# GEOLOGIC STRUCTURES IN KANSAS

By JOHN MARK JEWETT

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# GEOLOGIC STRUCTURES IN KANSAS

By
JOHN MARK JEWETT

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## ABSTRACT

Geologic structures, numbering 161, in Kansas that have received names are listed and defined. Some of them are discussed briefly.

## INTRODUCTION

A working definition of "geologic structures" is formulated with some difficulty. In the language of some people, geologic structures embrace geologic entities formed by diastrophism, sedimentation, and vulcanism, and even erosion. Thus included as geologic structures are land forms that are the result of sedimentation, elevation, and erosion; ore bodies; stratigraphic units; and igneous masses; in fact all forms that are present in the earth's crust. In this sense, structural geology is almost or quite as broad as is geology itself. Most geologists, however, use the term in a more exclusive way and geologic structures commonly are said to include elements that owe their form to folding or faulting in the earth's crust. In this sense, also, structures might mean many things and the continents and ocean basins would be regarded as great structures and there would be many structural elements of decreasing magnitudes. Here, however, structural elements are considered in the restricted sense (those of importance in reference to the geology of Kansas); hence they are mostly of relatively small size.

There may be some difference of opinion regarding the exact meaning of the terms folding and faulting but it is sufficient here to state that as the terms are used in this paper they necessarily do not mean results of deep-seated earth movements. On the other hand some of the Kansas "structures" are the effects of irregular compaction of sediments above buried hills or subsidence of strata following solution and removal of underlying rocks. They resulted from movements that affected a relatively shallow part of the earth's crust. Some of the "structures" may be cogenetic with the rocks—that is, sediments accumulated on slopes of hills that are now buried. Most of the features listed in this index, however, are geologic structures, in as narrow a sense as would be entertained by anyone.

Only inasmuch as this paper lists, defines, and discusses briefly the Kansas structures that have received published names during little more than half a century (but mostly during the last 30 years), should it be regarded as a discussion of the

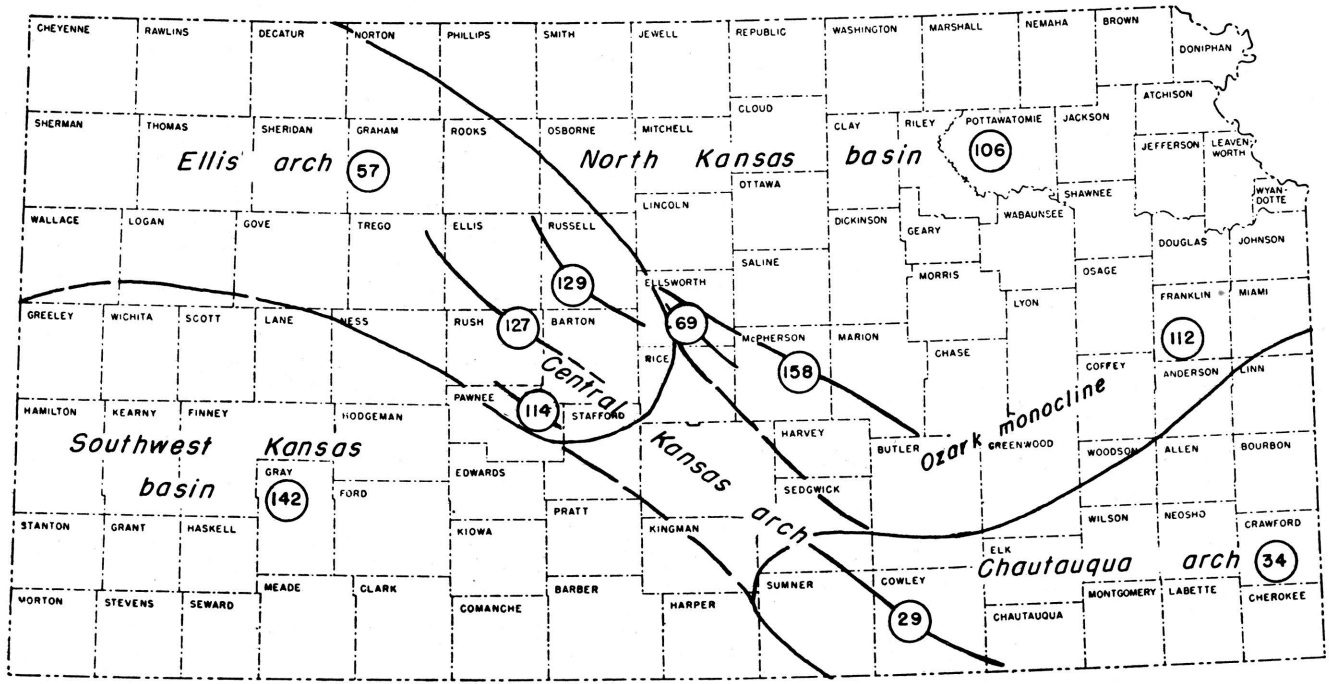


Fig. 1. Sketch map of Kansas showing locations of major pre-Mississippian structural provinces and locations of some minor structures that exemplify the ancient structural grain.

structural geology of Kansas. It is true that the major structures, which constitute the "framework" of the State (Figs. 1 and 2), are known fairly well, but only a fraction of the smaller structures have received formal designations and are included here. The density of structural names (Table 1) is only in part a reflection of the irregularity of the attitude of rock layers in various parts of Kansas. It is more an indication of areas that have been studied more closely. In part it reflects the attitude of many geologists toward giving names, for many anticlines and other structures in Kansas have been mapped and described but not named in published reports. Many privately held maps show named anticlines, domes, and synclines, comparable to many that are listed in this paper, but names on unpublished maps cannot be included here. Furthermore, it is well known that many, perhaps the majority, of Kansas oil fields lie above structural domes and anticlines, but only in comparatively few instances have the geologic structures been named formally in published reports.

In practical applications the structure of rock layers ranks with their physical character in importance. It is well known that structure plays an important role in oil and gas accumulation; it is scarcely less important in ground-water geology. Rock structure, even though not of great magnitude, has bearing on mining, quarrying, and other operations that involve removal or penetration of rocks. In consequence the structural geology of Kansas has interest for many people.

Kansas geologic structures may be divided roughly into classes called major and minor and that classification is used to some extent in this index. Because of the widespread and significant disconformity that separates rocks of Pennsylvanian age from older divisions, it is also convenient to classify some structures as post-Mississippian, segregating them from more ancient structures. In discussions of the structures listed in this paper some emphasis is placed on their age classification.

The structures listed in this paper are those that have received definite names in a published report. Most of the names are geographic. Good usage of structural terms should entail place names and priority and wide usage should have the same weight in naming structures as they do in naming rock formations. There has been considerable carelessness in this respect,

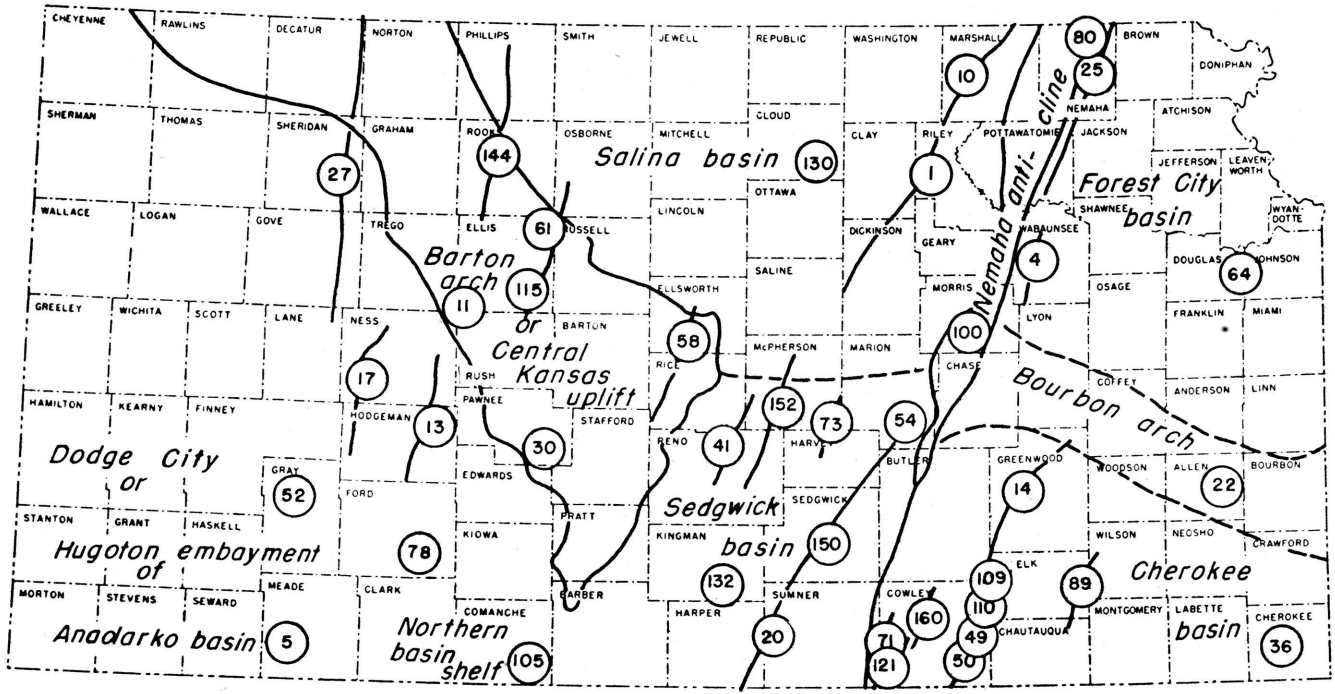


Fig. 2. Sketch map of Kansas showing locations of post-Mississippian structural provinces and locations of some minor structures that affect Mississippian and younger rocks.

and in cases where structures have received more than one name, priority and usage are cited. Indefinite geographic limitations to the application of names, especially along the lengths of anticlines or anticlinal trends, is another source of confusion.

There are many examples in the literature of a single structural element having received two or more common names in conjunction with or without the same geographic name. A segment that shows evidence of positive or rising movements may be called an arch, an anticline, a dome, or an uplift; and those that are relatively depressed are called synclines, troughs, or basins. According to the thinking of some geologists, the terms anticline, syncline, and related terms such as geanticline, geosyncline, and anticlinorium are technical terms with more restricted meanings than are ascribed to dome, arch, or basin or other common English names. Seemingly some geologists place rather definite restrictions on the more common names and use, for example, arch to designate a feature that separated *sedimentary* basins. In general, however, no such discrimination seems to have been exercised by most of the authors who have named Kansas geologic structures.

It seems unnecessary to include a glossary of terms here as meanings are reflected in the definitions and discussions under each listing.

*Purpose of the report.*—In general the purpose of this paper is twofold: to present the incomplete picture of structural conditions in Kansas as they are shown by the structures that have received names, and to have for reference a lexicon of named geologic structures in Kansas.

Figure 1 shows locations of major pre-Mississippian structural provinces in Kansas and locations of some minor structures that exemplify the ancient structural grain of the State. Figure 2 shows locations of post-Mississippian structural provinces and of some of the more important minor structures that affect Mississippian and younger rocks.

Table 1 is a list of minor structures by counties.

*Acknowledgments.*—Thanks are expressed to Dr. R. C. Moore, Dr. J. C. Frye, and Mr. Wallace Lee who have read and given valued suggestions concerning this paper.

TABLE 1.—*Finding list of more or less minor structures in Kansas (listed by counties)*

| County | Structures* | |
|---|---|---|
| Allen | Mildred dome (97) | |
| Anderson | Mildred dome (97) | |
| Barber | Northern basin shelf (105) | |
| Barton | Beaver hill (15) | Krier hill (86) |
| | Beaver Northwest hill (16) | Prusa hill (118) |
| | Breford hill (24) | Prusa North hill (119) |
| | Kraft-Prusa structure (85) | Rush rib (127) |
| Butler | Augusta anticlines (8) | Hegberg syncline (76) |
| | Bancroft syncline (9) | Lincoln syncline (88) |
| | Beaumont anticline (14) | Oil Hill dome (108) |
| | Bishop syncline (18) | Otto-Beaumont anticline (109) |
| | Boyer dome (23) | Ralston syncline (122) |
| | Burns dome (26) | Ramsey syncline (123) |
| | Chelsea dome (33) | Robinson dome (125) |
| | Chesney dome (38) | Shumway dome (137) |
| | Dunkle syncline (53) | Theta syncline (147) |
| | Elbing anticline (54) | Walnut syncline (153) |
| | El Dorado anticline (55) | Wilson dome (157) |
| | Fowler syncline (67) | Whitewater nose (161) |
| | Hammond syncline (74) | |
| Chase | Cedar Creek syncline (28) | Diamond Creek province (51) |
| | Cottonwood province (42) | Elmdale dome (60) |
| Chautauqua | Longton ridge (89) | |
| Cherokee | Commerce trough (40) | Lawton trough (87) |
| | Cow Creek anticline (44) | Miami trough (96) |
| | Joplin anticline (83) | Ozark uplift (113) |
| Clark | Ashland basin (6) | Northern basin shelf (105) |
| | Ashland-Englewood basain (7) | |
| Comanche | Northern basin shelf (105) | |
| Cowley | Beaumont anticline (14) | Otto-Dexter anticline (110) |
| | Dexter anticline (49) | Rainbow anticline (121) |
| | Dexter-Otto anticline (50) | Redbud dome (124) |
| | Graham anticline (71) | Slick-Carson dome (139) |
| | Otto-Beaumont anticline (109) | Winfield anticline (160) |
| Crawford | Pittsburg anticline (116) | |
| Decatur | Cambridge anticline (27) | Norcatur "high" (104) |
| | Darton's arch (47) | |
| Dickinson | Abilene anticline (1) | Barneston arch (10) |
| Elk | Longton ridge (89) | |
| Ellis | Fairport-Natoma anticline (61) | Russell rib (129) |
| | Pfeifer anticline (115) | Stockton anticline (144) |
| Ellsworth | Ellsworth-Kanopolis anticline (59) | Russell rib (129) |
| | Geneseo uplift (69) | Wilson-Burns element (158) |
| Finney | Finney basin (62) | Shallow Water basin (135) |
| Ford | Bazine anticline (13) | Meade basin (94) |
| Gove | Alanthus dome (3) | Darton's arch (47) |
| | Cambridge anticline (27) | Hell Creek structure (77) |
| Greenwood | Beaumont anticline (14) | Virgil anticline (151) |
| | Otto-Beaumont anticline (109) | |
| Hamilton | Syracuse anticline (145) | |
| Harvey | Halstead-Graber trend (73) | Voshell anticline (152) |
| | Harvey-Reno County basin (75) | |

| | | |
|---|---|---|
| Hodgeman | Bazine anticline (13) | Beeler anticline (17) |
| Jefferson | McLouth anticline (90) | McLouth North anticline (91) |
| Johnson | Morris anticline (99) | |
| Kingman | Cunningham dome (46) | |
| Leavenworth | Ackerland anticline (2) | McLouth anticline (90) |
| Linn | Mound City dome (99) | |
| Logan | Elkader dome (56) | Twin Buttes anticline (149) |
| | Hell Creek structure (77) | |
| McPherson | Conway syncline (41) | McPherson anticline (92) |
| | Geneseo uplift (69) | Voshell anticline (152) |
| | Halstead-Graber trend (73) | Wilson-Burns element (158) |
| Marion | Bluff City anticline (20) | Florence-Urschel fold (63) |
| | Burns dome (26) | Wilson-Burns element (158) |
| | Elbing anticline (54) | |
| Marshall | Abilene anticline (1) | Irving syncline (81) |
| | Barneston anticline (10) | |
| Meade | Crooked Creek fault (45) | Jones Ranch basin (82) |
| | Fowler fault (66) | Meade basin (94) |
| Mitchell | Salt Creek structure (131) | Tipton anticline (148) |
| Montgomery | Cherryvale anticline (37) | Coffeyville anticline (39) |
| Morton | Keyes dome (84) | |
| Nemaha | Brownville syncline (25) | Table Rock anticline (146) |
| | Humboldt fault (80) | |
| Ness | Bazine anticline (13) | Beeler anticline (17) |
| Norton | Norcatur "high" (104) | |
| Osborne | Fairport-Natoma anticline (61) | |
| Pawnee | Pawnee rib (114) | |
| Phillips | Central Nebraska basin (32) | Stockton anticline (144) |
| Pottawatomie | Brownville syncline (25) | Table Rock anticline (146) |
| Pratt | Cunningham dome (46) | |
| Reno | Conway syncline (41) | McPherson anticline (92) |
| | Harvey-Reno County basin (75) | |
| Rice | Ellsworth anticline (58) | Geneseo uplift (69) |
| Riley | Abilene anticline (1) | Barneston anticline (10) |
| Rooks | Russell rib (129) | Stockton anticline (144) |
| Rush | Rush rib (127) | |
| Russell | Fairport-Natoma anticline (61) | Pfeifer anticline (115) |
| | Gorham structure (70) | Russell rib (129) |
| Scott | Hell Creek structure (77) | Shallow Water basin (135) |
| | Scott basin (133) | |
| Sedgwick | Bluff City anticline (20) | Valley Center anticline (150) |
| Sheridan | Cambridge anticline (27) | Darton's arch (47) |
| Stevens | Hugoton trough (79) | |
| Trego | Rush rib (127) | |
| Wabaunsee | Alma anticline (4) | Davis Ranch anticline (43) |
| Wallace | Bat anticline (12) | Stockholm dome (143) |
| | Bone syncline (21) | Weskan anticline (154) |
| | Seisgood dome (134) | Western anticline (155) |
| | Sharon Springs anticline (136) | Willow Creek anticline (159) |
| | Smoky syncline (140) | |
| Wilson | Fredonia dome (68) | Silver City dome (138) |
| Woodson | Neosho Falls dome (103) | Silver City dome (138) |
| | Rose dome (126) | |
| Wyandotte | Maywood anticline (93) | Morris anticline (98) |

* Numbers in parentheses refer to numbers in the text and on the figures.

# GEOLOGIC STRUCTURES IN KANSAS

## Abilene Anticline (1)

This is a rather pronounced anticlinal fold west of and nearly parallel to the Nemaha anticline. Locally it is quite marked in outcropping rocks of early Permian age.

According to Barwick (1928, p. 179): "The Abilene anticline is another fold of considerable size trending slightly more east than the granite ridge. The McPherson gas field has recently been discovered upon it." The Nemaha anticline is the "granite ridge" of the sentence above.

Barwick (1928, fig. 1) showed the Abilene anticline extending from northern Kingman County to southwestern Marshall County. Seemingly in the light of present available data the southward extension of the Abilene anticline as shown by Barwick is too great. In summarizing deformation at the end of Mississippian time Lee, Leatherock, and Botinelly (1948, p. 136 and fig. 2C) wrote: "The prominent Abilene anticline on the northeast side of the Salina basin is recognized in the surface rocks in Riley County and extends southward into Dickinson County. It resembles the Nemaha anticline in that the beds dip steeply on its southeastern side and very gently to the northwest. Not very many subsurface data are available on the Abilene anticline. . . . The Abilene anticline is interrupted on the south by the Salina basin syncline." Lee and his associates showed that the Voshell anticline farther south is approximately in the same trend with the Abilene anticline, but the two probably are not connected. These two folds as the names now are recognized are the Abilene fold named by Barwick. Furthermore seemingly the Barneston anticline of Marshall County and neighboring parts of Nebraska is also continuous.

## Ackerland Anticline (2)

The name Ackerland anticline is used for a small domelike structure in western Leavenworth County. It contains the Ackerland oil and gas pools.

The name Ackerland was first used as a structural term by Lee and Payne (1944, p. 74). A structural map (Lee and Payne, 1944, pl. 2) indicates the structure by contours on outcropping Pennsylvanian rocks. The axis extends from the southern part of sec. 1, T. 10 S., R. 20 E. to sec. 35, T. 9 S., R. 20 E.

## Alanthus Dome (3)

An elongated dome in the southern parts of Ts. 14 and 15 S., Rs. 26 and 27 W., Gove County, has been called Alanthus. It was interpreted from dips read on outcropping rocks.

This structure was named by Lupton, Lee, and Van Burgh (1922, p. 79, pl. 5). According to a map accredited to Van Burgh the axis of the fold as suggested by dip observations extends in a nearly north-south line from near the Cen. sec. 36, T. 14 S., R. 27 W. to the north part of sec. 24 of the same township and range. The structure was regarded as a minor dome

on the Black Hills arch (also listed on this index) by the geologists who reported it.

## Alma Anticline (4)

The name Alma anticline has been coined recently to designate an anticlinal fold in Wabaunsee County.

According to Smith and Anders (1951, p. 35): "Approximately 9 miles east of the crest of the Nemaha anticline, and parallel to it, lies the axis of a similar structure very much smaller in detail which in this report will be called the Alma anticline. . . .While the amount of structural relief on the Pre-Cambrian surface of the Nemaha anticline is in the neighborhood of 2,000 feet, the amount of closure on the Alma anticline is only about 100 feet on the top of the Viola." Elsewhere Smith and Anders state that the Alma anticline extends the length of Wabaunsee County and reaches into Lyon County on the south and into Pottawatomie County on the north; and that the Davis Ranch anticline, which contains the Davis Ranch oil pool (producing from the Viola) is a part of the Alma anticline.

It is to be noted that the Alma anticline may actually consist of two or more *en echelon* folds. It is situated in the broad trough that lies east of the Nemaha uplift and which has been regarded as the deepest part of the Forest City basin in Kansas and the southern extension of the Brownville syncline of southeastern Nebraska.

## Anadarko Basin (5)

The Anadarko basin lies north of the Wichita Mountains and west of the Nemaha-Oklahoma City and Pauls Valley uplifts in Oklahoma and extends northwestward flanking the buried Amarillo Mountains across the Oklahoma panhandle into southwestern Kansas. Relatively thick sections of Mississippian and Pennsylvanian rocks in southwestern Kansas have led to the use of the terms Dodge City basin and Hugoton embayment for that part of the basin extending into Kansas.

The Anadarko basin was shown to extend into Kansas several years ago when Clifton (1923) published a map showing the deepest part of the Kansas portion as being in Comanche County. His map employs structural contour lines spaced at 250-foot intervals drawn on "base of the red rock," presumably of middle Permian age. Recently Wheeler (1947, p. 41, fig. 1) defined the Dodge City embayment as a geological province of the Anadarko basin and as an embaymentlike area extending from Oklahoma into Haskell County, Kansas. According to Wheeler (1947, p. 38): ". . . the Anadarko Basin came into existence as a subdivision of a much larger southern Oklahoma geosyncline and was further modified during Pennsylvanian and Permian times to create additional combinations of structure and stratigraphy . . ." More recently the Kansas area has been referred to by Maher and Collins (1949) as the Hugoton embayment of the Anadarko basin.

The structural names Dodge City and Hugoton are discussed elsewhere in this paper.

## Ashland Basin (6)

A lowland area in Clark County is called the Ashland basin. It was first described by Haworth (1897, pp. 21-22) who believed that it probably is the result of stream erosion, but later Johnson (1901, pp. 711-712, 722-724) expressed the opinion that solution and collapse were important factors.

The Ashland basin was well described by Smith (1940, p. 139) as a broad lowland area about 12 miles wide and about 500 feet below the High Plains level. He also attributed the formation of the basin to probable collapse following solution.

The name Ashland-Englewood basin has been used for the same structure.

## Ashland-Englewood Basin (7)

A large basin in southern Clark County that may be interpreted as structural as well as a physiographic basin has been called Ashland and later Ashland-Englewood.

According to Frye (1950, pp. 5, 7): "The Ashland-Englewood basin in southern Clark County is an area of coalescing partly filled and dissected depressions. In areal distribution the basins, or sinkholes, or sinks are sharply localized east of a prominent fault in central Meade County." And "The extensive Ashland-Englewood lowland . . . is the largest solution-subsidence feature in Kansas topography."

## Augusta (North and South) Anticlines (8)

The terms North Augusta and South Augusta are used frequently to designate the two prominent parts of the Nemaha anticline that contain the Augusta oil pools. Rocks of early Permian age crop out in the area and as elsewhere along the axis of the Nemaha uplift, the deeper abrupt folding is reflected but less sharply in surface rocks.

According to Berry and Harper (1948, p. 216): "The surface structure is characterized by a narrow anticline having a north-south axis at North Augusta and a broader northeast-southwest anticline at South Augusta. A narrow northeast-southwest trough passes through the city of Augusta and separates the two structures. Surface closure amounts to approximately 40 feet on the north structure and 60 feet on the south structure. Rate of dip is approximately the same on the east or reverse side of the structure as on the west or normal side."

The Augusta anticline, like the El Dorado dome and the Elmdale dome, are higher parts of the major uplift and are much more prominent in older rocks than in surface Permian beds. There probably are large faults, especially along the east side of the South Augusta structure. As elsewhere along the Nemaha uplift, the principal movement occurred after deposition of Mississippian rocks and before accumulation of Pennsylvanian sediments, which lie on a surface of eroded Mississippian and older formations.

## Bancroft Syncline (9)

The Bancroft syncline is a shallow minor synclinal element of the El Dorado anticline, Butler County, a prominent structural feature of the Nemaha anticline.

This structure was named by Fath (1921, p. 72): "This shallow downfold, trending northwesterly from sec. 4, T. 26 S., R. 5 E., to sec. 30, T. 25 S., R. 5 E. . . . separates the Shumway and Boyer domes from the Oil Hill dome."

## Barneston Anticline (10)

The name Barneston anticline is used for a somewhat conspicuous anticline in outcropping rocks in southern Nebraska and northern Kansas. It enters central Marshall County at the Kansas-Nebraska line and is the northern extension of the Abilene arch.

According to Condra and Upp (1931, p. 10): "A second major structure, described in Nebraska as the Barneston anticline, and in Kansas as the Abilene arch, although quite deeply eroded along its west border, does not expose the Pennsylvanian beds except in a small area at Blue Rapids, Kansas." At the time of publication of the above statement the top of the Eskridge shale was regarded as the top of Pennsylvanian beds; hence the reference to Pennsylvanian exposure.

The position of the Barneston arch is shown crossing the Kansas-Nebraska line by Condra and Reed (1943, fig. 2). The axis of a syncline previously called Irving (Condra and Upp, 1931, p. 10) is shown a short distance east of the arch. It should be noted that some published maps, based on pre-Pennsylvanian areal geology, show the Nemaha anticline extending into the western part of Riley County and including the Barneston arch (Moore and Jewett, 1942; Jewett and Abernathy, 1945; Jewett, 1949). However, there the Irving syncline is strongly expressed in outcropping rocks and in the distribution of Mississippian limestone beds (Lee, Leatherock, and Botinelly, 1948, pl. 8) and hence the Barneston is separated from the larger Nemaha structure.

## Barton Arch (11)

The names Barton arch and Central Kansas uplift are applied to the same major post-Mississippian structural province.

The Barton arch (originally called Russell arch and later known as the Central Kansas uplift) was named by Barwick (1928, p. 177): "The name Barton is here suggested for the broad pre-Pennsylvanian and probably in part pre-Mississippian high in Ellsworth, Rice, Barton, Russell, and near by counties. The presence of Ordovician strata directly underneath the Pennsylvanian in Russell County has been demonstrated by Udden (1926) and Twenhofel (1927). This arch is in line with the Chautauqua arch and is separated from it by a gentle saddle."

The Barton arch is now regarded as an important post-Mississippian structure of different grain than that of the ancestral uplift of the same area, which is called Ellis arch. Evidence of the post-Mississippian origin of this main uplift is found in the tilted and erosion-truncated margins of

Mississippian strata on its flanks and the absence of the Mississippian in the central high parts. Older Pennsylvanian rocks also are missing from higher parts of the Barton arch, but overlap of younger beds led to its ultimate burial. The structure was described in detail by Koester (1935), who preferred the name Central Kansas uplift introduced by Morgan (1932).

A. R. Denison (1926) was the first geologist to mention in print the existence of the broad structural feature that is now called the Barton arch; and Udden (1926) demonstrated the occurrence of Ordovician rocks in Russell County at comparatively shallow depths. Twenhofel (1927) a little later showed that Ordovician rocks underlie a large area in that part of Kansas. Denison called the structure the Russell arch, but his name was not generally used by other geologists.

Great amounts of oil and gas have been obtained from pools on and on the flanks of the Barton arch. Accumulations in places are in Pennsylvanian rocks and elsewhere in older beds just below the overlapping Pennsylvanian sediments.

## Bat Anticline (12)

The Bat is a small anticline in Wallace County. According to Elias (1931, p. 200): "The main structural highs, which constitute the Willow Creek structure, are Western anticline on the west, Seisgood dome on the north, and Bat anticline on the south." The Willow Creek anticline is in T. 13 S., Rs. 41 and 42 W. and is a part of a larger structure that has been called Weskan anticline.

## Bazine Anticline (13)

The term Bazine anticline is applied to an anticlinal fold in Ford, Hodgeman, and Ness Counties. It is discernible in Cretaceous rocks.

The Bazine anticline was named by Moss (1932, pp. 40, 42): "The regional dip of the Cretaceous strata in this general area is about 10 feet per mile slightly east of north. This structural slope has two northeastward-trending anticlines superimposed upon it in Ness and Hodgeman counties. One of these, here named the Beeler anticline, . . . . and the other, here named the Bazine anticline, is in the eastern part of the two counties." And, "This anticline enters Hodgeman county from Ford county a little east of the Jetmore meridian and trends slightly east of north, passing between Jetmore and Hanson. North of here it makes a slight eastward swing and then trends nearly due north, passing just east of Bazine." And, "The Bazine anticline is apparently a southward extension of the Stockton anticline."

## Beaumont Anticline (14)

One of several anticlinal folds that have been mapped in Greenwood County is called Beaumont. The name is applied also to a trend of anticlines extending from Virgil in northeastern Greenwood County to southeastern Cowley County.

According to Bass (1936, p. 59): "The monocline has superposed on it numerous anticlines, anticlinal noses, synclines, structural basins and terraces, the most prominent of which is the Beaumont anticline that extends from the southwestern part of T. 29 S., R. 8 E., slightly east of north to sec. 32, T. 26 S., R. 9 E., thence northeast toward Eureka." The "monocline" in the quotation is the Prairie Plains monocline, listed elsewhere in this index. There are other anticlines in the same general trend as the Beaumont as Bass used the name, and the same name has been used for the larger fold. According to Ver Wiebe (1930, p. 211): "In Greenwood County . . . there is a very pronounced anticlinal ridge over 70 miles long which is called the 'Beaumont anticline.' It has a reverse dip of nearly 100 feet in places and is well marked all along its trend." Maps published by Moore and Landes (1927, figs. 61, 69, and 75) show the Beaumont anticline extending from Virgil in Greenwood County to southeastern Cowley County.

Attention is called to the previously published map of surface structures in Greenwood and parts of Butler, Chase, Wilson, and Woodson Counties (Bass, 1936, pl. 7) and to the discussion of the Otto-Beaumont anticline in this index.

McCoy and Keyte (1934, pp. 298-301, fig. 4) discussed the Beaumont anticline (restricted) in relationship to oil accumulation. Their cross section of the fold shows Mississippian limestone with undiminished thickness on the crest of the anticline and they pointed out that structural adjustment did not take place during the hiatus that preceded Pennsylvanian deposition but that growth took place during the time of accumulation of Cherokee beds and later. Clark and Cooper (1927, p. 24, pl. 1) showed that the Beaumont anticline extends into Oklahoma where it is called Ponca.

## Beaver Hill (15)

The name Beaver was given by Walters (1946, p. 671) to a buried hill of Pre-Cambrian quartzite in the northwestern part of T. 16 S., R. 12 W., Barton County. The structure overlying the hill is regarded as a part of the larger Kraft-Prusa structure, in the Barton arch and Ellis arch area.

Beaver hill and five other buried hills of Pre-Cambrian rocks in the same area were named by Walters and their geologic history was discussed and diagrammed in detail by him (Walters, 1946; Walters and Price, 1943). Inasmuch as these hills underlie arched strata of Pennsylvanian age and older rocks are gently arched on their flanks, they are regarded as geologic structures.

The Beaver oil field lies above the buried hill of the same name.

## Beaver Northwest Hill (16)

A buried hill of Pre-Cambrian rock in the northwestern part of T. 16 S., R. 12 W., Barton County, which is a part of the Kraft-Prusa structure, is called Beaver Northwest hill, from the name of the oil field which lies above it.

Like five other buried hills of Pre-Cambrian quartzite, named by Walters (1946, p. 671) and described by Walters and Price (1948), Beaver North-

west hill is regarded as a geologic structure because overlying Pennsylvanian strata are gently arched and older rocks are arched on the flanks.

## Beeler Anticline (17)

Beeler anticline is the name of a fold revealed in Cretaceous rocks in Ness and Hodgeman Counties.

The Beeler anticline was named by Moss (1932, p. 40): "The regional dip of the Cretaceous strata in this general area is about 10 feet per mile slightly east of north. This structural slope has two northeastward-trending anticlines superimposed upon it in Ness and Hodgeman counties. One of these, here named the Beeler anticline, follows the west side of the two counties . . ." and "This anticline is the most prominent structural feature in the area. From available data the structure apparently trends due north along the west side of Hodgeman county and into Ness county as far as Beeler. Here it bends to the northeast and trends toward Ransom."

## Bishop Syncline (18)

The Bishop syncline is a secondary synclinal fold on the El Dorado anticline, Butler County.

The Bishop syncline was named by Fath (1921, p. 72): "Located in a direct line with the axis of the Hammond syncline, and also possibly genetically related to it, is another depression. . . in sec. 23, and into SW¼ sec. 13, T. 26 S., R. 4 E."

The El Dorado anticline and its parts were mapped by Fath (1921, pl. 1) by means of 10-foot contour lines with the Fort Riley limestone (early Permian) as datum.

## Black Hills Arch (19)

The broad arch extending southeastward from the Black Hills to Cambridge, Nebraska, and thence southward to the Smoky Hill Valley in Kansas shown by Darton (1905, 1918) was referred to by Lupton, Lee, and Van Burgh (1922, p. 77) as the Black Hills arch. The term Black Hills arch has never come into common use but the segment south of Cambridge, Nebraska, has long been known as the Cambridge arch.

Lupton, Lee, and Van Burgh (1922, p. 78) reported: "This broad arch is registered here [Smoky Hill River Valley] and has developed on it numerous minor anticlines and domes with their axis in general parallel to the axis of the broad arch."

Structures in the Smoky Hill River Valley in Gove and Logan Counties, Kansas, to which Lupton, Lee, and Van Burgh (1922) applied names which are listed in this index are Twin Buttes dome, Chalk Creek dome, Elkader anticline, Hell Creek anticline, and Alanthus dome. Lee (personal communication) has pointed out that inasmuch as these areas, in the absence of datum beds, were mapped on the basis of low dips in brittle Niobrara chalk, the structure contours which were sketched from the dips in an attempt to visualize the import of the dip readings do not necessarily reflect the structural features with accuracy.

## Bluff City Anticline (20)

The name Bluff City anticline has been given to an anticlinal trend in the Sedgwick basin, extending in a direction south-southeast from southwestern Marion County to southwestern Harper County or farther.

The name Bluff City anticline was applied by Barwick (1928, p. 179, fig. 1): "The Bluff City anticline, which approximately parallels the Abilene anticline, extends from the Florence-Urschel field in Marion County through the Elbing field in northwest Butler County to Bluff City in southeast Harper County." Presumably Barwick regarded the fold as one prominent in subsurface rocks.

The Florence-Urschel and Elbing structures are listed elsewhere in this index. Attention is called to maps showing the structures that contain the Florence, Elbing, and other oil pools by Thomas (1927, figs. 1-3; 1929, figs. 1-3). As stated by Ver Wiebe (1938, p. 143), the Valley Center oil field may be regarded as being on the Bluff City structure.

## Bone Syncline (21)

The Bone syncline is a small synclinal fold in western Wallace County. It is discernible in outcropping Cretaceous rocks.

This name was applied by Elias (1931, p. 200): "The northern closure of the structure [Willow Creek anticline] lies in the divide between Willow creek and Schoolhouse draw. A deep and comparatively sharp syncline was found here at the heads of the several northern tributaries to Willow creek. This syncline was named the Bone syncline after Bone draw, which is at the east end of the syncline."

## Bourbon Arch (22)

The Bourbon arch is a low post-Mississippian structure that separates the Forest City and Cherokee basins.

The Bourbon arch was named by Moore and Jewett (1942, fig. 8). It was shown as separating the two basins and extending from Bourbon County to Morris and Chase Counties, and was described briefly: "A low structural divide separates the Forest City basin in the north from the Cherokee basin in the south." The axis of the structure was shown earlier by Lee (1939, pl. 2) as an "anticlinal divide," and later Lee (1943, p. 85) described it: "A broad low structural divide (the Bourbon arch) of Mississippian rocks that separated the Forest City and Cherokee basins trends vaguely toward the northwest across Bourbon, Allen, and Coffey counties, Kansas. . . ." Still later Lee and Payne (1944, p. 61) wrote: "The Forest City basin and the Cherokee basin were at first separated by a broad flat arch (Lee, 1939, pl. 2, p. 24), which will be referred to as the Bourbon arch. This arch extended northwest from Bourbon county, Kansas, and was approximately parallel to the Chautauqua arch which is not known to have been active at this time."

The thickness of Mississippian limestones increases from 300 feet or less on the Bourbon arch to more than 450 feet in Miami County, on the north, and to more than 350 feet in southern Allen and Bourbon Counties on the south (Lee, 1939, pl. 1). This may be interpreted as indicating ex-

cessive erosion on the arch before deposition of Pennsylvanian beds. Pennsylvanian sedimentation seemingly began earlier in the Forest City basin than in the Kansas part of the Cherokee basin and for a while during accumulation of basal Pennsylvanian beds, the Mississippian limestone on the Bourbon arch remained exposed. There is evidence from higher outcropping rocks that later in Pennsylvanian time this area was one of meeting and overlap of sediments from southerly and northerly directions.

## Boyer Dome (23)

The name Boyer dome has been applied to a part of the El Dorado anticline, Butler County, which is a pronounced "high" on the Nemaha anticline.

The Boyer dome was named by Fath (1921, p. 68): "The Boyer dome is a quadrilateral-shaped area centering along the boundary of sections 8 and 17 of T. 26 S., R. 5 E. . . . and covering most of sections 7, 8, and 17, and extending into sections 5, 6, 9, 16 and 18 of the same township . . . This is about 20 feet higher than the Shumway dome. Its closure [in outcropping rocks] also is correspondingly greater, amounting to about 50 feet."

## Breford Hill (24)

A buried hill of Pre-Cambrian quartzite at the southeastern end of the Kraft-Prusa structure in the Ellis and Barton arch area of the Central Kansas uplift is called Breford hill (Walters, 1946, p. 671). It is in the western part of T. 17 S., R. 10 W. and the eastern part of T. 12 S., R. 11 W., Barton County. The Breford oil field lies above the buried hill.

The Breford hill and five other buried hills of Pre-Cambrian rocks were described and diagrammed by Walters (1946) and by Walters and Price (1948). Sedimentary beds are arched above and on the flanks of the crystalline rock hills and they and the overlying rocks are regarded as geologic structures.

## Brownville Syncline (25)

Brownville syncline is the name of the syncline that lies east of the Table Rock anticline in southeastern Nebraska, better known in Kansas as the Nemaha anticline.

According to Condra (1927, p. 14): "Dr. G. L. Smith, of Iowa, proposed the name Brownville Syncline for a trough in the vicinity of Brownville, Nebraska. This syncline extends past Nemaha City and probably to or beyond the Big Nemaha Valley. It lies east of the lowest part of the east flank of the Table Rock Anticline." Later Condra and Upp (1931, fig. 1) showed the Brownville syncline extending southward in Kansas into southeastern Pottawatomie County where it is now recognized as the deepest part of the Forest City basin.

In northern Kansas the syncline east of the Nemaha anticline is expressed in the outlier of Permian rocks extending from northern Nemaha and Brown Counties southward to Kansas River (Moore and Landes, 1937; Jewett and Abernathy, 1945, pl. 1). This is a part of the synclinal area east of the Nemaha anticline extending across the State. The syncline is

especially pronounced east of the higher parts of the uplift, as the Elmdale dome, Burns dome, and El Dorado anticline. The name Walnut syncline has been given to the trough bordering the El Dorado anticline on the east.

## Burns Dome (26)

A local "high" on the Nemaha anticline, with its crest near Burns in southeastern Marion County, is known as the Burns dome.

The Burns dome was named by Prosser and Beede (1904, p. 5): "South of the Cedar Creek syncline is the Burns anticline, the crest of which is about 200 feet or more above the trough of the syncline. The axis of this fold seems to extend more nearly east and west than does that of the syncline. The highest point of this anticline is about 3 miles southeast of Burns. It extends over a considerable area east and south of Burns, but is hardly as large as the Elmdale dome."

After the Burns dome was discovered and named by Prosser and Beede who were able to study its expression only in outcropping rocks, bore holes have revealed the structure as a conspicuously high part of the Nemaha anticline. Attention is called to cross sections and maps showing subsurface conditions in the structure by Thomas (1927, figs. 1-4; 1929, figs. 1-4). Lee, Leatherock, and Botinelly (1948, pls. 6-8) showed the crest of the subsurface dome in the central part of T. 23 S., R. 5 E.

Koester (1935, p. 1419) proposed the name Wilson-Burns element for a series of structural "highs" including the Burns dome and several others along a northwesterly line extending to eastern Russell County.

## Cambridge Anticline (27)

The Cambridge anticline, in northwestern Kansas, sometimes is called Darton's arch. Its axis extends from northeastern Lane County northward, passing along the east border of Decatur County into Nebraska.

According to Bass (1926, p. 88, pl. 7): "The most pronounced feature shown in Kansas on the structure map . . . , as well as on Darton's maps of 1905 and 1918, is the Cambridge anticline, more generally known as Darton's arch, the axis of which trends northward through the eastern edge of Decatur county into Nebraska." It is discernible in the subsurface in Dakota beds, and is represented on the map as a rather broad northward-plunging anticline.

Darton (1918) surmised that his Cambridge anticline was connected with the distant Chadron anticline in northwestern Nebraska. Fuenning (1942) demonstrated the correctness of this hypothesis. Condra and Reed (1943) applied the name Cambridge arch to the anticline that crosses Nebraska from Cambridge northwestward to the border of the Black Hills where it lies east of the main axis of the Black Hills uplift.

## Cedar Creek Syncline (28)

A synclinal fold separating two domes on the Nemaha anticline, in Chase County, is called the Cedar Creek syncline.

The Cedar Creek syncline was named by Prosser and Beede (1904, p. 5): "Roughly joining the Elmdale dome on the south is the Cedar Creek syncline, the lowest point of which is near the bed of Cedar Creek, just west of Wonsevu. This syncline approaches a basin in form, but its longer axis is directed a little east of north from the locality just mentioned, and it is nearly as low as Coon Creek north of Wonsevu. The depth of this depression is about 200 feet. The folding here is such that the rocks often lie parallel with the surface, so that a stratum of limestone may be seen cropping out all the way from a head of the ravine to its mouth."

Prosser and Beede (1904) gave the name Cottonwood province to a part of the Nemaha anticline in the Cottonwood Falls quadrangle and recognized the Elmdale dome, Cedar Creek syncline, and Burns dome as parts of the larger structure. At that time it was not known that the Nemaha anticline extended across the State and beyond.

## Central Kansas Arch (29)

The name Central Kansas arch, designating the combined pre-Mississippian elements, Ellis and Chautauqua arches, was coined by Rich (1933, p. 796, fig. 2).

Rich used the names Central Kansas uplift and Chautauqua arch in the sense of several authors as names of component parts of the arch. In the paragraph above Ellis is used instead of Central Kansas because it is believed to be the better term to designate the pre-Mississippian structure that was ancestral to the younger Central Kansas or Barton arch. Rich's (p. 796) definition of Central Kansas arch is: "As here used, the term 'Central Kansas arch' is made to include the whole of the uplifted arc here described. Its eastern end has been called the Chautauqua arch by Barwick . . . and its dome-like up-bulge in Barton, Rush, Ellis, and the adjoining counties . . . the Central Kansas uplift by Morgan . . . . "The lower, compound saddle along the arch between these features has, so far as known to the writer, remained unnamed."

The name Chautauqua-Barton arch was used in the same sense by McClellan (1930) as Central Kansas arch was used by Rich.

Because the names Barton and Central Kansas had been used previously for the uplift in central Kansas whose pre-Mississippian grain differs from its post-Mississippian grain, Moore and Jewett (1942) proposed the name Ellis arch for the ancestral structure.

## Central Kansas Uplift (30)

The name Central Kansas uplift has been used widely to refer to a major post-Mississippian structural uplift and its ancestral structure in north-central Kansas. Although at present this name is more commonly used than the name Barton arch, the latter name for the same structure has priority and should be accepted as the preferred term. The name Barton arch is listed in this index and the important structural province that it signifies is discussed there. The name Central Kansas uplift was first published by Morgan (1932, p. 483) and the structures were discussed in much detail by Koester (1935).

Actually the structure referred to here was previously called Russell arch (Denison, 1926) and if priority is observed Russell should be preferred over Barton or Central Kansas. The argument advanced by some geologists that Denison (1926) and Barwick (1928), who coined the earlier names, did not have a complete conception of the structure has little significance in regard to the choice of names.

It may be observed that although it was recognized that the strike of anticlinal folds in pre-Pennsylvanian rocks in the area differs from the axis of the uplift as a whole, several geologists used the terms Barton arch and Central Kansas uplift for both the pre- and post-Mississippian structure. However, Moore and Jewett (1942, pp. 485-486) gave the name Ellis arch to the ancestral uplift.

The need for two names is made clear from details observed by Morgan (1932, p. 483): "Its present form is believed to be caused by Caledonian folding or emergence in a direction parallel to the pre-Cambrian grain followed by Appalachian or Hercynian folding normal to the grain."

## Central Kansas Uplift (Ancestral) (31)

The name "ancestral Central Kansas uplift" appears on a map by Lee, Leatherock, and Botinelly (1948, pl. 5) for the structure that also is called Ellis arch. It is discussed under that name in this paper.

## Central Nebraska Basin (32)

The name Central Nebraska basin is used by the Nebraska Geological Survey for a post-Cretaceous basin whose axis extends across Nebraska and enters eastern Phillips County, Kansas, about 40 miles east of the axis of the Cambridge arch.

The position of the axis of the Central Nebraska basin in northern Kansas is shown by Condra and Reed (1943, fig. 2). In Kansas the Central Nebraska basin may be regarded as a more or less minor structure complimentary to the Cambridge anticline and affecting Cretaceous and older rocks. Its position is immediately east of the Barton arch or along the west flank of the Salina basin.

## Chelsea Dome (33)

The Chelsea dome is a part of the El Dorado anticline, Butler County, which is a prominent "high" on the Nemaha anticline.

The Chelsea dome was named by Fath (1921, p. 71): "This elongated structure may be termed a minor anticline . . . . The long axis of the dome extends from the center of sec. 35, T. 24 S., R. 5 E., to the center of sec. 8, T. 25 S., R. 6 E. . . . . The altitude of its crest, referred to the top of the Fort Riley limestone, exceeds 1,390 feet and its closure amounts of more than 40 feet."

Fath (1921, pl. 1) showed the location and size of the Chelsea dome along with other parts of the El Dorado anticline on a structural geologic map of the El Dorado oil and gas field.

## Chautauqua Arch (34)

The name Chautauqua arch is applied to the Kansas and Oklahoma parts of the ancestral Ozark uplift. It is a major pre-Mississippian structural element.

The Chautauqua arch was named by Earwick (1928, p. 177): "The Chautauqua arch is here suggested as a name for the pre-Mississippian extension of the Czark uplift along the Kansas-Oklahoma line."

In the Chautauqua arch area Chattanooga shale and Mississippian limestones overlie the eroded surface of rocks of early Ordovician age. On its flanks rocks of the Simpson group and younger were beveled before the deposition of the Chattanooga shale. The pre-Chattanooga outcrop of St. Peter sandstone (Simpson) extending from southwestern Sedgwick County northwestward to southeastern Miami County may be regarded as the boundary of the Chautauqua arch area in Kansas (Moore and Jewett, 1942, fig. 7: Jewett and Abernathy, 1945, fig. 3; Jewett, 1949, fig. 11; 1950, fig. 7).

In pre-Mississippian time the Chautauqua-Ellis axis or the Central Kansas arch divided the North Kansas and Southwest Kansas basins. Dipping pre-Mississippian beds on the north flank of the Chautauqua arch comprise a structure known as the Ozark monocline.

## Chautauqua-Barton Arch (35)

The name Chautauqua-Barton arch has been used to designate the pre-Mississippian structure that separated the North Kansas and Southwest Kansas basins.

According to McClellan (1930, p. 1550): "The real structural backbone of Kansas is a much larger and broader feature, the Chautauqua-Barton arch, which extends from the Ozark uplift in a northwesterly direction through Chautauqua, Barton, and Norton counties." Rich (1933, p. 796, fig. 2) used the name Central Kansas arch for the same major structure. As explained elsewhere in this paper the name Ellis arch is used to designate the ancestral Barton arch or Central Kansas uplift, hence for the Barton arch as the term is used in the quotation from McClellan. The pre-Mississippian structural grain in the area is different from the post-Mississippian grain; hence the name Ellis is deemed to be more acceptable. It may be noted, however, that probably in pre-Mississippian time the Ellis arch was low and distinctly subordinate in structural relief to the Chautauqua arch.

## Cherokee Basin (36)

The extension of the McAlester basin from Oklahoma into southeastern Kansas commonly is called the Cherokee basin. Seemingly the name Pryor, as listed elsewhere in this index, has been used in the same way. Because of extensive usage and priority, Cherokee is the preferred term.

According to common usage, the Cherokee basin in Kansas is regarded as lying west of the Ozark uplift, east of the Nemaha anticline, and south of the Bourbon arch, a low positive element that until middle or late Cherokee time separated the Cherokee basin on the south and the Forest City basin

on the north and which perhaps was an area in which sediments from the north and south met and overlapped in much of middle and late Pennsylvanian time.

## Cherryvale Anticline (37)

A structure that has been observed in outcropping rocks of Missourian age in northeastern Montgomery County is called the Cherryvale anticline.

The name Cherryvale anticline was used by Moore and Boughton (1921, p. 13): ". . . there is a well-defined fold in the vicinity of Cherryvale, and a somewhat smaller fold east of Coffeyville," and ". . . between the Coffeyville and Cherryvale anticlines there is another small fold, southwest of Liberty," and "The Cherryvale oil and gas district is situated on a broad anticline."

The Coffeyville structure is listed in this index. The fold near Liberty, Montgomery County, seemingly has not received a name.

## Chesney Dome (38)

The Chesney dome is a part of the El Dorado anticline, in Butler County. The El Dorado anticline is a local elevation of the Nemaha anticline.

This structure was named by Fath (1921, p. 69): "It centers in the SE¼ sec. 21, T. 25 S., R. 5 E. . . . and extends into the adjacent quarter section. . . . The closure . . . probably does not exceed 20 feet." The Chesney dome is somewhat elongated along a line extending from the northwest to the southeast.

## Coffeyville Anticline (39)

The name Coffeyville anticline is applied to a domelike structure discernible in surface beds in southeastern Montgomery County.

The Coffeyville anticline was named by Moore and Boughton (1921, p. 13): ". . . there is a well-defined fold in the vicinity of Cherryvale, and a somewhat smaller fold east of Coffeyville. . . . and between the Coffeyville and Cherryvale anticline there is another small fold . . ." Later Foster (1929, p. 49) described the Coffeyville structure: "The Coffeyville structure can be worked from surface limestone beds. It is a gently dipping dome with about 40 feet of closure. Subsurface contours on the Oswego limestone, Mississippian limestone, and 'Siliceous' limestone, respectively, show the position of the apex of the dome farther and farther west with depth."

The Coffeyville (Ordovician) oil pool, sec. 17, T. 35 S., R. 17 E., Kansas, and secs. 15 and 16, T. 29 N., R. 16 E., Oklahoma, is in the Coffeyville dome, as described by Foster.

## Commerce Trough (40)

A synclinal fold that has been observed in basal Pennsylvanian beds in southern Cherokee County and neighboring parts of Oklahoma is reported to have been called Commerce trough (Pierce and Courtier, 1938, p. 55) but is more commonly known as Miami trough. The term Miami trough is listed in this index.

## Conway Syncline (41)

The Conway syncline is a synclinal fold in McPherson and Reno Counties lying between the Voshell anticline and the Central Kansas uplift.

According to Koester (1935, p. 1421): "The lowest part of the Salina basin from a structural standpoint is demonstrated by the contours in Mitchell County. The low area west of the McPherson anticline, or Voshell trend, here named the Conway syncline, is evident in western McPherson County and northeastern Reno County."

## Cordilleran Basin (43)

The term Cordilleran basin is used to designate a large late Paleozoic structural province in western central North America including all of Kansas.

An example of usage of the term Cordilleran basin is by Ver Wiebe (1930a, p. 767): "The continental segment, Monzonia . . . formed the western border of the Cordilleran basin, while on the northwest lay Laurentia, on the east Ozarkia, and on the southeast Llanoria." According to Ver Wiebe (1930a, fig. 1) the ancestral Rocky Mountains in Colorado lay in the central part of the basin which includes Kansas in its eastern part.

## Cottonwood Province (42)

The name Cottonwood province has been applied to a conspicuous part of the Nemaha anticline, as it is expressed in surface rocks in the Cottonwood Falls quadrangle, in Chase, Marion, and Butler Counties.

This name was first used for a structural element by Prosser and Beede (1904, p. 5): "This is a local series of small folds extending from near Strong to the southwest corner of the quadrangle. There are three of these folds, the Elmdale dome, the Cedar Creek syncline, and the Burns anticline."

Prosser and Beede named the northern part of the Nemaha anticline in the Cottonwood Falls area the Diamond Creek province. Although they did not know that the anticlines they recognized are in a series that extends across Kansas and beyond, it is to be noted that these—Cottonwood and Diamond Creek—are the first names that were given to the structure now known as the Nemaha anticline, and if strict priority were observed there would be some basis for using one of these names for the regional structure.

## Cow Creek Anticline (44)

The name Cow Creek has been applied to a small anticlinal fold in Cherokee County.

According to Smith and Siebenthal (1907, p. 9): "West of the mouth of Cow Creek there is a short and rather sharp anticline in the Cherokee formation. Commencing in the SE. ¼ sec. 10, T. 33 S., R. 25 E., it extends west of north to the SE. ¼ sec. 33, T. 32 S., R. 25 E., a distance of a little over 2 miles. The eastern limb of this anticline is much the steeper, having dips of 35° to 40°, while those of the western limb vary from slight angles up to 10° or 12°." From mapping by Pierce and Courtier (1938, pl. 5) this may be interpreted as the southwestern limit of the Lawton trough.

## Crooked Creek Fault (45)

The Crooked Creek fault has affected outcropping Tertiary and Quaternary rocks in central Meade County.

Frye and Schoff (1942, fig. 1) and Frye (1950, fig. 2) reported that the Crooked Creek fault has a strike slightly east of north, that the first movements along the fault took place at the close of middle Pliocene time, and that together with movements along the Fowler fault, a short distance to the east, they formed the ancestral Meade basin.

## Cunningham Dome (46)

The structure in Kingman and Pratt Counties that contains the Cunningham oil and gas pools is known as the Cunningham dome.

The Cunningham dome was thoroughly described by Rutledge and Bryant (1937). It was discovered by core drilling and has 25 feet of closure on the Cimarron anhydrite (Stone Corral) and 30 feet of closure on the base of the Wellington at a depth of about 1,500 feet. The map shows more than 100 feet of closure on the Lansing limestone. The axis of the dome extends from the central part of sec. 20, T. 27 S., R. 10 W., to the southeastern part of sec. 25, T. 27 S., R. 11 W. The crest of the dome on the Lansing rocks (Pennsylvanian) is nearly directly below the crest in the Permian beds about 400 feet below the land surface.

Rutledge and Bryant (1937, p. 515) believe that the first important movement that produced the Cunningham structure took place at the time of Wichita orogeny at the same time that the Barton arch, Nemaha anticline, Voshell anticline, and other anticlines were uplifted. The initial uplift was judged to have amounted to at least 220 feet inasmuch as that amount of Mississippian limestone is absent from the top of the dome. The next period of structural growth is said to have been post-Lansing pre-Douglas. About 40 feet of Pennsylvanian beds seemingly were removed during or following that growth period. Minor movements are believed to have preceded the last period of growth in post-Cretaceous time. According to Ver Wiebe (1938, p. 70) there is evidence of faulting in pre-Pennsylvanian rocks on the east side of the structure.

## Darton's Arch (47)

The Cambridge anticline, extending from southeastern Gove County northward along the eastern edge of Decatur County and into Nebraska, sometimes is called Darton's arch. It has been given this nongeographic name because it was shown on maps made by N. H. Darton and published in 1905 and 1918.

This structure is a broad northward-plunging anticline that is discernnible in Cretaceous rocks, especially the Dakota (Bass, 1926, p. 88, pl. 7).

## Davis Ranch Anticline (48)

The small anticline in Wabaunsee County which contains the Davis Ranch oil pool in Viola rocks is called the Davis Ranch anticline. The Davis Ranch oil field is in sec. 33, T. 13 S., and sec. 4, T. 14 S., R. 10 E.

The Davis Ranch anticline was named by Smith and Anders (1951) who believe it to be a part of a longer up-fold, extending across Wabaunsee County, which they called the Alma anticline. The Davis Ranch anticline is believed to be faulted on its east flank and to have about 100 feet of closure on the Viola limestone. It was discovered by surface mapping by Dr. C. W. Couser, and is said to have about 20 feet of closure in outcropping rocks of early Permian age.

## Dexter Anticline (49)

The Dexter is an anticlinal fold in Cowley County several miles east of and approximately parallel to the Nemaha anticline. The axis of the fold, which was shown by Eass (1929, fig. 18) by means of 10-foot contour lines on the Wreford limestone, extends from about sec. 7, T. 35 S., R. 7 E. to sec. 36, T. 34 S., R. 6 E.

According to Bass (1929, pp. 119-120): "Of all the structural features in the county [Cowley] the Dexter anticline . . . has the most pronounced expression in the surface beds. It is an asymmetric fold with its steeper flank on the east trending nearly due north for several miles near Otto, thence swinging to the northeast near Dexter." On a map showing structure on the upper surface of Mississippian rocks by means of 50-foot contour lines, Bass (1929, pl. 11) used the name Dexter-Otto anticline for a structure whose axis extends from the east part of T. 35 S., R. 6 E. to sec. 33, T. 32 S., R. 7 E. He (Eass, 1929, p. 121) stated: "These three anticlinal folds, the Dexter-Otto, Winfield, and 'granite ridge,' are the three most extensive structural units evident in the surface beds in the county, and their general features are duplicated in many other lesser folds."

## Dexter-Otto Anticline (50)

The names Dexter anticline and Dexter-Otto or Otto-Dexter anticline have been used more or less interchangeably in reference to a rather prominent fold in Cowley County. The structure is discussed more fully under the heading Dexter anticline.

## Diamond Creek Province (51)

Diamond Creek province is the name that has been applied to the northern part of the Cottonwood Falls part of the Nemaha anticline.

The names Diamond Creek province and Diamond Creek fold were first used by Prosser and Beede (1904, p. 5): "The other two provinces are limited areas, perhaps confined to this quadrangle. The more important of these may be designated the Cottonwood province . . .; the other may be called the Diamond Creek province." And "In the northern part of the quadrangle there are several small folds, but only two are of sufficient interest to be discussed here. On Fox Creek, near the northern border of the quadrangle, is one of the most abrupt folds in the area. On the western side of the creek the rocks are found to be about 80 feet higher than on the eastern side. The summit of the fold, however, is located farther west, on the township line at the divide between Fox and Diamond creeks."

## Dodge City Embayment (52)

The name Dodge City embayment commonly is applied to a large structural province of southwestern Kansas. It was classed as a major post-Mississippian structural province by Moore and Jewett (1942).

The name Dodge City basin was applied first by McClellan (1930, p. 1550) to the synclinal area of southwestern Kansas into which rocks dip off the west flank of the Central Kansas uplift (Barton arch). At the time of McClellan's paper few wells had been drilled in western Kansas and consequently little was known about the boundaries of the "basin." Wheeler (1947, p. 37) recently applied the term Dodge City embayment to a portion of the Anadarko basin extending into parts of Stevens, Seward, Haskell, Meade, and Clark Counties, Kansas, and Beaver and parts of Texas and Ellis Counties, Oklahoma. It may be noted, however, that the Anadarko basin had for many years been regarded as extending into Kansas (Clifton, 1926). Cliftion showed the Kansas part, based on "red rock," as being deepest in Comanche County. More recently Maher and Collins (1948, p. 814) stated their belief that the "embayment" extends northward and westward including the area between the Sierra Grande uplift, the Los Animas arch, and the Central Kansas uplift (Barton arch); and they proposed the term Hugoton embayment as more suitable than Dodge City.

It is to be noted also that although Wheeler's map shows the Dodge City embayment extending only about 30 miles into Kansas, he mentions the gradual thinning of the Paleozoic section toward the granite core of the Central Kansas uplift, which is many miles farther north. Hence seemingly Maher and Collins' (1948) northward extension of the embayment is not a departure from ideas previously held; and in fact the name Dodge City had been used since its introduction as the name of a structural province bordering the Barton arch or Central Kansas uplift (McClellan, 1930; Moore and Jewett, 1942; Jewett and Abernathy, 1945; Jewett, 1947, 1948, 1949).

Although as argued by Maher and Collins Hugoton lies more nearly in the center of the basinal area, it is believed that Dodge City is the more acceptable name because of priority and wide usage; and it is believed that Dodge City embayment is a better term than Dodge City basin, and the structure should be regarded as a part of the larger Anadarko basin, which is a large complex structure, all parts of which are not of equivalent ages. Hugoton trough, as defined by Maher and Collins (1948, p. 815), is regarded as a suitable name for a part of the embayment.

## Dunkle Syncline (53)

The name Dunkle has been applied to a synclinal fold that modifies the crest of the El Dorado anticline, Butler County. The El Dorado structure is a prominent "high" on the Nemaha anticline, which crosses Kansas from Nebraska to Oklahoma.

The Dunkle syncline was named by Fath (1921, p. 73): "Starting on the Dunkle lease in sec. 4, T. 25 S., R. 5 E., this depression trends southeastward across section 9 to the Walnut syncline and separates the Wilson and Robinson domes."

The El Dorado anticline and its parts were mapped by Fath (1921, pl. 1) by means of 10-foot contour lines with the top of the Fort Riley limestone (lower Permian) as datum.

## Elbing Anticline (54)

The name Elbing is used to designate the structure that contains the Elbing (Viola) oil pool, in Butler and Marion Counties. The Elbing field is in Ts. 22 and 23 S., R. 4 E.

Thomas (1929) showed by means of contour lines on the outcropping Herington limestone, on the buried Lansing limestone, and Ordovician rocks, an anticlinal fold with prominent domes containing respectively the Elbing, Peabody, and Covert-Sellers oil pools. He (Thomas, 1929, p. 63) referred to the Elbing anticline as one of the structures on the larger element, which essentially is the same as the Bluff City anticline (Barwick, 1928, p. 179).

## El Dorado Anticline (55)

The El Dorado anticline, Butler County, is one of the larger domes that lie along the axis of the Nemaha anticline. It has been mapped in detail by several geologists (McDowell, 1917, p. 294; Fath, 1921, pl. 1) and has been pictured in cross sections (Kellett, 1932; Moore, 1936, fig. 5; Jewett and Abernathy, 1945, pl. 3). Fath (1921, p. 67) showed that it is divisible into several minor domes and synclines. According to him (Fath, 1921, p. 66): "One major fold, the El Dorado anticline, extends in a somewhat sinuous line and in a southwesterly direction across the entire area embraced in this report, from the southeast corner of T. 24 S., R. 5 E. . . . The El Dorado anticline is limited on the east by the pronounced Walnut syncline."

The most prolific oil pools known in Kansas are in the El Dorado anticline. The following subordinate component parts of this structure are described in this paper: Bancroft syncline, Bishop syncline, Boyer dome, Chelsea dome, Chesney dome, Dunkle syncline, Fowler syncline, Hammond syncline, Hegberg syncline, Koogler nose, Lincoln syncline, Oil Hill dome, Ramsey syncline, Ralston syncline, Robinson dome, Shumway dome, Theta syncline, Whitewater nose, and Wilson dome.

## Elkader Dome (56)

The name Elkader dome has been used to designate a domelike anticline interpreted from dip readings on outcropping Cretaceous rocks in Logan County.

The Elkader dome was reported by Wallace Lee (Lupton, Lee, and Van Burgh, 1922, pl. 4). The axis of the fold as indicated by observations of dip extends from the central part of sec. 2 to the central part of sec. 26 with a broad westward curve through secs. 15 and 22, T. 14 S., R. 32 W. Two faults are shown. The structure was regarded as a minor structure on the Black Hills arch by the geologists who reported it. The use of the term Black Hills arch as the name of a structure extending into Kansas is discussed elsewhere in this index.

## Ellis Arch (57)

The Ellis arch is a major pre-Mississippian structure in central and northwestern Kansas, partly in the same area as the Barton arch or Central Kansas uplift. The Ellis arch may be regarded in part as the ancestral Barton arch. It is the western part of the most important positive early Paleozoic structural element in Kansas, comprising with the Chautauqua arch, the Central Kansas arch, which in pre-Mississippian time separated the North Kansas and Southwest Kansas basins.

The Ellis arch was named by Moore and Jewett (1942, p. 485, fig. 7): "Southwest of the North Kansas Basin, in the region now defined as belonging to the Central Kansas Uplift, Mississippian rocks are absent and lower Pennsylvanian strata rest directly on Ordovician, Cambrian, or locally on pre-Cambrian rocks. The strike of anticlinal folds in these pre-Pennsylvanian rocks differs materially from the axis of the uplift as a whole. These folds are interpreted as pre-Mississippian in age. They are aligned with folds in the Chautauqua Arch area and they seem best interpreted as older in origin than other structural features of the Central Kansas Uplift. The area is here designated as the Ellis Arch, in order to differentiate it from the Central Kansas Uplift, main features of which are post-Mississippian in origin."

The Ellis arch was called the Ancestral Central Kansas uplift by Lee, Leatherock, and Botinelly (1948, pl. 5).

## Ellsworth Anticline (58)

A structure that underlies a part of west-central Rice County is called the Ellsworth anticline.

The name Ellsworth anticline was used by Koester (1934, p. 51): "This Ellsworth anticline . . . runs through Rs. 8, 9 and 10 from the vicinity of Ellsworth to and beyond the southern limits of Rice County." And (Koester, 1935, pp. 1419-1420): "From the southwestern portion of Rice County to the vicinity of Ellsworth extends a relatively steep fold to which the name Ellsworth anticline has been given. Its position can be approximately found on the pre-Mississippian area map by the north-south Simpson band of outcrop in this area. The Chase, Ploog, and Lorraine pools are on this axis. This is an early Pennsylvanian fold. . . ." Later Ver Wiebe (1938, p. 105) wrote concerning the structures in Rice County: "Perhaps the most prominent buried structure is the Ellsworth Arch which trends toward the south through Range 9 W. On it are located the various parts of the Chase pool."

The axis of the Ellsworth anticline of Koester is nearly normal to the axis of the Ellsworth-Kanopolis anticline of Lee (1939).

## Ellsworth-Kanopolis Anticline (59)

An anticline in Ellsworth County whose axis is shown on several published geologic maps (Lee, 1939, pl. 1; McNeil, 1941, fig. 2; Lee, Leatherock, and Botinelly, 1948, pl. 9) is called Ellsworth-Kanopolis.

A trend on the line of this anticline was first noted by Koester (1935, p. 1419) who pointed out pre-Pennsylvanian exposures of "Siliceous lime,"

at Wilson and at Ellsworth in Ellsworth County. These high areas, he reported, "represent a line of pre-Mississippian warping which can be traced northwestward from the Burns dome in northern Butler County through the Peabody, Ritz-Canton, and McPherson fields." The name was applied by Lee (1939, p. 33, pl. 1) to that portion of the trend extending from Kanopolis to Wilson: "The activity of northwesterly trending folds is exemplified by the Ellsworth-Kanopolis anticline in Ellsworth county, on which Pennsylvanian, Permian and Cretaceous beds are folded."

This structure is not to be confused with the Ellsworth anticline as the name has been used by Koester (1935) and by Ver Wiebe (1938).

## Elmdale Dome (60)

The Elmdale dome, Chase County, is one of the larger domes that lie along the axis of the Nemaha anticline.

The Elmdale dome was named by Prosser and Beede (1904, p. 5): "The Elmdale dome is a broad, low upward fold of the rocks, the center of which is about 3 miles southwest of Elmdale. The total elevation of the upper part of this fold is over 200 feet. The top has been worn away and Cottonwood River now runs through the central part of it, making the center lower than the sides. The sides form a rim around the central portion, with the rocks turned upward, sometimes as much as 3° or 4°. The east-west diameter of this fold is about 9 miles, while the north-south diameter is about 12 miles."

Pennsylvanian rocks of Desmoinesian or Missourian age are in contact with Pre-Cambrian rocks at a depth of about 1,750 feet on the Elmdale dome. A short distance to the east the basement rocks are about 1,200 feet lower. The westward dip is more gentle. The Elmdale dome is plainly represented in a cross sectional diagram by Lee, Leatherock, and Botinelly (1948, pl. 13). The Elmdale dome is separated from the Burns dome on the south by the Cedar Creek syncline.

## Fairport-Natoma Anticline (61)

The name Fairport-Natoma is applied to an anticline measurable in outcropping rocks on the Barton arch in Russell County.

According to Rubey and Bass (1925, p. 67): "The best developed example of the larger folds in the vicinity of Russell county is the Fairport-Natoma anticline, which is traceable in a line that runs uniformly 8° or 10° east of north for at least 20 miles along the northern half of the western border of Russell county. The dips on the west side are steeper, the rocks commonly descending at rates of 50 to 200 feet to the mile into a parallel syncline in which the beds are 100 feet or more below their elevation on the axis of the anticline. East of the axis the beds dip 15 to 40 feet to the mile. Minor domes and depressions occur on top of the anticlinal axis and in the synclines." The location of the fold is shown on plate 4 of Rubey and Bass's report.

The discovery of the Fairport-Natoma anticline is credited to V. H. McNutt, whose structural mapping occasioned the drilling of the M. M. Valerius Oil and Gas Company No. 1 Oswald well in the SW cor. SE¼ sec.

8, T. 12 S., R. 15 W. This is the discovery well of oil in central Kansas. Subsequent drilling led to the discovery of the Barton arch and of the Ellis arch.

Rubey and Bass (1925) described several other structures in Russell County to which names were not given.

## Finney Basin (62)

A physiographic division and a structural basin in western Finney County have been called Finney basin. The basin has been regarded a part of a larger synclinal fold that has been called Shallow Water basin. However, it seems more proper to regard the structural term Finney as a synonym of Shallow Water.

Smith (1940, p. 138) described the Finney basin and identified it as a structural feature attributed to post-Ogallala downwarping and with an axis extending from Garden City to Scott City. Hence its axis lies along the same line as the Shallow Water basin's axis (Moss, 1933). Latta (1944, p. 21) regarded the southern part of the Shallow Water basin, as defined by Moss, as the Finney basin and the northern part as the Scott basin but stated that the two are continuous. Waite (1947, p. 18) described the Scott basin as a part of a broad synclinal trough whose axis extends from Garden City to Scott City and northward.

## Florence-Urschel Fold (63)

The name Florence-Urschel fold has been used to designate the anticlinal fold that contains the oil pool of the same name. It was mentioned by Barwick (1928, p. 179) in discussing the structures near the Nemaha anticline. The Florence-Urschel oil field is in T. 21 S., R. 5 E., Marion County.

Shea (1922, pp. 427-429, figs. 1-2) described the structure that contains the Florence-Urschel pool (p. 427) "It consists of an anticline with a long curved axis which lies immediately west of the 'Granite Ridge arch' and extends from the northeast corner of section 16 through the center of section 21 and into the northwest quarter of section 27," and (p. 429) "The subsurface structure, as defined by datum elevations on the producing horizon, shows very little conformation with the surface." The producing rock is the Viola limestone. Shea's maps show structure mapped on outcropping Permian rocks and on the Viola limestone. Thomas (1927, figs. 1-3; 1929, figs. 1-3) published maps showing structure as revealed in outcropping rocks, Lansing rocks, and Ordovician rocks.

## Forest City Basin (64)

The term Forest City basin has come into general usage as the name of a major post-Mississippian sedimentary basin east of the Nemaha anticline in northeastern Kansas and neighboring parts of Missouri, Nebraska, and Iowa. The name is used in this manner by several geologists (McQueen and Greene, 1938, pp. 12-13; Moore and Jewett, 1942, fig. 8; Lee, 1941, 1943; Lee and Payne, 1944, p. 61; Jewett and Abernathy, 1945, p. 43, fig. 5; Lee

and others, 1946; Jewett, 1947, fig. 1; 1948, fig. 1; 1950, fig. 1; Jewett and Smith, 1949, p. 86).

However, Forest City was first used as a structural term to indicate the part of a pre-Mississippian basin that lies east of the younger Nemaha anticline. In this sense it is a part of what is commonly known as the North Kansas basin. It would be defined as a structural negative segment of pre-Mississippian rocks formed at different times by the uplifting of the Chautauqua arch (ancestral Ozark uplift), the Nemaha anticline, and other positive segments and by downwarping within the basin itself, for it was defined principally on the basis of present extent of Devonian and Silurian rocks, which largely is the result of pre-Chattanooga and post-Mississippian erosion. This is made clear by Ockerman (1935, pp. 8-9): "The basin was named after Forest City, Missouri, where a deep well was drilled in 1901. The correlation of this well, as given by Ulrich, indicated that there is a basin, and subsequent drilling in Kansas has fairly well defined the boundaries and outline of the southern end of the basin in eastern Kansas. The general outline of the basin is marked by the distribution of the Hunton 'lime' east of the Granite Ridge." The term "Hunton lime" refers to Silurian and Devonian beds.

Later the term was used in a different sense. According to McQueen and Greene (1938, pp. 12-13): "The area has the aspects of both a structural and depositional basin, and these factors make difficult a close definition of the limits of this regional feature . . . . The southern boundary is poorly defined and can be drawn only on the basis of a zone in which drilling has revealed the Cherokee formation to be thinner than in the Forest City basin to the north and the Oklahoma basin to the south. The Pennsylvanian beds are probably largely responsible for the general use of the name 'Forest City basin' among geologists and if a definition is to be closely drawn, it will be drawn on the basis of the thickness of the pre-Ardmore limestone portion of the Cherokee."

The zone of thinner Cherokee section, referred to by McQueen and Greene, is the Bourbon arch, which is listed and discussed in this index. The Ardmore limestone lies in the upper middle part of the Cherokee group of rocks, which is Desmoinesian in age and comprises the basal Pennsylvanian sediments of eastern Kansas.

The details of stratigraphic and structural developments within the area of the Forest City basin have been thoroughly discussed and diagrammed by Lee (1943) and Lee and others (1946), who used the term as the name of a post-Mississippian regional structure.

The present usage of the term Forest City basin is well expressed by Lee and Payne (1944, p. 13): ". . . Forest City basin, a low broad structural feature whose central area lies in northeastern Kansas and whose margins extend into the adjoining parts of Nebraska and Missouri and into Iowa. The basin was formed by regional warping of the pre-Pennsylvanian rocks, and it was originally both a topographic and structural feature in which the earliest Pennsylvaniian rocks of this part of Kansas were deposited."

## Forest City Basin (Ancestral) (65)

Forest City basin (ancestral) has been used for a structural basin in northeastern Kansas interpreted from present thicknesses of Mississippian rocks.

Lee and others (1946, sheet 5) showed the ancestral Forest City basin with an axis extending from southeastern Atchison County to southern Miami County, with its deeper parts (more than 450 feet of Mississippian limestone) in southwestern Miami County and in northeastern Johnson County and neighboring parts of Jackson County, Missouri.

## Fowler Fault (66)

The Fowler fault affects outcropping Tertiary and Quaternary rocks in Meade County.

As shown by Frye and Schoff (1942, fig. 3) and by Frye (1950, fig. 2), the Fowler fault has a strike that trends slightly east of north and is situated in northeastern Meade County. The east side is the upthrown side. Frye and Schoff stated that the initial movements along the fault took place at the close of middle Pliocene time and that they, with movements along the Crooked Creek fault, formed the ancestral Meade basin.

The Fowler fault is not to be confused with the Fowler syncline in Butler County.

## Fowler Syncline (67)

The Fowler syncline is a synclinal fold that modifies the El Dorado anticline, a prominent part of the Nemaha anticline, in Butler County.

The Fowler syncline was named by Fath (1921, p. 72): "Still farther north, and located in line with the Hammond and Bishop synclines . . . is the Fowler syncline, extending from . . . sec. 1, T. 26 S., R. 4 E., into section 13 of the same township, and into sec. 6, T. 26 S., R. 5 E. The Fowler syncline separates the Shumway and Boyer domes . . ."

The El Dorado anticline was mapped in surface rocks (early Permian) by Fath (1921, pl. 1).

## Fredonia Dome (68)

A dome discernible in outcropping rocks of Pennsylvanian age but much more pronounced on the upper surface of Mississippian rocks in central Wilson County is called the Fredonia dome or anticline.

According to Stryker (1925, p. 1208): "The most decided structural feature in the surface strata of the county is a dome lying 3 to 4 miles east of Fredonia, the apex being in Sec. 10, T. 29 S., R. 15 E., and is known as the Fredonia anticline, or dome. This anticline has a northwest southeast trend and is 6 or 7 miles long."

On a structural geologic map of Wilson County Stryker (1925, pl. 23) shows the Fredonia dome as having two apexes, one in sec. 34, T. 28 S., R. 15 E. and one in sec. 10, T. 29 S., R. 15 E. The whole structure is shown as having more than 200 feet of closure in the upper surface of Mississippian rocks.

## Geneseo Uplift (69)

The name Geneseo uplift is applied to the eastern part or lobe of the Barton arch in Rice, Ellsworth, and McPherson Counties.

The Geneseo uplift was discussed in detail by Clark, Arnett, and Royds (1948). According to these geologists the uplift occupies a triangular area including Ts. 17 and 18 S., the west half of R. 5 and all of Rs. 6, 7, and 8 W. It contains the Bornholdt, Edwards, Geneseo, Smyres, Welch, and Wherry oil pools, and the Lyons gas pool. The Edwards, Geneseo, and Lyons pools are on higher parts of the structure along its general axis. The other pools are in stratigraphic traps on the southeastern flank of the dome. As shown by contours drawn on the Arbuckle limestone, the smaller structure that contains the Geneseo oil pool has about 125 feet of closure, but in shallow Permian rocks the closure is only about 30 feet. The dome that contains the Edwards pool, as measured on the eroded surface of Arbuckle rocks, has about the same height, and the Lyons gas pool is in a somewhat higher dome. Rocks ranging from early Ordovician (Arbuckle) to Mississippian age are truncated by post-Mississippian erosion and are overstepped by Pennsylvanian deposits.

## Gorham Structure (70)

The name Gorham structure has been used for an anticlinal structure containing the Gorham oil pool, Russell County. The structure is in the Barton arch area.

An example of usage is by Hintze (1928) who mentions the discovery of the Gorham structure by J. S. Irwin in 1923 following the discovery of oil in Russell County. The Gorham oil field is in the southern part of T. 13 S., R. 15 W.; the northwest part of T. 14 S., R. 14 W.; and the northeast part of T. 14 S., R. 15 W. Oil is produced from Pennsylvanian rocks known as the "Oswald" and "Gorham" zones. The discovery well was drilled in 1926.

## Graham Anticline (71)

This is an anticlinal or domelike structure that contains the Graham oil pool, Cowley County. The Graham field is in the north-central part of T. 33 S., R. 3 E. The structure mapped on the upper surface of Mississippian limestone was shown by Bass (1929, fig. 13). More than 50 feet of closure is indicated.

Graham was used as a structural name by Snow and Dean (1929, p. 54): "Along this general axis of folding, isolated structures of several types occur, of which the Graham and Rainbow structures are fair types." The axis of folding referred to in the quotation extends southward from the Clark oil field, Cowley County, to the Blackwell, Oklahoma, field and probably beyond. It seemingly is a short distance east of and approximately parallel to the axis of the Nemaha anticline.

## Granite Ridge (72)

The terms granite ridge, granite ridge uplift, Nemaha granite ridge, and Nemaha granite mountains have been used widely, especially in papers

that were published during the two decades that followed 1917. These names indicate the major uplift properly called the Nemaha anticline which is listed and discussed in this paper.

## Halstead-Graber Structural Trend (73)

The Halstead-Graber structural trend is an anticline in McPherson and Harvey Counties approximately parallel to and about 10 miles east of the Voshell anticline. It contains Mississippian limestone oil pools.

The name Halstead-Graber was introduced as a structural term by Lee (1939, p. 35). The axis of the anticlinal fold extends from T. 21 S., R. 1 W. to T. 23 S., R. 2 W.

## Hammond Syncline (74)

The Hammond syncline is a deep sharp syncline that modifies the southern part of the El Dorado anticline in Butler County.

The Hammond syncline was named by Fath (1921, p. 72, pl. 1): "This depression centers in sec. 34, T. 26 S., R. 4 E., and its southeastward extension, according to McDowell, separates the south extension of the Eldorado anticline from the North Augusta anticline . . . the sharpness of this depression has resulted in a marked reversal of dip on the west, producing there a plunging anticlinal flexure, the Whitewater nose, which is a southwesterly offshoot from the Shumway dome."

Inclination of strata on either flank of the Hammond syncline amounts to about 100 feet within a half mile. This structure probably lies above a graben in deeper rocks.

## Harvey-Reno County Basin (75)

The name Harvey-Reno County basin was used to designate a structural feature by Rich (1933, p. 798) in a discussion of post-Mississippian crustal movements: "Such a change [an increase in the southward dip of pre-Mississippian formations] is indicated by the greater depth to the pre-Mississippian rocks on the subsidiary arch south of the Harvey-Reno County basin."

## Hegberg Syncline (76)

Hegberg syncline is the name of a small synclinal modification of the El Dorado anticline, a pronounced "high" on the Nemaha anticline, which crosses Kansas from north to south and extends into Oklahoma and Nebraska.

The Hegberg syncline was named by Fath (1921, p. 73): "This depression. . . separates the Oil Hill and Chesney domes." It is principally in the NE¼ sec. 28, T. 25 S., R. 5 E.

## Hell Creek Structure (77)

Hell Creek structure is the name given to a large domelike structure interpreted from local dip readings on outcropping Niobrara chalk in southern Gove, southeastern Logan, and northeastern Scott Counties.

A map of the Hell Creek structure sketched from dips by Lee (Lupton, Lee, and Van Burgh, 1922, pl. 6) shows the center of the dome near the Cen. S. line SW¼ sec. 27, T. 15 S., R. 31 W., Gove County. The structure was regarded by the geologists as being a minor dome on a larger structure that they regarded as the southern extension of the Black Hills uplift (Cambridge arch). Use of the names Black Hills uplift and Cambridge arch is discussed elsewhere in this index.

## Hugoton Embayment (78)

The name Hugoton embayment was proposed by Maher and Collins (1948) to replace Dodge City embayment as used by Wheeler (1947) and Dodge City basin as used by McClellan (1930).

As stated under the discussion of Dodge City basin in this index, the term Dodge City is believed to be more acceptable because of priority and long usage. Furthermore, Maher and Collins in the same paper coined the name Hugoton trough for a part of the structure they called Hugoton embayment. It is held here that employment of the same name for both a structural unit and one of its component parts is not consistent with good usage.

## Hugoton Trough (79)

The name Hugoton trough was given by Maher and Collins (1948) to the deeper part of the Hugoton (Dodge City) embayment as defined in Mississippian rocks.

According to Maher and Collins (1948, p. 815): "The axis of the trough extends northwestward across the southwestern corner of Kansas near the town of Hugoton, which is about 85 miles southwest of Dodge City . . ." The part of the large Anadarko basin (mostly in Oklahoma) that extends into southwestern Kansas is called the Dodge City basin or embayment or by some geologists the Hugoton embayment. Hence the Hugoton trough is, as far as is known, the deepest part of the Kansas part of the Anadarko basin.

## Humboldt Fault (80)

The Humboldt fault is on the east flank of the Table Rock anticline, cutting outcropping rocks in the vicinity of the Kansas-Nebraska line in Nemaha County. The Table Rock anticline is the northern extension of the Nemaha anticline of Kansas.

The Humboldt fault was named and described by Condra (1927, p. 15): "*Humboldt Fault.* The steep dip of the beds in the east flank of the Table Rock Anticline passes into a fault at places. The maximum displacement is just northwest of Humboldt where there is an upthrow of more than 100 feet on the west." Humboldt is about 12 miles north of the center of R. 13 E. on the state line. Condra and Reed (1943, figs. 1-2) showed the fault extending into Kansas and as the fault that bounds the Nemaha ridge on the east. Humboldt may be regarded as the proper name for the fault that is believed to be present intermittently in the east flank of the Nemaha anticline along much of its length across Kansas.

## Irving Syncline (81)

A synclinal fold east of the Barneston or Abilene anticline and west of the Table Rock or Nemaha anticline in northern Kansas is called Irving.

The Irving syncline was named by Condra and Upp (1931, p. 10): "The narrow trough between the Barneston arch and the Table Rock arch is herein named the Irving syncline from Irving, Kansas." Irving is in southern Marshall County. The axis of the syncline is shown extending from about the Riley-Marshall County line near Big Blue River northward a short distance into Nebraska.

## Jones Ranch Basin (82)

A basinal area that seemingly is structural in Meade County is called Jones Ranch.

According to Smith (1940, p. 136): "The basin in which the 'Jones Ranch beds' were deposited lies east of the Meade trough, and seems to represent an isolated structural depression. . . . not necessarily much greater than 3 miles in diameter, it may be satisfactorily explained as of solution-and-collapse origin." Elsewhere he (Smith, 1940, p. 110) stated that the "Jones Ranch beds" occur in the southern part of T. 32 S. and the northern part of T. 33 S., R. 27 W.

## Joplin Anticline (83)

The Joplin anticline, principally in southwestern Missouri, lies partly in northeastern Cherokee County, Kansas.

The Joplin anticline was named by Smith and Siebenthal (1907, p. 9): "The principal orogenic feature of the Joplin district . . . is the pronounced anticline which enters the district from the south just east of Shoal Creek and bears northwestward to the vicinity of Waco." Waco is in Missouri, 1 mile east of the State line. According to Pierce and Courtier (1938, p. 55): "The Lawton trough . . . is just southwest of and parallel to the Joplin anticline." The axis of the Joplin structure may be regarded as extending into Kansas, but interrupted by depressions. This fold is discernible in outcropping Mississippian and Pennsylvanian rocks.

## Keyes Dome (84)

The name Keyes dome is applied to a geologic structure that extends into Morton County, Kansas, from Baca County, Colorado, and Cimarron and Texas Counties, Oklahoma. An example of this usage is shown by Maher and Collins (1948, fig. 1) on a map showing structural features of Mississippian rocks in southwestern Kansas, southeastern Colorado, and the Oklahoma panhandle. These geologists state (p. 814): ". . . the Keyes dome and the undefined anticlinal features east of Liberal, Kansas, may be considered within the [Hugoton] embayment."

## Kraft-Prusa Structure (85)

An elongated anticline trending in a northwest-southeast direction in Barton County in the Barton arch or Central Kansas uplift area is called

the Kraft-Prusa structure. An example of usage of the term is by Lalicker (1949, p. 255). The structure contains the Kraft-Prusa and neighboring oil pools.

An extremely comprehensive discussion of the stratigraphy, structure, and geologic history of the Kraft-Prusa oil district is found in papers by Walters (1946) and by Walters and Price (1948). The outstanding features of the structure are six buried hills of Pre-Cambrian rocks. Pennsylvanian sediments are in contact with ancient crystalline rocks on the hills and the Pennsylvanian beds are gently arched above them. The unconformable contact of Pennsylvanian deposits and Cambro-Ordovician beds is gently arched on the flanks of the hills.

Walters (1946, p. 671) named six buried hills of Pre-Cambrian quartzite in the Kraft-Prusa structure. The names given by him are: Beaver hill, Beaver Northwest hill, Breford hill, Krier hill, Prusa hill, and Prusa North hill.

## Krier Hill (86)

The name Krier hill was given by Walters (1946, p. 671) to a buried hill of Pre-Cambrian quartzite in the southwestern part of T. 16 S., R. 11 W. and the southeastern part of T. 16 S., R. 12 W., Barton County.

Six buried hills in the Kraft-Prusa oil district were described in detail by Walters (1946) and by Walters and Price (1948). The hills and the overlying arched Pennsylvanian beds with gently arched Cambro-Ordovician strata on their flanks are here regarded as geologic structures within the larger Kraft-Prusa structure of the Barton arch and Ellis arch area.

## Lawton Trough (87)

Lawton trough is the name of a small synclinal fold in Cherokee County. It is recognized in Mississippian and basal Pennsylvanian rocks.

According to Pierce and Courtier (1937, p. 55): "The two most pronounced northwestward-trending features are the troughs near Lawton and Treece. The Lawton trough, which extends southeastward into Missouri, is just southwest of and parallel to the Joplin anticline. It continues with some interruptions beyond the Miami trough."

## Lincoln Syncline (88)

Lincoln syncline is the name that has been given to a structural depression on the El Dorado anticline. It marks the north and northwestern boundary of the Chelsea dome. The El Dorado structures are on the Nemaha anticline in Butler County.

The Lincoln syncline was named by Fath (1921, p. 73): "It is located principally in Lincoln (political) township, which extends across sec. 25, T. 24 S., R. 5 E. and secs. 30, 31, 32 and 29, T. 24 S., R. 6 E."

The El Dorado anticline was mapped by Fath (1921, pl. 1). The Lincoln syncline and several other structures are shown by means of 10-foot contour lines, with the top of the Fort Riley limestone as datum.

## Longton Ridge (89)

The name Longton ridge has been given to a subsurface anticline in Elk and Chautauqua Counties.

According to Ley (1924, p. 449): "Other regional features, as the buried Longton ridge, are not evident at the surface, though it is true that there are surface 'wrinkles' scattered along its axis" and "The Longton ridge of Elk and Chautauqua Counties has been outlined for a distance of about 25 miles. The highest part of the ridge is found in Sec. 33, T. 31 S., R. 12 E. From this point east, the base of the Pennsylvanian system drops fully 250 feet to the axis of the southeast plunging syncline in Sec. 31, T. 31 S., R. 13 E."

## McLouth Anticline (90)

The name McLouth anticline is applied to a small more or less domelike fold in Jefferson and Leavenworth Counties. It was first mapped in outcropping Pennsylvanian rocks. This structure, which is faulted in Mississippian and lower rocks, contains oil and gas pools of the McLouth field.

This structure was discovered by Huntsman Haworth (Lee, 1941, p. 266): "Haworth's map indicates a broad, somewhat irregular, plunging anticline that is about 9 miles long and 2 to 4 miles wide. The axis of the anticline trends northwestward and extends from sec. 1, T. 10 S., R. 20 E., to sec. 7, T. 9 S., R. 20 E. . . . Several domes with closures of 5 to 20 feet occur on the crests and flanks of the above-described anticline." Elsewhere Lee (1941, p. 278) referred to the structure as the "McLouth anticline." Ackerland and McLouth North were used as names for other anticlines in the same area.

## McLouth North Anticline (91)

The McLouth North anticline is in eastern Jefferson County. It contains the oil and gas pools of the McLouth North field.

The structural name McLouth North was first used by Lee and Payne (1944, p. 74). The crest of the fold, as indicated by contours on outcropping Pennsylvanian rocks, lies along a line extending from sec. 7 to sec. 27, T. 9 S., R. 20 E. (Lee and Payne, 1944, pl. 2).

## McPherson Anticline (92)

The name McPherson anticline is sometimes used in the same sense as Voshell anticline. An example is shown by Koester (1935, p. 1421): "The lowest part of the Salina basin . . . is demonstrated by the contours in Mitchell County. The low area west of the McPherson anticline, or Voshell trend, here named the Conway syncline, is evident in western McPherson County and northwestern Reno County." The Voshell anticline and Conway syncline are listed elsewhere in this index.

## Maywood Anticline (93)

The name Maywood anticline is applied to a somewhat prominent, though minor, anticline or elongated dome that is measured in rocks of Missourian age in western Wyandotte County.

This structure was referred to as the Maywood anticline by Jewett and Newell (1935, p. 190): "Such an anticline extends nearly across the county from southwest to northeast, from near Bonner Springs to sec. 25, T. 10 S., R. 23 E."

This anticline was mapped in outcropping rocks and has about 25 feet of closure (Jewett and Newell, 1935, pl. 21). It is one of several small folds that can be measured in outcropping rocks in the lower Kansas River Valley.

## Meade Basin (94)

The Meade basin, chiefly in Meade County, may be regarded as a physiographic and structural basin. It sometimes is called the Meade artesian basin.

Ground-water conditions in the Meade basin were discussed by Frye (1940) and the stratigraphy was discussed by Frye and Hibbard (1941). Later Frye and Schoff (1942, p. 36) wrote: "Recent studies have indicated that the Meade artesian basin is partly structural in origin, but that many nearly filled depressions to the east of the basin appear to be due wholly to solution and subsidence." Cross sections through the basin (Frye and Hibbard, 1941, fig. 2; Frye and Schoff, 1942, fig. 3; Frye, 1950, fig. 2) show the basin bounded by faults on two sides. According to Frye and Schoff (1942, p. 36): "At the close of middle Pliocene time, the first movement occurred along the Crooked Creek and Fowler faults displacing Permian and Pliocene beds and thus giving rise to a basin, here termed the ancestral Meade basin . . . ." Frye and Hibbard (1941, fig. 2) showed the faults as on the east and west sides of the basin and about 4 miles apart. It is assumed that the basin, bounded by the faults that have been mapped in western Meade County, is regarded as extending northwestward into Ford County.

## Meade Basin (Ancestral) (95)

Ancestral Meade basin appears as the name of the Tertiary structure that exists in the Meade basin, seemingly in reference to the Meade basin being a recent physiographic feature. The Meade basin chiefly is in Meade County.

According to Frye and Schoff (1942, p. 36): "At the close of middle Pliocene time, the first movement occurred along the Crooked Creek and Fowler faults displacing Permian and Pliocene beds and thus giving rise to a basin, here termed the ancestral Meade basin."

## Miami Trough (96)

The Miami trough is a structural fold in Cherokee County, discernible in the basal part of the Cherokee shale which crops out there (the basal Pennsylvanian rock of the region, of Desmoinesian age).

According to Pierce and Courtier (1938, p. 55): "The sharp northwestward trending depression that extends from Commerce, Oklahoma, through Picher and into Kansas has been variously termed 'Commerce trough.'

'Miami fault,' 'Miami trough,' 'Miami syncline,' and 'Miami shear trough.' The name 'Miami trough' is here used for this feature, which seems to represent along its extent a combination of three features—folding, faulting, and solution followed by collapse."

## Mildred Dome (97)

A small uplift in southern Anderson and northern Allen Counties is called the Mildred dome.

According to Charles (1927, p. 30): "Two and a half miles south of Kincaid and on the southern edge of the county is a very pronounced structure known as the Mildred dome. Its axis is oriented about N. 65° W. The steep-dipping flanks form a closure of at least 30 feet." Charles (1927, pp. 28-30) described several other small structures in Anderson County to which he did not apply names.

## Morris Anticline (98)

The Morris anticline is a minor anticline or dome in the vicinity of Morris, Wyandotte County. It is observed in outcropping rocks of Missourian age.

The Morris anticline was named by Jewett and Newell (1935, p. 190): "Another conspicuous upfold is near Morris . . . and probably extends into Johnson County. The Morris anticline brings the Winterset limestone high above the flood plain of the river and has a dip of nearly forty feet to the north and northwest within a quarter of a mile."

This structure is one of several anticlinal folds that can be measured in outcropping rocks in the lower Kansas River Valley. As indicated from distribution of rock outcrops and structural contour lines based on elevations of the Argentine limestone (Jewett and Newell, 1935, pls. 13, 21) the Morris anticline is a local fold whose axis extends northeastward from the W½ sec. 27, T. 11 S., R. 24 E., with steep dips to the northwest and more gentle dips to the southeast.

It is perhaps of some significance that in the lower Kansas River Valley, where there are several local folds, the overall or regional westward dip of outcropping rocks amounts to only about 10 feet per mile (Jewett and Newell, 1935, p. 188) and is much less than the common regional inclination of outcropping rocks in eastern Kansas.

## Mound City Dome (99)

The name Mound City dome is applied to a rather pronounced structural high in Linn County; it is discernible in outcropping rocks of middle Pennsylvanian age.

The name Mound City was first used as a structural name by Jewett (1949, p. 215): "The smaller Mound City oil pool, in the 'Squirrel sand,' is on a structural dome that is rather large in comparison to most eastern Kansas structures. Seemingly the apex of the dome . . . lies a short distance north and east of Mound City. . . . The Evans et al. No. 1 Charles Cook well in the SE¼ SE¼ NW¼ sec. 4, T. 22 S., R. 24 E., was drilled on

the Mound City structure in 1938. . . . The top of Mississippian limestone was encountered at 455 feet."

## Nemaha Anticline (100)

The Nemaha anticline, or uplift, is a major post-Mississippian element that crosses Kansas from Nemaha County to Sumner County and extends into Nebraska and Oklahoma. It is discernible in surface rocks along most of its length but is much more pronounced in the subsurface and is believed to be faulted in many places along its eastern steeper flank (Kellett, 1932; Moore, 1936; Jewett and Abernathy, 1945, pls. 1-3; Jewett, 1949, pl. 3). A fault flanking the northern part is called the Humboldt fault.

In many papers the Nemaha anticline has been referred to as "Nemaha mountains," the "Nemaha granite ridge," or the "granite ridge." This is because Pre-Cambrian crystalline rocks are at comparatively shallow depths along the axis of the uplift. The anticline was first recognized as an uplift of great length and the name Nemaha first used as a structural term by Moore and Haynes (1917, p. 168): ". . . it is proposed to name the buried granite mountain ridge of central Kansas the Nemaha mountains." However, comparatively prominent anticlines or domes along the axis of the uplift had been recognized earlier. Prosser and Beede (1904) named the Burns dome, Diamond Creek anticline, Elmdale anticline, and Cottonwood province, which now are recognized as parts of the larger structural unit. Condra and Bengston (1915, pp. 25, 39) used the term "Table Rock anticline" for the part of the structure in the vicinity of the Kansas-Nebraska line. The great length of the uplift is emphasized by the use of the name Nemaha-Oklahoma City uplift by some geologists.

Lee (1943, pp. 115-119) discussed in detail the structural history of the Nemaha anticline and the development of geologic thought concerning it. It is now commonly thought that "mountains" is an unsuitable term to describe any stage of the uplift. The present concept includes deductions that were presented by Ley (1926, p. 96), Moore (1926, fig. 2), McClellan (1930, p. 1553), Rich (1931, p. 1437), and Lee (1943). This may be summarized: Mississippian and older rocks are tilted and eroded on the flanks. Pennsylvanian strata on the anticline overstep and overlap rocks ranging in age from Pre-Cambrian to Mississippian. Pennsylvanian beds lie on Pre-Cambrian rocks in a belt extending in a northwestward-trending direction from a point in T. 10 S., R. 10 E. to the Nebraska line and in isolated areas farther south. The northern part of the ridge, which had been eroded down and into the crystalline rocks, was not covered by Pennsylvanian sediments until Virgilian or late Missourian time. Older Pennsylvanian beds overstep and overlap Pre-Cambrian and Paleozoic rocks along the southern part of the axis of the upift.

It is probable that the first report of crystalline rock at shallow depth in the Nemaha anticline was that of Russell (1888) who reported crystalline rock at 552 feet in Pawnee County, Nebraska. In 1905 Darton (p. 284) stated that the rock in the Nebraska well possibly was Pre-Cambrian in age.

## Nemaha Mountains (101)

Nemaha mountains and Nemaha granite mountains were used widely, especially in the 1920's and 1930's, to designate the Nemaha anticline or more specifically its core of Pre-Cambrian crystalline rocks. The names granite ridge and Nemaha granite ridge have been used in many publications in the same sense.

The Nemaha anticline was first recognized as an uplift of great length and with a comparatively shallow crystalline rock core by Moore and Haynes (1917) and they coined the name "Nemaha mountains."

## Nemaha-Oklahoma City Uplift (102)

Nemaha-Oklahoma City uplift is used by some geologists to designate the elongated Nemaha anticline indicating that it includes in its southern part the Oklahoma City structure. The name is used in this manner by Wheeler (1947, fig. 1). It is shown on Wheeler's maps as the eastern boundary of the Anadarko basin in southern Oklahoma.

According to Wheeler (1947, p. 38): "The Nemaha Ridge culminates southward in the Oklahoma City Uplift, properly described as a buried mountain comparable in magnitude with segments of the Arbuckle Mountains to which it is closely related in age and mechanics of structure. In fact, the Oklahoma City Uplift is connected with the northern Arbuckle, Pauls Valley Uplift, by an extensive plateau which separates the Anadarko Basin from the McAlester Basin . . . ."

## Neosho Falls Dome (103)

An elliptical dome having a general north and northeast trend in the southeast part of sec. 8, T. 24 S., R. 17 E. and parts of neighboring sections, northeastern Woodson County, is called Neosho Falls dome.

According to Knight and Landes (1932, p. 8): "The Neosho Falls dome lies about 1 mile west and 1½ miles south of the town of Neosho Falls." Mapping on the top of Mississippian beds by those geologists shows more than 20 feet of closure in an area about half a mile long and a quarter of a mile wide. The Vernon oil field covers an area that includes the Neosho Falls dome.

Knight and Landes (1932) expressed the opinion that the Neosho Falls, Rose, and Silver City domes (all in Woodson County) are the results of arching of sedimentary rocks above laccoliths.

## Norcatur "High" (104)

Norcatur "high" is used to designate a pre-Mississippian structural feature on the Ellis arch in Norton and Decatur Counties and extending into Nebraska.

Referring to a map showing pre-Mississippian areal geology, Koester (1935, fig. 2, p. 1420) stated: ". . . wells in Nebraska along the Cambridge anticline have found pre-Cambrian underlying the Permian or upper Pennsylvanian, so it seems there may be a broad area in northern Kansas with little or no pre-Pennsylvanian sediments. The Norcatur 'high' ap-

parently is a continuation of the Rush rib." Koester's term Rush rib is listed in this index.

## Northern (Anadarko) Basin Shelf (105)

Northern (Anadarko) basin shelf is the name applied by Wheeler (1947, p. 41, fig. 1) to a somewhat indefinitely limited area along the northwest flank of the Anadarko basin, extending from Oklahoma into Clark, Comanche, and Barber Counties, Kansas.

According to Wheeler (p. 41): "Thus, although the Ordovician rocks rise northward into Kansas with only a gradual flattening, the Mississippian and particularly the Pennsylvanian rocks tend to show an abrupt decrease in the rate of thinning, suggestive of a northern basin platform. As a consequence, facies changes from basinal sands to platform limestones in the Pennsylvanian create an unusual class of oil possibilities."

## North Kansas Basin (106)

The North Kansas basin is a large pre-Mississippian basin north of the Chautauqua arch and north and east of the Ellis arch. The name was first used by Rich (1933, p. 796, fig. 2).

Location of the North Kansas basin is shown by Rich (1933, fig. 2); Moore and Jewett (1942, fig. 7); Jewett and Abernathy (1945, fig. 3); Lee, Leatherock, and Botinelly (1948, fig. 2); and Jewett (1949, fig. 11). The basin is regarded as one of the major structures that shaped the framework of Kansas before the development of the Nemaha uplift and other post-Mississippian major structural elements. The name Ancestral North Kansas basin has been used for the pre-Devonian stage of essentially the same structure (Lee and others, 1946, sheet 2), but later Lee, Leatherock, and Botinelly (1948, p. 124) wrote: "After St. Peter time a broad area in southeastern Nebraska and northeastern Kansas known as the North Kansas basin which had previously been a positive area (the Southeast Nebraska arch) began a long period of differential subsidence. Also at this time the Ozark region of Missouri rose and the Chautauqua arch and the Central Kansas uplift began their upward movement."

## North Kansas Basin (Ancestral) (107)

The name Ancestral North Kansas basin has been used to designate a large pre-Devonian basin in northeastern Kansas and southeastern Nebraska.

Lee and others (1946, sheet 2) showed a structure called the Ancestral North Kansas basin by means of isopachus lines. The line indicating 700 feet of rock section between the base of the St. Peter sandstone (upper early Ordovician) and the base of Devonian limestone passes through central Marshall and Nemaha Counties, Kansas, and encloses the basin by passing through Cass County, Nebraska, about 100 miles to the north. As explained in the discussion of the North Kansas basin in this index, Lee and his associates later dropped the prefix ancestral.

## Oil Hill Dome (108)

The Oil Hill dome is one of the parts of the El Dorado dome, a local "high" on the Nemaha anticline in Butler County. It has been very prolific in oil production from the upper part of beveled Ordovician beds that lie next below Pennsylvanian rocks.

The Oil Hill dome was named by Fath (1921, p. 69): "The Oil Hill dome is slightly elongated in a northwesterly direction and centers in the north-central part of sec. 33, T. 25 S., R. 5 E. . . . . The Oil Hill dome is separated by the Bancroft syncline from both the Boyer and Shumway domes and its apex lies at the same elevation as that of the Boyer dome, about 1,440 feet above sea level. Its closure amounts to over 25 feet."

## Otto-Beaumont Anticline (109)

An anticlinal fold containing several prominent domelike parts extending from the vicinity of Otto in southeastern Cowley County to near Beaumont in southeastern Butler County, a distance of about 50 miles or more, is sometimes referred to as the Otto-Beaumont anticline. An example of the usage is by Condra and Upp (1931, fig. 1) who showed the position of the axis of the anticline. The Dexter or Dexter-Otto and the Beaumont anticlines are discussed elsewhere in this index. Attention is also called to the term Beaumont anticline seemingly being used for the same extensive trend of anticlinal structures. However, Moore and Landes (1927, fig. 69) published a map of Cowley County showing the axis of the Beaumont anticline about 6 miles west of the axis of the Dexter anticline, and the axis of the Beaumont structure is shown passing through the southeast corner of Butler County and across Greenwood County through Beaumont, Eureka, and Virgil (Moore and Landes, 1927, figs. 61, 75).

The southern part of this structure was mapped by Bass (1929, fig. 18) who employed contour lines spaced at 10-foot intervals and on the Wreford limestone. A high part is shown in the vicinity of Dexter, in secs. 7 and 18, T. 33 S., R. 7 E. and in secs. 24 and 25, T. 33 S., R. 6 E. Another high part has its center in sec. 13, T. 34 S., R. 6 E. and another is in secs. 35 and 36, T. 34 S., R. 6 E. Bass referred to the structure both as the Dexter and the Dexter-Otto anticline.

## Otto-Dexter Anticline (110)

The anticline in Cowley County that in this index is discussed more fully under the heading Dexter anticline, sometimes is referred to as the Otto-Dexter anticline. An example of this usage is by Condra and Upp (1931, p. 10). The Otto and Dexter folds, in restricted sense, are in an anticlinal trend that has been called Otto-Beaumont and Beaumont.

## Ozark Basin (111)

The name Ozark basin has been used for a large pre-St. Peter basin whose axis extended from south-central Missouri to southeastern Iowa. It was formed by synclinal movements that were active during late Cambrian and early Ordovician time. Eastern Kansas is on the western flank of the basin.

According to Lee, Leatherock, and Botinelly (1948, p. 122): "That a subsiding basin, the Ozark basin, prior to St. Peter time extended from south-central Missouri northward into eastern Iowa is indicated by maps showing the thickness of the rocks between the top of the Roubidoux and the Pre-Cambrian in southern Missouri . . . , and between the base of the St. Peter and the Pre-Cambrian in northern Missouri."

In discussing the development of the Southeast Nebraska arch and the Ozark basin Lee (1943, pp. 102-103) wrote: "These structural movements are the first known to have deformed the sedimentary rocks of northeastern Kansas."

## Ozark Monocline (112)

Ozark monocline refers to a pre-Mississippian principal structural element in eastern Kansas.

The name Ozark monocline was used by Rich (1933, p. 796): ". . . . the Ozark monocline, comprising the eastern part of the state where the pre-Chattanooga dip was primarily west-northwestward into the North Kansas basin. The Ozark monocline had a very gentle westward inclination and was broken by a number of low domes whose extent and trend can not yet be determined definitely. . . . The most prominent of these interruptions to the general monoclinal dip into the North Kansas basin are found in central Osage and northern Lyon counties . . . and in northeastern Greenwood county."

The Kansas part of the Ozark monocline is interpreted as the northwest flank of the Chautauqua arch.

## Ozark Uplift (113)

The Ozark uplift or dome, a large post-Pennsylvanian structure, is regarded as lying partly in southeastern Kansas. The exposed line of contact between Mississippian and Pennsylvanian rocks in Cherokee County may there be regarded as the boundary of the structure as well as the land form, the Ozark plateau. However, westward- and northwestward-dipping Pennsylvanian beds in eastern Kansas, comprising a part of the structural province known as the Prairie Plains monocline, in reality represent the northwest flank of the Ozark uplift.

The Ozark uplift has been described by Siebenthal (1915, p. 23) more as a land form than a geologic structure: "The Ozark uplift is a low asymmetric dome with rudely elliptical outline, lying in southern Missouri, northern Arkansas, southeastern Kansas, and northeastern Oklahoma. It is roughly bounded on the north and northeast by Missouri and Mississippi rivers, on the west by Spring and Neosho (Grand) rivers, on the west and south by Arkansas River, and on the southeast by Black River and some of its tributaries. To the north and west it merges into the Prairie Plains; to the east and southeast it passes into the low-lying Gulf Costal Plain; on the south it is separated from the Ouachita Mountains by the valley of Arkansas River. . . . Near and parallel to its southern margin the uplift culminates topographically in the Boston Mountains, a long, narrow plateau rising to an elevation of 2,000 feet." Siebenthal (1915, p. 29),

however, defined the Ozark uplift as a broad geanticline. The structural crest of the uplift is in southeastern Missouri where crystalline rocks of Pre-Cambrian age are exposed.

Although the extension of the ancestral Ozark uplift in southeastern Kansas and northeastern Oklahoma is called the Chautauqua arch, the pre- and post-Mississippian structures in the main part of the Ozark region commonly are not differentiated. According to Wilson (1922, p. 28): "The dome [Ozark] is the result of uplift during several periods of crustal elevation which took place slowly at widely separated intervals."

## Pawnee Rib (114)

A pre-Mississippian structure in Pawnee County, which may be regarded as a part of the Ellis arch, is called Pawnee rib.

The name Pawnee rib was introduced by Koester (1935, p. 1419): "The broad area in Pawnee County in which the 'Siliceous lime' underlies the Pennsylvanian represents a third rib running approximately parallel with the other two. . . . not much is known about this Pawnee rib." The other two ribs mentioned in the quotation are the Russell and Rush, which are listed in this index.

## Pfeifer Anticline (115)

Pfeifer is the name of an anticlinal fold discernible in Cretaceous rocks in Ellis and Russell Counties.

The Pfeifer anticline was named by Bass (1926, p. 42): "The most pronounced structural feature of Ellis County is a northeastward-trending fold that crosses the southeast corner of the county and extends into Russell County. This fold, here called the Pfeifer anticline, appears to be in general alignment with the Fairport-Natoma anticline of Russell and Osborne counties. . . . Like the Fairport-Natoma anticline, it is steeper on the west flank, where dip readings as great as 3½ degrees were noted."

Bass (1926, p. 43) described several other unnamed folds in Ellis County.

## Pittsburg Anticline (116)

Pittsburg anticline is the name of an anticlinal fold in Crawford County. It was measured in outcropping Cherokee beds of Desmoinesian age.

The Pittsburg anticline was named and described by Pierce and Courtier (1938, p. 53): "The most prominent structural feature is the Pittsburg anticline, which is here named from the town of Pittsburg in southeastern Crawford county. It has a maximum structural relief of about 70 feet and ranges in width from 4 miles in the southeastern part to 2 miles in the northwestern part. The anticline extends for an undetermined distance in Missouri. It enters Kansas near the southeast corner of T. 30 S., R. 25 E., trends northwestward to Capaldo, and then swings west-northwest to Girard. In T. 30 S., R. 25 E., the crest of the anticline plunges to the northwest, but beyond Capaldo it rises again and the anticline is a narrow, slightly domed fold which has a minimum closure of about 20 feet."

## Prairie Plains Monocline (117)

Prairie Plains monocline is the name applied to a somewhat indefinite area embracing eastern Kansas and parts of neighboring states in which outcropping Pennsylvanian and Permian rocks dip westwardly and northwestwardly.

According to Prosser and Beede (1904, p. 5): "This term is applied to all of the area of eastern Kansas and parts of adjoining States, because the rocks dip generally to the north of west." The name Prairie Plains monocline has come into general usage and was summarized (Jewett, 1949, p. 59): "In eastern Kansas and parts of neighboring states, outcropping Permian and Pennsylvanian rocks dip gently in a general westward direction. This regional dip, which generally is about 20 feet per mile, is modified locally, especially in the area of the Nemaha anticline. Because of this regional dip, the area is called the Prairie Plains monocline. Outcropping Pennsylvanian rocks dip gently outward from the Ozark dome, and Permian beds, whose strike is more nearly directly north-south, dip westward into a Mesozoic basin. Hence the so-called monocline is a large, more or less indefinitely limited, tectonic element. It is chiefly post-Permian in age. Overstep of Cretaceous rocks on beveled Permian beds in eastern Kansas and on beveled Pennsylvanian rocks in southeastern Nebraska and southwestern Iowa indicates pre-Cretaceous age for the Prairie Plains structure."

The name Prairie Plains is sometimes used as that of the land form that occupies the same area as the tectonic unit, but Osage Scarped Plains is the more common name for most of the eastern Kansas area.

## Prusa Hill (118)

A buried hill of Pre-Cambrian quartzite overlain by gently arched Pennsylvanian beds and flanked by gently dipping Cambro-Ordovician strata in the western part of T. 16 S., R. 11 W., Barton County, is called Prusa Hill (Walters, 1946, p. 671).

Walters (1946) and Walters and Price (1948) discussed six buried hills of the Kraft-Prusa oil district in great detail in comprehensive papers that describe the geologic events that produced them and the overlying structures, and discussed the role of the structures in oil accumulation.

## Prusa North Hill (119)

The Prusa North hill (Walters, 1946, p. 671) is a buried hill of Pre-Cambrian rock in the northwestern part of T. 16 S., R. 12 W., Barton County. It is a part of the Kraft-Prusa structure in the Barton arch of the Central Kansas and Ellis arch area.

## Pryor Basin (120)

The term Pryor basin has been used for the site of accumulations of basal Pennsylvanian (Cherokee, Desmoinesian age) sediments in southeastern Kansas and northeastern Oklahoma. It may be regarded as a synonym of Cherokee basin.

Pryor was first used as a structural name by Lowman (1933): "The lower Cherokee was deposited in the McAlester basin and in a compara-

tively narrow, elongated basin in northeastern Oklahoma, here called the Pryor basin. The Pryor basin is continuous with but separated by a saddle from the Kansas extension of the Forrest City basin of northwestern Missouri."

The Forest City and Cherokee basins are separted by the Bourbon arch; and unless Lowman regarded the Forest City basin (the spelling Forrest City in Lowman's paper is regarded as a typographical error) as being limited on the south by the Chautauqua arch, the Pryor basin is the same as the Cherokee. It may be noted that Cherokee sediments are not diminished in thickness in the area of the Chautauqua arch as they are on the Bourbon arch, nor is there evidence that any thick stratigraphic units in the Cherokee section are absent on the Chautauqua arch. Hence the Chautauqua arch is not to be regarded as a boundary between sedimentary basins that existed while Cherokee beds were being deposited.

Other structures mentioned in the paragraph above are listed and discussed elsewhere in this index.

## Rainbow Anticline (121)

The name Rainbow anticline has been applied to the structure that contains the Rainbow Bend oil pool, Cowley County.

The name Rainbow was used as a structural term by Snow and Dean (1929, p. 54): "The subsurface structure of this district, as shown on the general map in 50-foot contours on the top of the 'Mississippi lime' indicates an axis of folding from the Clarke field in Sec. 6, T. 31 S., R. 4 E., extending south through the Rainbow Bend field to Blackwell. . . . Along this general axis of folding, isolated structures of several types occur, of which the Graham and Rainbow structures are fair types."

The axis of folding referred to in the quotation apparently is a short distance east of and approximately parallel to the axis of the Nemaha uplift, a trend of folding that is fairly persistent for a great distance in the eastern edges of the Forest City and Cherokee basins. Bass (1929, fig. 11) showed the structure on the top of the "Mississippi lime" in the Rainbow Bend oil field, T. 33 S., R. 3 E.

## Ralston Syncline (122)

The Ralston is a syncline in northwestern Butler County.

Fath (1921, p. 160) mentioned the Ralston syncline in sec. 36, T. 25 S., R. 4 E. It is a minor structure on the El Dorado anticline, which is a prominent part of the Nemaha anticline. Fath named and described several other structures in the area of the El Dorado oil and gas field in Butler County.

## Ramsey Syncline (123)

Ramsey is the name of a small synclinal fold that separates the Robinson and Chelsea domes, parts of the El Dorado anticline. The El Dorado structure is a prominent "high" on the Nemaha anticline. It is in Butler County.

The Ramsey syncline was named by Fath (1921, p. 73). It lies principally in the W½ sec. 2, T. 24 S., R. 5 E. Oil is produced from an outlier of Mississippian limestone in this depression.

## Redbud Dome (124)

A domelike fold observed in outcropping rocks of early Permian age in northwestern Cowley County is called Redbud. It may be regarded as a minor structure on the Nemaha anticline.

The Redbud dome was named by Bass (1929, p. 180): "*Redbud dome.* Another dome-shaped fold occurs about 3 miles northeast of the Udall pool, in sec. 10, T. 30, R. 3 E., in line with the 'granite ridge' . . . The Winfield limestone dips westward beneath overlying beds in the east half of section 14 but again rises to the surface in the north-central part of section 10, near the crest of the dome." The granite ridge mentioned in the quotation is the Nemaha anticline.

## Robinson Dome (125)

The Robinson dome is a part of the El Dorado anticline. It is almost entirely in sec. 3, T. 25 S., R. 5 E., Butler County.

The Robinson dome was named by Fath (1921, p. 70): "The altitude of its apex is about 1,375 feet, the lowest of the El Dorado domes, and its closure is probably less than 25 feet."

## Rose Dome (126)

The name Rose dome is applied to a rather large dome in southern Woodson County. The Rose dome was discussed by Ley (1924, p. 450): "The Rose dome located in Secs. 18 and 19, T. 26 S., R. 16 E., and Secs. 13 and 24, T. 26 S., R. 15 E., is one of the most marked surface structures in the eastern tier of counties. It has at least 80 feet of surface 'closure,' covering fully ten square miles. Subsurface structure on the 'Oswego' lime and the attitude of the upper surface of the pre-Pennsylvanian, which has shifted southward, are quite similar to the surface."

Ley (1924, p. 450) noted that the section of sedimentary rocks in the area has the normal thickness for the district and that this indicates wholly post-Pennsylvanian movement. It is noteworthy that coarse-grained granite is exposed in sec. 13, T. 26 S., R. 15 E. This granite is more or less commonly interpreted as occurring in a small dike (Moore and Landes, 1937). Igneous rock "apparently an altered dike rock" (Knight and Landes, 1932, p. 7) and peridotite (Twenhofel and Bremer, 1928, p. 758) have been reported in the subsurface in this area. The Silver City dome, an area in which metamorphic and igneous rocks crop out, is a short distance west and slightly south of the Rose dome. Small amounts of gas but no oil have been found in the Rose dome. Knight and Landes (1932) expressed the opinion that the Neosho Falls, Rose, and Silver City domes resulted from arching of sedimentary rocks above laccoliths.

## Rush Rib (127)

The term Rush rib refers to a structural high in Ordovician and older rocks in the Barton and Ellis arch areas.

The term Rush rib was used by Koester (1935, p. 1419): "Within the nucleus are two somewhat narrow bands, marked by the outcrop of pre-Cambrian rocks, which may be called the 'Russel rib' and the 'Rush rib.' These are true structural 'highs' in the Ordovician and pre-Ordovician rocks, as well as being topographic monadnocks. . . . From southeastern Barton County the Rush rib trends northwestward to the northwestern part of Rush County, whence it turns slightly northward through western Ellis County and eastern Trego County into Graham County."

## Russell Arch (128)

The major pre-Mississippian structure in central Kansas that is commonly known as the Barton arch (Barwick, 1928) and as the Central Kansas uplift (Morgan, 1932) was first called Russell arch.

The name Russell arch was first used by Denison (1926): "There is here a large area, the limits of which are as yet undefined, where Ordovician is encountered directly beneath Pennsylvanian beds, with a large part of the Pennsylvanian which should correspond to the Cherokee of eastern Kansas missing. . . . I believe that the Welch chert . . . was derived mainly from an uplift, . . . the Russell arch."

## Russell Rib (129)

The somewhat unusual structural term Russell rib refers to a part of the Barton arch or Central Kansas uplift, perhaps more properly of the Ellis arch.

This name was used by Koester (1935, p. 1418-1419). In discussing pre-Mississippian areal geology he called an area within the large U-shaped band of Simpson outcrop the nucleus of the Central Kansas uplift. In this area Pennsylvania beds lie on Arbuckle limestone and older rocks except for a Simpson outlier in Rooks and Ellis Counties (Koester, 1935, fig. 2). He wrote (p. 1419): "Within the nucleus are two somewhat narrow bands, marked by the outcrop of pre-Cambrian rocks, which may be called the 'Russell rib' and the 'Rush rib.' These are true structural 'highs' in the Ordovician and pre-Ordovician rocks. . . . The Russell rib extends in a northwest direction from southwestern Ellsworth County across southern Russell County to the vicinity of Gorham, whence it curves more northward through the Fairport oil field, thence northwestward across a small part of Ellis County into Rooks County. . . . the effect of the warping which caused the Russell rib is apparent in the Geneseo pool of north-central Rice County, where Pennsylvanian rests on a very thin section of Simpson."

It may be noted that this structural fold may be regarded as a part of the Ellis arch, the older structure that has more or less the same position as that of the Barton arch, but with an axis extending in a more northwesterly direction (Moore and Jewett, 1942, figs. 6-8). Attention also is called to the Geneseo structure, which is listed in this index.

## Salina Basin (130)

The Salina basin occupies an area in north-central Kansas between the northern end of the Nemaha anticline and the Central Kansas uplift (Barton arch). It is an area of depressed Mississippian and older rocks between the two anticlinal areas and is bounded on the south by an unnamed archlike structure which separated it from the Sedgwick basin. Its age is post-Mississippian. Middle Pennsylvanian sediments were deposited on peneplaned Mississippian rocks there, and at the end of post-Mississippian beveling 350 feet of Mississippian limestone remained in the deepest part of the basin.

The Salina basin was named by Barwick (1928, p. 179): "The Salina basin is herein defined as the pre-Pennsylvanian syncline bounded on the east by the Nemaha granite ridge, on the southwest by the Barton arch, and on the south by the saddle between the Chautauqua arch and the Barton arch."

The Nemaha "granite ridge" of Barwick's definition is now commonly called Nemaha anticline and the Barton arch is more generally known as the Central Kansas uplift (see Barton arch and Central Kansas uplift). Barwick did not differentiate the post-Mississippian Barton arch from its ancestral structure now called Ellis arch. More properly the Chautauqua-Ellis axis or the Central Kansas arch separated the North Kansas and Southwest Kansas basins, which are pre-Mississippian structures. Thinning of Mississippian rocks in McPherson and Marion Counties (Lee, Leatherock, and Botinelly (1948, pl. 8) reveals the post-Mississippian separation of the Salina and Sedgwick basins. On this map the northern boundary of the pre-Pennsylvanian Salina basin has been mapped by the wedging out of Mississippian limestones along a line crossing Clay, Cloud, Republic, Jewell, and Smith Counties. More recent data reveal that an arm of the basin extends northward into Nebraska west of the Nemaha and the Barneston anticlines (Wallace Lee, personal communication).

The stratigraphy and structural development of the Salina basin area have been discussed comprehensively by Lee, Leatherock, and Botinelly (1948), and briefly by Moore and Jewett (1942, p. 437), Jewett and Abernathy (1945, p. 43), Jewett and Smith (1942), and Jewett (1949, 1950). The first named authors described the following five principal periods during which folding took place within the area: (1) late Cambrian to early Ordovician, (2) St. Peter to Mississippian, (3) Mississippian to Permian, (4) post-Permian and pre-Cretaceous, and (5) post-Cretaceous.

## Salt Creek (Twins) Structure (131)

Two domes forming an "amoeboid" structure in southern Mitchell County have been called Salt Creek Twins.

Landes and Ockerman (1933, fig. 2) showed the centers of the "twins" in the SE¼ sec. 30 and in the SE¼ sec. 29, T. 9 S., R. 7 W. Closure, presumably measured in surface Cretaceous rocks, according to a map published by Landes and Ockerman and credited to T. H. Allen, of the west dome amounts to about 50 feet, and of the east dome about 80 feet. These

structures are believed by Landes and Ockerman to be due to Cretaceous deposition conformable to the uneven surface on eroded Permian rocks.

## Scott Basin (133)

The term Scott basin has been used for an area in Scott County described primarily as a physiographic division, but attributed chiefly to folding that took place prior to the accumulation of enduring Tertiary sediments.

Waite (1947, pp. 18, 35) referred to the Scott basin as a physiographic division but stated: "Prior to the deposition of Tertiary sediments there was a period of folding. . . . A broad asymmetrical trough, with its axis extending from Garden City to Scott City and northward, was developed." Hence the axis of the trough that underlies and is chiefly accountable for the Scott basin as the term was used by Waite and by Latta (1944, p. 21) coincides with the axis of the Shallow Water basin as defined earlier by Moss (1933). It seems that, as a structural term, Scott should be regarded as a synonym of Shallow Water.

## Sedgwick Basin (132)

The Sedgwick basin, regarded as one of the major post-Mississippian structural provinces in Kansas, occupies an area in central Kansas southward from McPherson and Marion Counties. It is west of the Nemaha anticline and south of a low archlike structure that marks the southern boundary of the Salina basin, and west of a similar separation from the Dodge City basin or embayment.

The Sedgwick basin was named by Moore and Jewett (1942, p. 487, fig. 8): "A basinal area lying southeast of the Central Kansas Uplift is here differentiated as the Sedgwick Basin, partly because it is more or less separated geographically from the continuations northward and southward in contiguous basinal areas and partly because of the general nature of geologic structure and production in [oil] fields of the region."

The Sedgwick basin is to be regarded as post-Mississippian in age because it was formed chiefly after Mississippian rocks were deposited and before burial of their edoded surface below Pennsylvanian sediments. Rocks of the Cherokee group (middle Pennsylvanian) lie on Mississippian limestones there, but rocks older than Mississippian are next below Pennsylvanian beds in neighboring parts of the Nemaha anticline and Central Kansas uplift.

Thinning of Mississippian rocks in McPherson and Marion Counties (Lee, Leatherock, and Botinelly, 1948, pl. 8) indicates post-Mississippian separation of the Sedgwick and Salina basins.

## Seisgood Dome (134)

Seisgood is the name that has been given to a small dome in Wallace County, a part of an anticlinal fold that is called Willow Creek anticline.

The name was given by Elias (1931, pp. 200-201): "The main structural highs, which constitute the Willow Creek structure, are Western anticline on the west, Seisgood dome on the north, and Bat anticline on the

south." According to Elias the Willow Creek anticline is in T. 13 S., Rs. 41 and 42 W. and is a part of what has been called the Weskan anticline.

## Shallow Water Basin (135)

The Shallow Water basin may be regarded as both a structural and topographic basin.

According to Moss (1933, p. 1, fig. 2) the Shallow Water basin lies in central southern Scott and the adjacent part of Finney County and derives its name from the fact that water is obtained at depths ranging from 20 to 75 feet and that there is no surface drainage from the area. The town of Shallow Water is near the central part of the basin as mapped by Moss (1933, fig. 2). A cross section by Moss (1933, fig. 1) shows beds of clay, silt, sand, and gravel dipping into the basin from two sides, presumably east and west. Structure in underlying Cretaceous rocks is not shown.

Latta (1944, p. 21) referred to the southern part of the Shallow Water basin, as defined by Moss, as the Finney basin, and the northern part as the Scott basin, but stated that the two are continuous. Latta (1944, fig. 2) called the Finney basin a physiographic division but in a cross section (fig. 8) showed synclinal structure in Cretaceous rocks that are overlain by Pliocene and Pleistocene beds that are represented as lying in a horizontal position. Earlier Smith (1940, p. 138) observed the structural nature of the Finney basin: "It obviously can not be explained as a product of stream erosion, and consequently can be attributed only to post-Ogallala downwarping." Waite (1947, p. 18) referred to the Scott basin as a physiographic division, but stated (Waite, 1947, p. 35): "Prior to the deposition of Tertiary sediments there was a period of folding. . . . A broad asymmetrical trough, with its axis extending from Garden City to Scott City and northward, was developed." Hence the axis of the trough mentioned by Waite coincides with the axis of the Shallow Water basin. Smith (1940, p. 138) described the Finney basin also as having an axis extending from Garden City to Scott City. Hence, seemingly both Finney and Scott as structural terms may be regarded as synonyms of Shallow Water; Shallow Water may be regarded as a geographic name and preferred term.

## Sharon Springs Anticline (136)

The name Sharon Springs anticline is applied to an anticlinal fold in Wallace County. It is discernible in outcropping Cretaceous and Tertiary rocks.

The Sharon Springs structure was discussed by Elias (1931, p. 196): "Two meridianal ridges . . . can be recognized in Wallace County. One . . . can be called the Weskan . . . anticline. . . . The other . . . runs slightly west of Sharon Springs and can be called the Sharon Springs ridge or anticline."

## Shumway Dome (137)

The name Shumway dome is applied to a part of the El Dorado anticline in the El Dorado oil field, Butler County. The El Dorado anticline is part of the Nemaha anticline.

The Shumway dome was named by Fath (1921, p. 67): "This dome is located principally in the northeast corner of T. 26 S., R. 4 E. . . . It is slightly elongated in a northeasterly direction, extending from the SW¼ sec. 31, T. 25 S., R. 5 E., on the northeast, to sec. 14, T. 26 S., R. 4 E., on the southwest, a distance of about three miles. Its width ranges from 1½ to about 2 miles."

At the surface the Shumway dome like the other parts of the El Dorado anticline can be measured in lower Permian rocks and has about 30 feet of closure (Fath, 1921, pl. 1). In the "Stapleton zone" which is the sub-Pennsylvanian surface of Ordovician rocks, which were elevated and eroded before burial, it is much more steeply defined. The most prolific wells in the El Dorado oil field are on the Shumway dome. The "Stapleton zone" is the reservoir.

## Silver City Dome (138)

The Silver City dome is in southwestern Woodson and northwestern Wilson Counties. The first published map of the structure is one by Twenhofel and Edwards (1921, p. 65), but metamorphic rocks that occur at the surface there were described by Mudge (1880) and by Hay (1833).

Knight and Landes (1932, p. 3) discussed this structure: "The anticline is elliptical in plan with its major axis trending nearly due west. The greater part of the structure lies in Sec. 36, T. 26 S., R. 14 E.; Sec. 1, T. 27 S., R. 14 E.; Secs. 31-33, T. 26 S., R. 15 E.; and Secs. 4-6, T. 27 S., R. 15 E. The north flank of the dome has a short but prominent northeastward trending spur, which extends from Section 32 into the southern half of Section 29. This 'bulge' of the ellipse is especially interesting, for here occurs a mass of hydrothermally metamorphosed rocks . . ."

Bass (1936, pl. 7) showed the center of the structure in the vicinity of the Cen. S. line sec. 32, T. 26 S., R. 15 E.

The Silver City dome is of unusual interest because of the presence of outcropping quartzite derived from sandstone of early Virgilian age and of outcropping and shallow abundantly micaceous rock that is believed to be igneous. Oil was discovered on the north flank of the dome in the SE¼ SE¼ SE¼ sec. 19, T. 26 S., R. 15 E., in 1946 (Jewett, 1949, pp. 293-294). Knight and Landes (1932) expressed the opinion that the Neosho Falls, Rose, and Silver City domes are the result of doming of stratigraphic rocks above laccoliths.

## Slick-Carson Dome (139)

The name Slick-Carson is applied to a small dome, measured in subsurface rocks that underlie the Slick-Carson oil field in T. 32 S., R. 3 E., Cowley County.

Bass (1929, p. 124, fig. 7) showed the apex of the Slick-Carson dome in sec. 19, T. 32 S., R. 3 E. and according to him the horizon at the base

of the Fort Scott limestone is much less steeply folded than the pre-Chattanooga surface and the restored upper surface of the Mississippian limestone.

## Smoky Syncline (140)

Smoky syncline is the name that has been given to a synclinal fold in western Wallace County. It is discernible in outcropping Cretaceous rocks.

The name was applied by Elias (1931, p. 200): "The Smoky Hill river flows through a syncline, which closes the Willow creek structure on the south. This syncline is named the Smoky syncline." According to Elias (1931, p. 200) the Willow Creek anticline lies in T. 13 S., Rs. 41 and 42 W.

## Southeast Nebraska Arch (141)

Southeast Nebraska arch is the name of a large pre-St. Peter (late early Ordovician) structure in northeastern Kansas and southeastern Nebraska. The name was first applied by Lee (1943, p. 102).

Lee, Leatherock, and Botinelly (1948, fig. 2, pp. 122-123) showed the Southeast Nebraska arch extending from Nebraska into Washington, Marshall, Nemaha, Clay, Riley, and Pottawatomie Counties, Kansas, and wrote: "Also, at that time a broad beveled southward plunging arch, the Southeast Nebraska arch, extended from southeastern Nebraska southward across Kansas more or less parallel to the contemporaneous Ozark basin." Usage of the term Ozark basin is discussed elsewhere in this index.

## Southwest Kansas Basin (142)

The name Southwest Kansas basin is applied to a major pre-Mississippian structural province in southern Kansas.

The Southwest Kansas basin was named by Moore and Jewett (1942, p. 486, fig. 7): "Southwest of the Ellis Arch and west of the Chautauqua Arch is a basinal area of pre-Mississippian date which is designated as the Southwest Kansas Basin. Little is known except that 'Hunton' and a thick section of Ordovician rocks is present in this region." In the light of present knowledge it seems that Devonian and Silurian rocks ("Hunton") are absent in southwestern Kansas and that Mississippian beds overlie at least locally the Viola limestone.

As interpreted by Edson (1947), the Champlin Refining Company No. 1 Becker well, sec. 34, T. 28 S., R. 29 W., Gray County, penetrated about 300 feet of Ordovician rocks above the Eminence dolomite which lies at about 6,500 feet below the surface. The deepest well that has been drilled in Kansas is the Stanolind Oil and Gas Company No. 1 Pearl Feather, sec. 15, T. 35 S., R. 33 W., Seward County. The following datum points are reported: top of Mississippian rocks, 6,200 feet; top of Simpson, 7,965 feet; top of Arbuckle rocks, 8,013 feet. The total depth is 8,043 feet. The elevation of the well is reported as 2,823 feet. According to Clair and Edson (1950, p. 90): "In far western Kansas the Arbuckle group varies from 249 feet with only Cambrian beds present, to a maximum of 645 feet made up of both Ordovician and Cambrian beds."

The major pre-Mississippian basins in Kansas are the North Kansas basin and the Southwest Kansas basin, which were separated by the Central Kansas arch or the Ellis-Chautauqua axis.

## Stockholm Dome (143)

An inferred dome in Cretaceous shale in southwestern Wallace County has been called Stockholm dome.

The name Stockholm dome was introduced by Elias (1931, p. 197): "In the southwest corner of Wallace County, on the high, slightly dissected plateau, there is an area of about nine square miles along the south fork of Ladder creek in which all the wells dug or drilled to the top of the Pierre shale are dry. . . . It seems to the writer that the absence of water in the wells can be accounted for by the presence of a very low and broad structural hill (Stockholm dome) of shale covered with Ogallala and loess."

The area of the Stockholm dome is shown by Elias (1931, pl. 42) as an area "with no sheet water."

## Stockton Anticline (144)

The name Stockton anticline has been used for a fold, discernible in Cretaceous rocks in Ellis, Rooks, and Phillips Counties.

The Stockton anticline was named by Bass (1926, p. 88, pl. 7): "A rather pronounced and extensive series of structural 'highs' extend from northwestern Ellis county north-northeastward across Rooks county, passing a few miles west of Stockton and thence into Phillips county near Phillipsburg. It is possible that the nose crossing the southeast corner of Trego county is the southward continuation of the Stockton fold or one *in échelon* with it." On the accompanying structural map Bass used the name Stockton anticline for the axis of the series of "highs" that he described.

## Syracuse Anticline (145)

The Syracuse anticline is mainly in Hamilton County. It is a faulted southeast-northwest trending fold that is discernible in Cretaceous rocks.

The Syracuse anticline was discovered by Darton (1918, p. 5, fig. 4) and according to Bass (1926, p. 88): ". . . the Syracuse anticline, in Hamilton county, is the most pronounced feature and is shown here much as presented on Darton's map, although some changes have been made." Bass (1926, pl. 7) showed the axis of the fold extending from northwestern Grant County across the northeastern part of Stanton County and across Hamilton County in a southeast-northwest direction. It is now recognized that a fault forms the southern margin of this structure. The presence of the fault was suspected by Smith (1940, pp. 136-137) and was proved conclusively by Latta (1941, p. 25, pl. 4). The fault was discussed in detail by McLaughlin (1943, p. 124) who wrote: "A test hole was drilled on the Hamilton-Stanton county line at a point about 1.2 miles southeast of an outcrop of the Dakota formation. In this test hole the Dakota formation was encountered at a depth of 230 feet. The altitude of the top of the Dakota

formation is more than 300 feet higher at the outcrop than in the near-by test hole."

## Table Rock Anticline (146)

The Table Rock anticline is the conspicuous anticline in Permian and Pennsylvanian rocks in southeastern Nebraska and northeastern Kansas and constitutes a part of the more extended Nemaha anticline.

The Table Rock anticline was named by Condra and Bengston (1915, pp. 25, 39) and was discussed by Condra (1927, pp. 14-15): "It is a large structure extending from northwest of Talmage [Nebraska] southward . . . past Du Bois and through Kansas to beyond Wamego and the Kansas River. Its highest point is at the Kansas line where erosion has removed more than 100 feet of Permian beds and cut through the Pennsylvanian . . . a vertical distance in the general section of about 700 feet." And ". . . the known length in Kansas is 60 miles. A buried granite ridge, . . . the Nemaha Mountains . . . , is not far below the surface in parts of this anticline."

Table Rock anticline should be regarded as a proper designation of a part of the longer Nemaha anticline. The Burns dome, El Dorado anticline, and Elmdale anticline are other high parts of the major structure which also were discovered from the uplift's conspicuous local expressions in outcropping rocks. The syncline west of the Table Rock anticline is called Irving and the syncline on the east is the Brownville; the fault in the east flank of the Table Rock anticline near the Kansas-Nebraska border is called the Humboldt fault. These structures are listed in this index.

## Theta Syncline (147)

The Theta syncline is a synclinal fold that modifies the El Dorado anticline, which is a prominent part of the Nemaha anticline in Butler County. The Nemaha anticline crosses Kansas and extends into Nebraska and Oklahoma.

The Theta syncline was named by Fath (1921, p. 73): "A pronounced depression . . . crosses leases of the Theta Oil Company in secs. 16 and 17, T. 25 S., R. 5 E., and separates the Chesney dome from the Wilson dome. It is a westward extension of the deep basin of the Walnut syncline . . . ."

## Tipton Anticline (148)

The name Tipton anticline has been given to a rather pronounced northward-plunging anticlinal fold in western Mitchell County. It is discernible in outcropping Cretaceous rocks.

The name Tipton was applied by Landes (1930, p. 43, pl. 10) to a fold represented on a structural geologic map of Osborne and Mitchell Counties. He left the structure unnamed on the map but in the next referred to it as the Tipton anticline: "The Tipton anticline is not apparent on the subsurface map, but this may be due to lack of control points in southwestern Mitchell County." Landes (1930) mapped and described several unnamed surface and subsurface structures in Osborne and Mitchell Counties and

Wing (1930) mapped and described several structures in Cloud and Republic Counties.

## Twin Buttes Anticline (149)

A domelike structure interpreted from local dip readings on Cretaceous beds in the southwestern part of T. 14 S., R. 36 W., Logan County, has been called Twin Buttes anticline.

The structure was named by Lupton, Lee, and Van Burgh (1922, p. 79, pl. 2) who published a map of the fold interpreted from dips taken on Niobrara chalk. The center of the dome lies in the southwestern part of sec. 31, T. 14 S., R. 36 W. Faults are shown on the southwestern flank in the N½ sec. 1, T. 15 S., R. 37 W. The structure as revealed by dips was regarded as a minor dome on the southern extension of the Black Hills arch (Cambridge anticline). The Cambridge anticline and Black Hills arch are discussed elsewhere in this paper.

## Valley Center Anticline (150)

A deeply buried structure in Sedgwick County that contains the Valley Center oil pool (produces from the Viola) is known as the Valley Center anticline.

McCoy and Keyte (1934, p. 296, fig. 3) published a cross section of the Valley Center anticline and discussed it in reference to oil accumulation. The fold is developed principally in Mississippian and older rocks and probably is faulted. It may be regarded as lying in the long structural trend known as the Bluff City anticline.

## Virgil Anticline (151)

Virgil anticline is used as a structural name to designate the domelike structure that contains the Virgil oil pool (produces from Mississippian rocks), Greenwood County.

Bass (1936, p. 59), in discussing structures in Greenwood County, wrote: "The Virgil anticline that is largely in T. 24 S., R. 12 E., the anticline in T. 23 S., R. 13 E., and that in T. 24 S., Rs. 13 and 14 E.; and T. 23 S., R. 14 E., and the anticline that lies close to the range line between T. 22 S., R. 12 E., and T. 22 S., R. 13 E., are other prominent folds." According to the usage of terms by some geologists the Virgil structure is the northern part of a long fold called Beaumont anticline.

Beekly (1929 p. 146) referred to the Virgil structure: "The Virgil structure is a textbook example of a closed anticline which makes a perfect trap for oil accumulation. . . ." The structure was mapped on outcropping Lecompton limestone and on the top of the buried Mississippian rocks (Beekly, 1929 figs. 1-2) and according to Beekly (p. 145): "The Virgil pool is located on a surface structure having more than 60 feet of closure with its top in the west-central part of Section 23 and its long axis extending approximately from the center of Section 12 to the center of Section 27 [T. 24 S., R. 12 E.]."

## Voshell Anticline (152)

The Voshell is an anticline in McPherson and Harvey Counties that is approximately parallel to the Nemaha anticline which lies about 50 miles to the east; it is approximately in line with the Abilene anticline which is farther north in Kansas. The structure extends from T. 18 S., R. 2 W. to T. 24 S., R. 4 W.

The Voshell anticline and its development were thoroughly discussed by Bunte and Fortier (1941) who published also excellent cross sections and maps showing the structure. According to those geologists (p. 110): "The Voshell trend consists of an anticlinal fold extending in a northeasterly direction and plunging southwest. A reverse fault with a throw of about 400 feet is present on the west side of this anticlinal structure. The strike of the fault is almost parallel with the axis of the Voshell anticline and it is situated approximately ¼ mile west of the axis. It appears that the major structural uplift took place in post-Mississippian time and minor movements followed in late or post-Permian time. It appears that no structural movement had taken place here before Kinderhookian deposition. In all probability the Voshell anticline was formed contemporaneously with the forming of the Nemaha Granite ridge of east-central Kansas." The granite ridge mentioned in the quotation is the Nemaha anticline.

The McPherson, Chindberg, Johnson, Voshell, Nikkel, Hollow, and Burrton oil pools are associated with the Voshell structure. All oil accumulations there, with the exception of the Nikkel pool, which is regarded as a stratigraphic trap, are the result of closed anticlinal structures.

## Walnut Syncline (153)

The name Walnut syncline applies to the synclinal fold east of the El Dorado anticline in Butler County.

The Walnut syncline was named by Fath (1921, p. 66): "The Eldorado anticline is limited on the east by the pronounced Walnut syncline, which is located in the main valley and west branch of Walnut river, after which it is named. This syncline is a rather straight trough extending from beyond the south border of the Eldorado district to the east-central part of T. 25 S., R. 5 E. Here it terminates in a slightly accentuated depression from which minor synclines radiate to the northwest and east. The maximum vertical differences between the crest of the Eldorado anticline and the trough of the Walnut syncline is about 180 feet."

It is to be noted that there is a deep trough bordering the Nemaha anticline, of which the El Dorado anticline is a part, on the east along its entire length. This condition is represented in various published cross sections that show conditions along east-west sections in eastern Kansas (Kellett, 1932; Moore, 1936; Jewett and Abernathy, 1945, pls. 1-3; Jewett, 1949, pl. 3). This situation is strongly expressed in the pattern of outcropping rocks northward from northern Wabaunsee County, where there is a broad inlier of Permian rocks (Moore and Landes, 1937). The syncline there is called Brownville. The "180 feet difference in elevation" in Butler County is

measured in surface rocks. In the subsurface the difference is much more. In Butler County Pre-Cambrian rocks are about 1,600 feet lower in the Walnut syncline than in the El Dorado anticline. In northern Kansas the crest of the granite core of the anticline is nearly 3,000 feet higher than are Pre-Cambrian rocks a few miles to the east.

## Weskan Anticline (154)

Weskan is the name of an anticlinal fold in western Wallace County. It is discernible in outcropping Cretaceous rocks.

The Weskan anticline was named by Elias (1931, p. 196): "Two meridianal ridges, each representing a chain of several uplifts that are stretched along a north-south direction, can be recognized in Wallace County. One runs through Weskan and can be called the Weskan structural ridge or anticline."

The Stockholm dome, which is listed in this report, is an inferred structure that was described by Elias as a part of the Weskan anticline. The Weskan fold and other structures in Wallace County are shown on a structural geologic map of the county by Elias (1931, pl. 42).

## Western Anticline (155)

The name Western anticline has been given to a part of the Willow Creek anticline, Wallace County.

According to Elias (1931, pp. 200-201): "The main structural highs, which constitute the Willow Creek structure, are Western anticline on the west, Seisgood dome on the north and Bat anticline on the south. . . . The highest elevations of Western and Bat anticlines are marked by the 4,020-foot contour."

The location of the Willow Creek anticline is given as T. 13 S., Rs. 41 and 42 W. (Elias, 1931, p. 200). It is a part of a structure that has been called Weskan anticline.

## Western Kansas Basin (156)

The term Western Kansas basin was introduced recently as a structural term. It designates a regional post-Permian basin in western Kansas.

On a map by Wallace Lee (Moore and others, 1951, fig. 46) the western Kansas basin is shown by generalized 250-foot contours on the Stone Corral dolomite (Leonardian). The caption in part is: "Western Kansas basin, evolved from Hugoton embayment . . . . This basin is now the result of post-Dakota movements that tilted the Hugoton embayment northward toward a large basin in western Nebraska."

## Whitewater Nose (161)

The name Whitewater nose was applied by Fath (1921, p. 66) to a southwesterly extending part of the Shumway dome which is a part of the El Dorado anticline, a local "high" on the Nemaha anticline, in Butler County.

According to Fath (1921, p. 67): "A plunging anticlinal nose, apparently related to the Shumway dome, from which it offshoots to the south, is

located in secs. 22, 27 and 33, T. 26 S., R. 4 E. This plunging fold is called the Whitewater nose."

The Whitewater nose is discernible in outcropping rocks of early Permian age. It is bordered on the east by a very sharp depression, the Hammond syncline.

## Willow Creek Anticline (159)

The Willow Creek anticline is in Wallace County. It can be measured in surface Cretaceous rocks.

The Willow Creek anticline was described by Elias (1931, p. 200): "The Willow Creek anticline lies in the townships 13 south of ranges 41 and 42 west, Wallace county, Kansas. The center of the structure is five miles north-northeast of Weskan. On the south the structure is bordered by the valley of South Smoky Hill river. . . . The northern closure of the structure lies in the divide between Willow creek and Schoolhouse draw."

As defined by Elias the Willow Creek anticline is a part of a larger fold, the Weskan anticline.

## Wilson Dome (157)

The Wilson dome is a part of the El Dorado anticline, a prominent part of the Nemaha anticline in Butler County.

The Wilson dome was named by Fath (1921, p. 70): "This dome is elongated with a west-northwesterly trend, and although centering in sec. 8, T. 25 S., R. 5 E., includes also parts of secs. 4, 5, 6, 7, 9, 16 and 17 of the same township. . . . Its closure probably exceeds 40 feet."

## Wilson-Burns Element (158)

The name Wilson-Burns element has been proposed for a northwestward trend of domelike structures in pre-Mississippian rocks that extends from the Burns dome in Butler and Marion Counties to eastern Russell County.

The name Wilson-Burns was introduced as a structural term by Koester (1935, p. 1419): "Two high areas of 'Siliceous lime' cropped out in early Pennsylvanian time northeast of the nucleus of the uplift, one in central Ellsworth County near Ellsworth, the other at Wilson on the Russell-Ellsworth County line. They represent a line of pre-Mississippian warping which can be traced northwestward from the Burns dome in northern Butler County through the Peabody, Ritz-Canton, and McPherson fields. While this tectonic feature, for which the name Wilson-Burns element is proposed, is closely related to the central Kansas uplift, at least in part, in age and alignment, it does not seem to be a part of that structure."

The Wilson-Burns trend and pre-Mississippian structures in the Ellis arch area are in accordance with the ancient grain of Kansas rocks. Attention is called to the Central Kansas arch, as defined by Rich (1933) which is listed in this index. It is the combined Chautauqua and Ellis arches and its axis is essentially parallel to the axis of the Wilson-Burns element as defined by Koester.

## Winfield Anticline (160)

The name Winfield anticline is applied to an anticlinal fold, discernible in outcropping lower Permian rocks in central Cowley County.

According to Bass (1929, p. 121): "The Winfield anticline, which is about midway between the Dexter and 'granite ridge' folds, trends approximately parallel to them and is discernible in the surface beds. . . . The degree of dip of the surface beds is much less than in either of the other two folds, but like them this fold has the steeper dip on the east flank, and local constrictions divide it into a number of 'highs' separated by low structural saddles." The "granite ridge" is the Nemaha anticline.

Mapped by means of 50-foot contour lines with the upper surface of Mississippian rocks as datum, Bass (1929, pl. 11) showed the Winfield anticline extending from about sec. 14, T. 33 S., R. 4 E. northward to about sec. 31, T. 31 S., R. 5 E., but without closure.

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