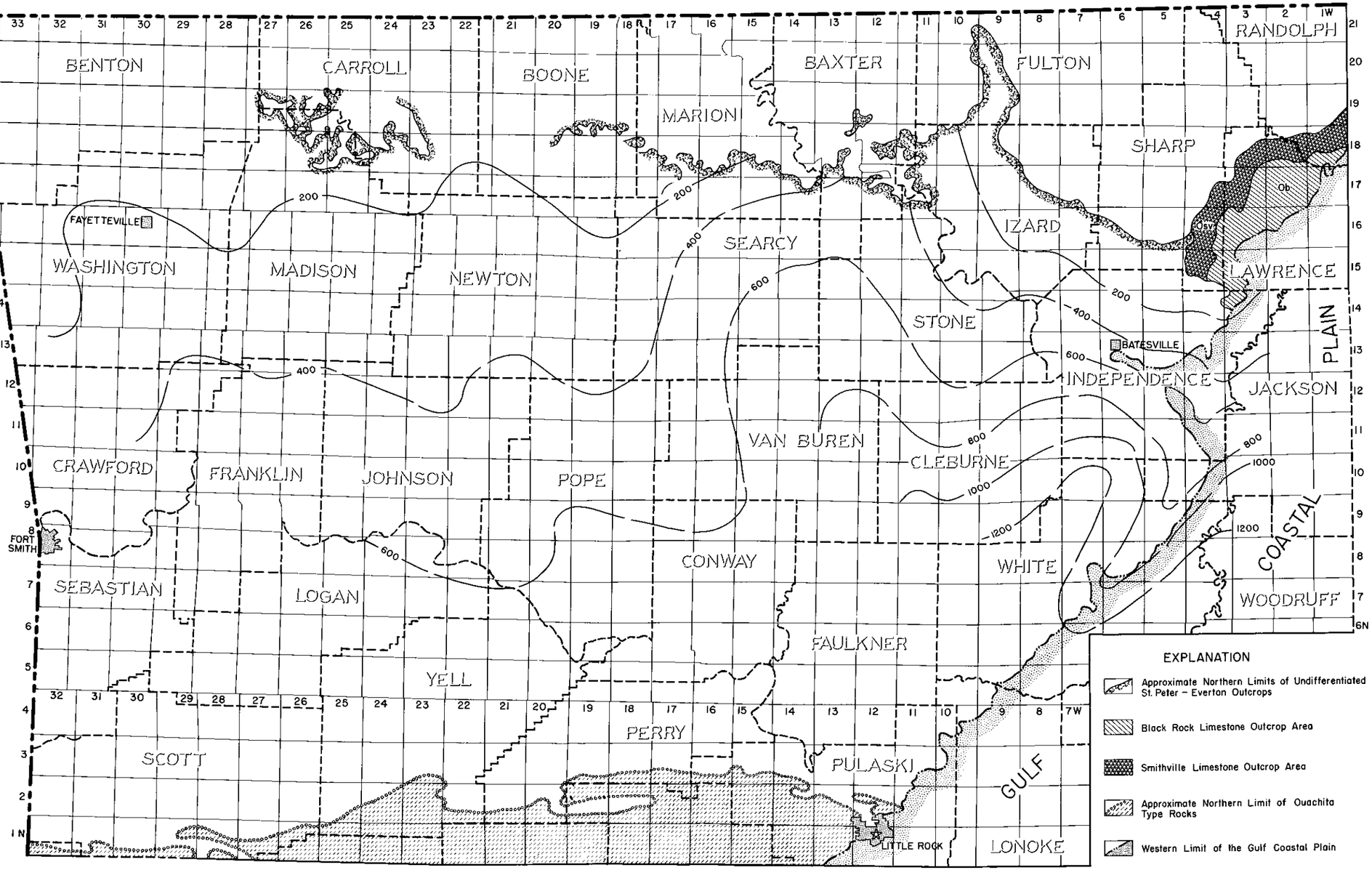
1957

Plate XV. EVERTON ISOPACH



ISOPACHOUS MAP OF THE EVERTON FORMATION

SCALE IN MILES

10 5 10 20 30 40 50

CONTOUR INTERVAL: 200 FEET

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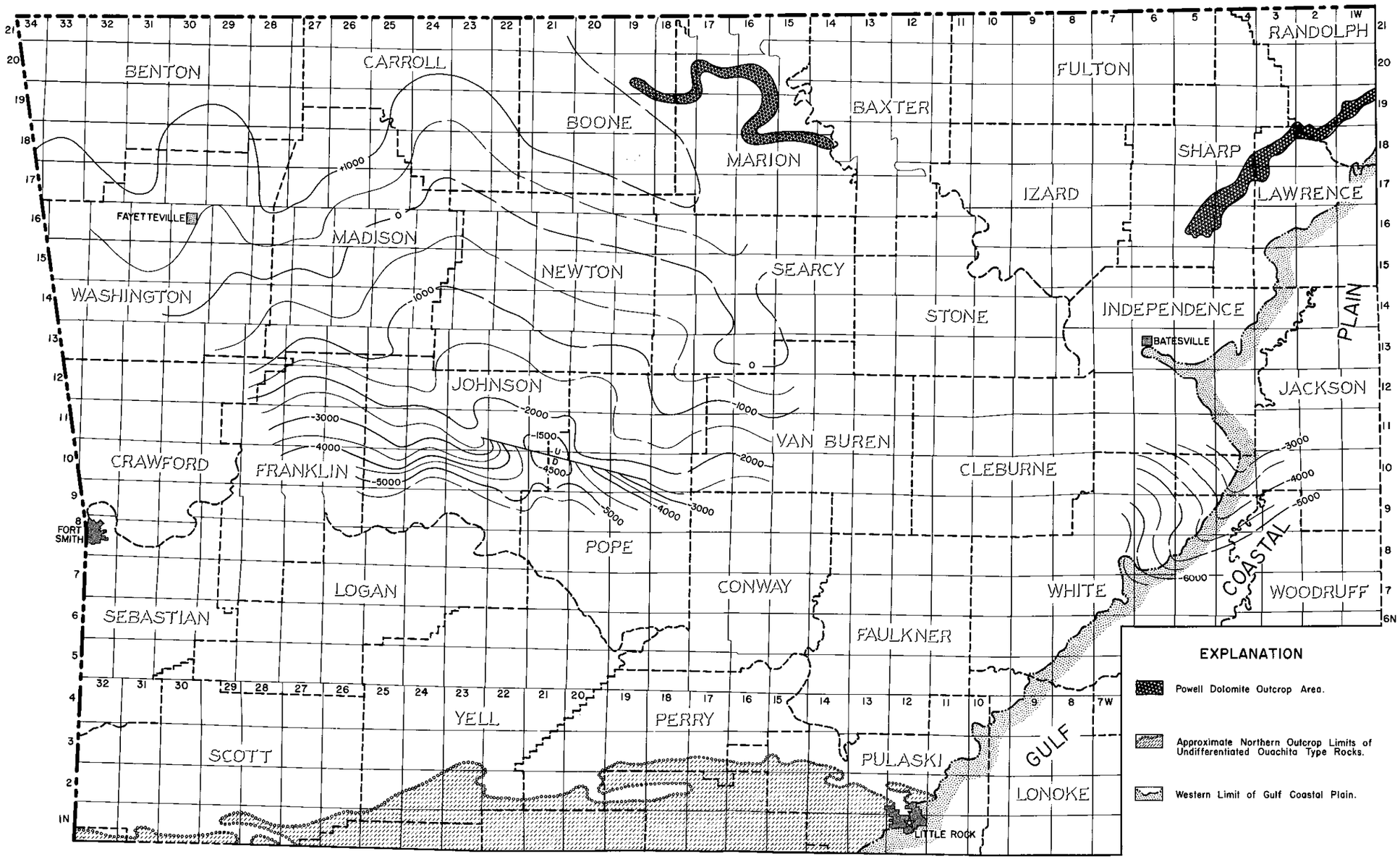
1957

Plate XVI. POWELL STRUCTURE



STRUCTURAL MAP CONTOURED ON TOP OF THE POWELL DOLOMITE

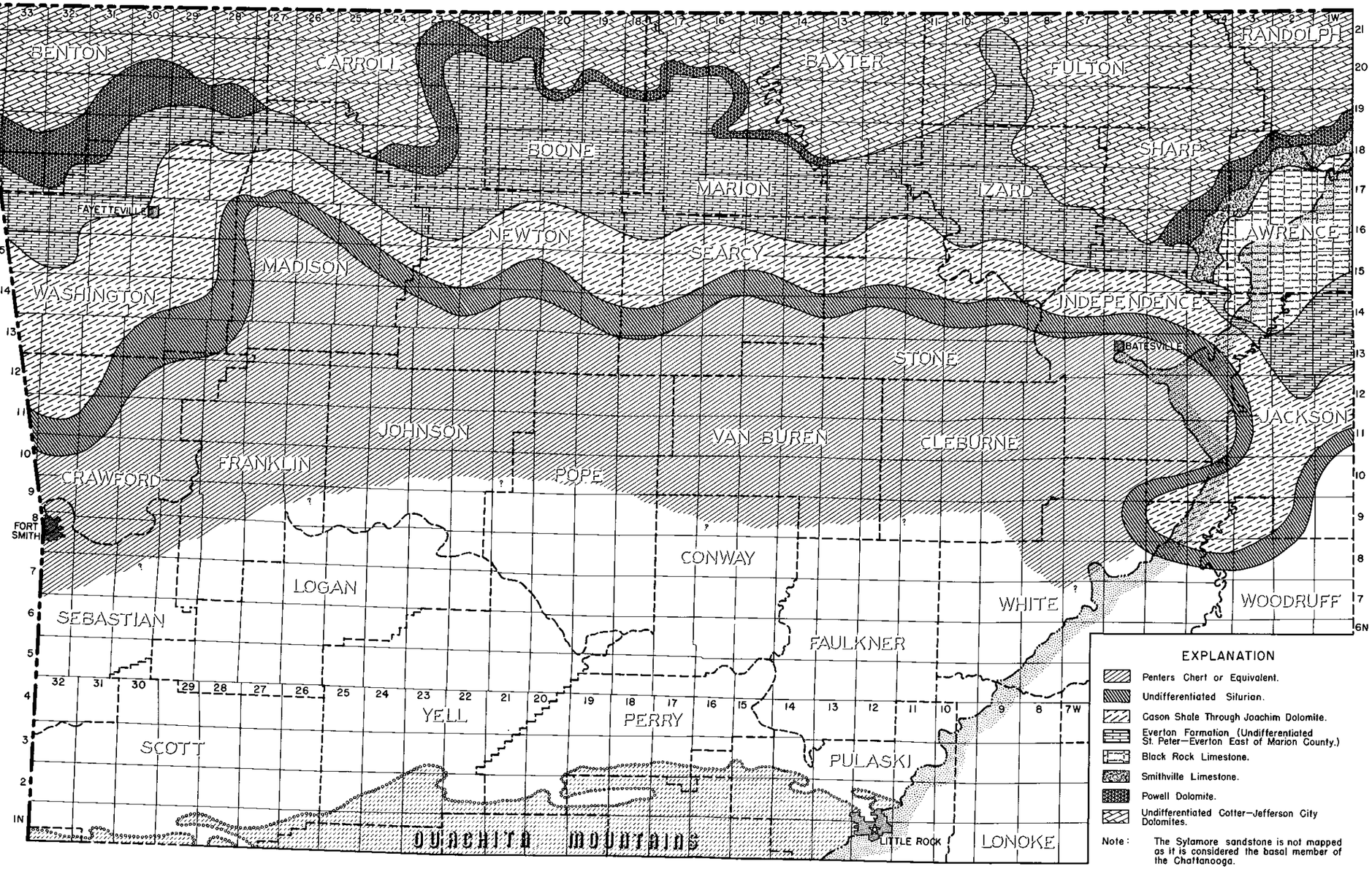
SCALE IN MILES

10 5 10 20 30 40 50

CONTOUR INTERVAL: 500 FEET DATUM: SEA LEVEL

W. M. CAPLAN
1957

Plate XVII. PRE-CHATTANOOGA PALEOGEOLOGY



GENERALIZED PRE-CHATTANOOGA PALEOGEOLOGIC MAP

SCALE IN MILES

0 5 10 20 30 40 50

W. M. CAPLAN

1957