Relation of Uranium Deposits to Tectonic Pattern of the Central Cordilleran Foreland

By FRANK W. OSTERWALD *and* BASIL G. DEAN

CONTRIBUTIONS TO THE GEOLOGY OF URANIUM

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RELATION OF URANIUM DEPOSITS TO TECTONIC PATTERN OF THE CENTRAL CORDILLERAN FORELAND

By FRANK W. OSTERWALD and BASIL G. DEAN

ABSTRACT

The Cordilleran foreland is one of the major tectonic units of western North America. It includes the area between the Cordilleran geanticline and the interior platform and extends from the southern margin of the Colorado Plateau to the Rocky Mountain foothills in south-central Canada. Within the foreland a series of simple anticlinal mountains alternates with broad asymmetric basins. Most of the surface structures, including flexures and high-angle normal and reverse faults, are the result of recurrent vertical movements of blocks in the Precambrian basement rocks. For convenience of description, the foreland is subdivided into 15 large tectonic units: 1. the Williston or Dakota basin; 2. the central Dakota terrace; 3. the Black Hills uplift; 4. the Lake Basin fault zone, Cat Creek fault zone, and Blood Creek syncline; 5. the Bighorn Basin, Bighorn Mountains–Pryor Mountains uplift, and Powder River Basin; 6. the Chadron arch uplift; 7. the Absaroka Mountains uplift; 8. the Owl Creek Mountains uplift, Wind River Basin, Sweetwater arch uplift and northern Laramie Mountains uplift; 9. the Wind River Mountains uplift; 10. the Green River basin and Rock Springs uplift; 11. the Uinta Mountains uplift; 12. the Great Divide Basin, Washakie basin, and uplift and basin complex; 13. the Sand Wash basin, Axial Basin uplift, and White River uplift; 14. Front Range–Park Range–southern Laramie Mountains uplift; and 15. the Denver basin and Hartville uplift.

Within the 15 tectonic units, uranium deposits can be related to the following large-scale structural environments: (a) crests of large-scale anticlines; (b) troughs of major basins; (c) flanks of large-scale uplifts where smaller structures are arranged in echelon; (d) flanks of large-scale uplifts where subordinate structures are parallel to the major structure; (e) conjunctions of major structures where trends intersect or merge with loss of identity of one or all trends and without an associated pattern of smaller scale structures; (f) conjunctions of major structures where trends intersect or merge with loss of identity of one or all trends and where subordinate structures are parallel to or in echelon with the trend of one or all major structures.

Many uranium deposits can be more closely related by second-order discrimination to small- to intermediate-scale structures. Repetitions of the patterns to which known deposits are related may provide clues to areas containing presently unknown deposits.

INTRODUCTION

The Cordilleran foreland (King, 1951, p. 58–62; Horberg and others, 1949, p. 192–194) is a broad north-south belt (fig. 28), parallel to and east of the Cordilleran geanticline. The predominant geologic structure of the foreland is a series of anticlinal mountains and broad asymmetric basins that contrast markedly with the folds and overthrusts along the eastern margin of the Cordilleran geanticline. The mountains of the foreland are bordered by flexures and high-angle normal and reverse faults. Many structures are completely or partly covered by nearly flat-lying sedimentary rocks of Tertiary age. Most of the eastern margin of the foreland is beneath the Tertiary rocks of the Great Plains; it can be defined only by the pronounced change in trend of gravity and magnetic anomalies, from a northwest trend in the foreland to a northeast trend east of the foreland (Lyons, 1950, p. 34; Petsch and Carlson, 1950). The eastern margin of the foreland as shown in figure 28 coincides approximately with the change in trend shown on the geophysical maps.

Mountain ranges in the foreland characteristically have a core of crystalline rocks of Precambrian age, covered in part by sedimentary rocks of Paleozoic and Mesozoic age that are flexed downward into the intervening basins. Erosion has removed much of the cover of sedimentary rocks from most ranges, and the debris, combined with pyroclastic material from local volcanic centers, makes up the nearly undeformed rocks of Tertiary age that cover many mountains and basins. The distribution of mountain ranges in the foreland is related in part to the distribution of Precambrian granite massifs (Thom, 1947, p. 176). Precambrian cores of many ranges in the foreland, and in adjacent parts of Kansas and Oklahoma (Hiestand, 1935, p. 950), are granitic in the center and metamorphic around the margins.

Many large-scale and small-scale structures of the foreland record the sequence of tectonic events. In many places preexisting structures controlled the pattern of later structures (Thom, 1947, p. 176). These major controlling structures include the ancestral Rocky Mountains, which formed during the Pennsylvanian period on the site of the present Front Range uplift and adjacent ranges (Eardley, 1951, p. 230–233); the central Kansas uplift which was elevated in pre-Mississippian time, in Pennsylvanian time, and in Late Cretaceous or early Tertiary time (King, 1951, p. 61); the Williston basin of western North Dakota and eastern Montana, which occupies about the same position as an early Paleozoic depositional basin (King, 1951, p. 61); a large trough between the Cat Creek

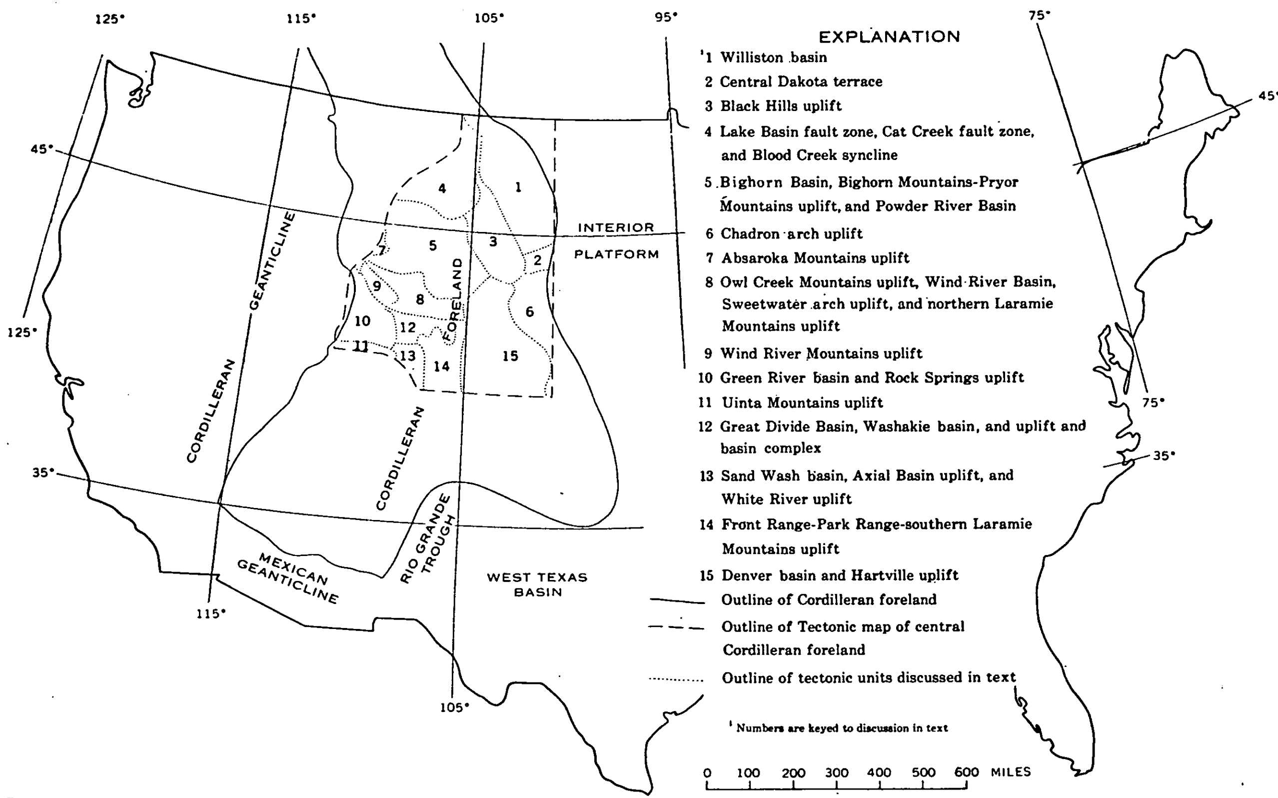

FIGURE 28.—Index map showing the Cordilleran foreland, area included in the tectonic map of the central Cordilleran foreland, and location of large tectonic units discussed in text.

fault zone and another fault zone 30 miles to the north, which is filled with a thick series of sedimentary rocks of Precambrian and Mississippian age (Eardley, 1951, p. 287) and which has many small- to intermediate-scale structures along its flanks owing to movements during the Late Cretaceous, apparently along steep fractures bordering the old trough (Eardley, 1951, p. 341–342); the prominent Laramide anticlines in Wyoming which began to form early in geologic time (Curry and Curry, 1954, p. 2155); and the Tertiary uplifts in the Beartooth and Bighorn Mountains and in the Black Hills that coincide with Precambrian structures (Cloos and Cloos, 1934).

The various structures of the foreland may be divided into three classes based on relative size:

1. Large-scale structures, such as large mountain ranges, major basins, and fault zones, with structural relief as much as a few tens of thousands of feet; some are several hundred miles long;
2. Intermediate-scale structures, such as folds and faults superimposed on large-scale structures; these have a structural relief of a few hundred feet and few exceed several tens of miles in length;
3. Small-scale structures, such as folds, faults, and joints of lesser size.

The tectonic map (pl. 28) was compiled as an aid in studying the geologic setting of uranium deposits within the region and in determining what relationships may exist between the distribution of uranium deposits and the regional tectonic pattern (Osterwald, 1956). The map shows faults, folds, uranium deposits, and outcrop areas of rocks of selected types and ages. The relationship between distribution of uranium deposits and the regional tectonic pattern may suggest new areas favorable for the discovery of uranium deposits in the central Cordilleran foreland as well as in other areas with similar tectonic history.

The compilation of the tectonic map was done by the Geological Survey on behalf of the Division of Raw Materials of the U.S. Atomic Energy Commission. Structural data shown on the map have been obtained in part from published geologic sources. In addition, many companies and individuals have contributed geologic data for use in this compilation and have advised the writers concerning the many geologic problems of the foreland. Particular acknowledgment is given to J. A. Albanese, Seaboard Oil Co.; W. L. Dockery, Pure Oil Co.; J. A. Barlow and G. R. Veronda, Forest Oil Co.; F. C. Sims, W. N. Zakis, and L. W. Heiny, Continental Oil Co.; B. D. Carey, Jr., California Co.; V. L. White, Gulf Oil Co.; H. D. Hand and P. T. Jenkins, Globe Mining Co.; H. D.

Thomas, University of Wyoming; F. H. Brady, J. R. Lynn, W. E. West, Jr., and R. M. Thompson, independent geologists, and A. F. Bateman, Jr., K. G. Bell, W. H. Bradley, C. E. Dobbin, T. L. Finnell, W. R. Hansen, G. H. Horn, J. D. Love, E. J. McKay, G. N. Pipiringos, P. W. Richards, C. S. Robinson, P. K. Sims, and J. D. Vine, of the U.S. Geological Survey.

The maps showing sources of geologic data (pls. 29–34) were compiled by Arloa Shipman in 1955 and 1956.

D. L. Blackstone, Jr., of the University of Wyoming, J. A. Noble of the California Institute of Technology, and H. F. Murray, of the University of Colorado, supplied unpublished structure contour maps.

STRUCTURAL TRENDS OF THE CORDILLERAN FORELAND

The predominant trends of most tectonic structures in the Cordilleran foreland are northwest, northeast, and west to west-northwest; these trends probably originated during Precambrian time (Burbank and Lovering, 1933; Chamberlin, 1945; Osterwald, 1956), and although many individual structures are probably of much more recent age, they may be genetically related to structures of Precambrian age (Hudson, 1955, p. 2040–2045). Locally, the trend of some structures, as, for example, the Front Range uplift, the Denver basin, the Rock Springs uplift (Wyoming structure 245)[1] and the Laramie Mountains uplift, is north-south at an angle oblique to the predominant trend of structures in the foreland. Many of these north-south structures are high topographically and form impressive mountains.

Fifteen large tectonic units, each characterized by one or more prominent large-scale structures, are outlined in figure 28. These units, established for convenience in this discussion, are—

1. Williston or Dakota basin
2. Central Dakota terrace
3. Black Hills uplift
4. Lake Basin fault zone, Cat Creek fault zone, and Blood Creek syncline
5. Bighorn Basin, Bighorn Mountains–Pryor Mountains uplift, and Powder River Basin
6. Chadron arch uplift
7. Absaroka Mountains uplift
8. Owl Creek Mountains uplift, Wind River Basin, Sweetwater arch uplift, and northern Laramie Mountains uplift
9. Wind River Mountains uplift
10. Green River basin and Rock Springs uplift
11. Uinta Mountains uplift

[1] Numbers in parentheses following structure names refer to the numbered structure symbols on the tectonic map (pl. 28).

12. Great Divide Basin, Washakie basin, and uplift and basin complex
13. Sand Wash basin, Axial Basin uplift, and White River uplift
14. Front Range–Park Range–southern Laramie Mountains uplift
15. Denver basin and Hartville uplift

The west-northwest trend is shown by the Uinta Mountains uplift; by the Sweetwater arch-Owl Creek Mountains uplift; and by the linear structural belts in the Lake Basin fault zone, Cat Creek fault zone, and Blood Creek syncline tectonic unit. The northwest trend is indicated throughout the foreland by many small-, intermediate-, and large-scale structures within the Wind River Mountains uplift, the Bighorn Basin-Bighorn Mountains uplift-Powder Basin, the Black Hills uplift, the Chadron arch uplift, the Laramie Mountains uplift, the Front Range-Park Range uplift, and the Sand Wash basin-Axial Basin uplift-White River uplift tectonic units. The northeast trend, though less pronounced and somewhat more variable than the northwest trend, is widespread throughout the foreland, as shown by the northern part of the Denver basin and Hartville uplift tectonic unit and by many intermediate- and small-scale structures within other tectonic units.

WILLISTON BASIN

The Williston or Dakota basin (Kunkle, 1954; Ballard, 1942; Hennen, 1943) is the major tectonic unit centered in western North Dakota. The general position and shape of the basin is indicated on the tectonic map by the minus 9,000-foot structure contour line drawn on the base of the rocks of Mississippian age. The basin is bounded on the southwest by the Cedar Creek anticline and probably on the northeast by the monocline beneath the Missouri Coteau; it extends into Montana and Canada to the northwest (called in Canada the Moosejaw synclinorium) and into central South Dakota (the Lemmon syncline, South Dakota structure 4) to the southeast. The position of the Williston basin trough as shown on the map is only approximate, and positions of troughs drawn on different stratigraphic units do not coincide. (See pl. 28.) This lack of coincidence is caused by the slight shifting of its position since early Paleozoic time or possibly Precambian.

The amplitude of all folds in the Williston basin is characteristically small. Dips throughout most of the Williston basin are less than 10° and exceed 40° to 50° only in locally deformed areas and along the northeast boundary. Numerous small anticlines, synclines, and monoclines trend either northwest or northeast. At the surface, most of these structures are very small and may have only a few feet or a few tens of feet of structural relief. However, these small structures may reflect larger structures at depth as shown by the small structures overlying the Cedar Creek anticline (Lyons, 1950, p. 39–40), and the Fryburg anticline (North Dakota structure 9). Dips of sedimentary rocks locally exceeding 40° to 50° are exemplified by areas with numerous small faults in eastern Harding County and western Ziebach County, S. Dak. (Russell, 1925, p. 12–23). The orientation of these small folds and faults is parallel to many larger folds (pl. 28) and to the widespread regional pattern of northwest-trending and northeast-trending joints in western North Dakota and South Dakota and eastern Montana, Nebraska, and Wyoming. This parallelism suggests that the trend of old geologic structures establishes the trend of slight folding and fracturing of younger overlying rocks (Hudson, 1955; Osterwald, 1956).

Several small, almost equidimensional domes and noses, in McKenzie, Golden Valley, Stark, and Hettinger Counties, N. Dak., occur in a part of the Williston basin otherwise characterized by elongate structures. A domal structure in central Slope County, N. Dak., suggested by the drainage pattern of several small streams, overlies a probable intrusion suggested by geophysical investigations (unpublished data from private companies). Other small domes and noses may also overlie intrusions that do not crop out. Hidden intrusive masses may be related to some of the zones of silicified sandstone described at many places in southwestern North Dakota and northwestern South Dakota (Hares, 1928; Winchester and others, 1916).

The Lemmon syncline (South Dakota structure 4), which is the southeastern part of the Williston basin, trends northwest in South Dakota and is approximately parallel to several other long broad anticlines and synclines of small amplitude. Some smaller folds in western South Dakota trend generally northeast, but the trends vary from north to east. In addition, most of these smaller folds are shorter than the northwest-trending folds. A north-northeast-trending syncline and anticline, near the southeast end of the Cedar Creek anticline in northwestern South Dakota, probably marks a structural separation between the Lemmon syncline and the northern end of the Black Hills uplift. The north-northeast-trending anticline is crossed by several smaller northeast-trending structures; a broad monocline trends southeastward from the anticlinal crest. Swarms of normal and reverse faults, spatially related to this monocline, trend northwest. These faults of small displacement, some of which may have been planes of weakness for pre-Miocene landslides (Gill and Moore, 1955, p. 255), cut inclined beds of Oligocene and older age, but do not cut overlying rocks of Miocene age.

The Missouri Coteau, also called the Max moraine or the Altamont moraine, is a northwest-trending belt of hills mantled by glacial debris, extending from north-central North Dakota 800 miles northwest into Canada (Townsend and Jenke, 1951). The structure underlying the coteau probably is a monocline (Townsend, 1954) and is the northeastern boundary of the Williston basin; it may also be the eastern limit of the Cordilleran foreland as suggested by regional gravity and seismic maps (Lyons, 1950, p. 34; Sawatzky, 1956 a–c). Though the lateral extent of the monocline is not known, it may underlie most of the coteau. The monoclinal structure of the coteau probably was a barrier to sedimentation during early Tertiary time, because it marks the approximate eastern limit of volcanic debris included in some rocks of that age (Blackstone, oral communication, 1956).

The Cedar Creek anticline, which forms the southwestern margin of the Williston basin, is an asymmetric structure extending from east-central Montana into the northwest corner of South Dakota. The southwest limb of the anticline dips more steeply than the northeast limb, and it is probable that the rocks of Precambrian age beneath the steep limb are strongly faulted, as suggested by geogphysical data (Lyons, 1950, p. 39). The crest of the anticline is modified by several small northeast-trending cross folds and domes.

Within the Williston basin are large anticlines and synclines of small amplitude, most of which trend nearly parallel to the trough; examples are the Sanish basin (North Dakota structure 6) and the Fryburg anticline (North Dakota structure 9). Some large anticlines and synclines, however, trend north-south; examples are the Keene dome (North Dakota structure 4) and the Nesson anticline (North Dakota structure 2).

CENTRAL DAKOTA TERRACE

A broad structural terrace in central South Dakota is probably the southeastern margin of the Lemmon syncline. Superimposed upon the terrace are several intermediate-scale anticlines and synclines of small amplitude that trend approximately northwest and a few small-scale anticlines, synclines, and faults that trend northeast subordinate to and roughly parallel to the trend of the terrace.

BLACK HILLS UPLIFT

The Black Hills uplift, the major tectonic unit in western South Dakota, is indicated on the map by the outcrop of rocks of Precambrian age and also by the positions of the intermediate-scale monoclines that bound the hills on the northeast, southeast, and southwest sides. The northwestward extension of the Black Hills uplift into Montana is a series of intermediate-scale northwest-trending anticlines and synclines, most of which nearly parallel the Cedar Creek anticline to the north and northeast. A broad northeast-trending trough about 12 miles south of the Yellowstone River probably is the northwestern margin of the Black Hills uplift.

The uplift is elliptical in plan (Darton, 1951), and consists of two flat-topped uplifted blocks (Noble, 1952, p. 31). The uplift is presently the highest point on what probably is a large-scale structural arch that extends southeast into Nebraska as the Chadron arch uplift and into Kansas as the central Kansas uplift. A broad low arch probably trends northwest from the Black Hills uplift to the Porcupine dome in Montana (Montana structure 26). The present Black Hills uplift is near the site of a structural high during Paleozoic time (Noble, 1952, p. 31). Stratigraphic evidence indicates that the Black Hills were also topographically high during Precambrian time (Darton and Paige, 1925, p. 6, 24). Recent detailed stratigraphic data on the sedimentary rocks of Tertiary age indicate that the most recent uplift in the Black Hills probably took place since Oligocene time (H. R. Sharkey, oral communication, 1955).

Small intrusions of early Tertiary age, most of which are of alkalic composition, crop out in the northern half of the Black Hills uplift. In the same area other masses of intrusive rock probably underlie the small-scale domelike structures at depth; for example, one small-scale dome in Crook County, Wyo., overlies an intrusion discovered in the drilling of an oil well; sandstones of Jurassic age at the crest of the dome were strongly silicified (F. H. Brady, written communication, 1956). Additional intrusive masses have been located in northwestern Wyoming, Montana, and North Dakota by subsurface investigations. According to Darton and Paige (1925, p. 25), the intrusive igneous rocks in the Black Hills intrude and uplift rocks of Cretaceous age, but do not intrude or deform rocks of Oligocene age. A few small scattered flows and dikes of rhyolitic rock of late Tertiary age crop out in the northern Black Hills and are younger than the intrusives.

Many intermediate-scale open folds in sedimentary rocks of Paleozoic and Mesozoic age extend south, southwest, and southeast from the southern end of the Black Hills uplift and northwest from the northwestern end of the uplift. These trends are approximately parallel to the trends of intermediate- to small-scale structures of Precambrian age, particularly those near the Bear Mountain dome (South Dakota structure 13) and the Harney Peak dome (South Dakota structure 14). This parallelism between trends in the younger rocks and in the Precambrian rocks strongly suggests that the original Precambrian structures guided later and recurrent deformation. A zone of northeast-trending intermediate- to small-scale folds in eastern Fall River County, S. Dak., separates the southern Black Hills uplift from the northern end of the Chadron arch uplift, and a narrow strip of northeast-trending small-scale faults and folds transects the north end of the uplift. These intermediate- to small-scale structures also are parallel to some of the structures of Precambrian age in the core of the Black Hills uplift.

LAKE BASIN FAULT ZONE, CAT CREEK FAULT ZONE, AND BLOOD CREEK SYNCLINE

To the west of the Lake Basin fault zone, Cat Creek fault zone, and Blood Creek syncline tectnic unit, the structure of central Montana is characterized by a series of long west-northwest-trending belts of small- to intermediate-scale faults and folds which presumably overlie faults or shear zones in the rocks of Precambrian age (Chamberlin, 1919; Thom, 1923, p. 11–12). Some of these belts extended eastward into this tectonic unit; for example, the Lake Basin and Cat Creek fault zones (Chamberlin, 1919; Thom, 1923, p. 8–12). The location and trend of these west-northwest-trending fault and fold belts probably were established during Precambrian time (Osterwald, 1956). Adjacent to these west-northwest-trending belts of structures some of the other intermediate-scale structures, such as the Sumatra anticline and syncline (Montana structures 28, 30) where close to the Cat Creek fault zone, change their trend from northwest to west-northwest, which suggests that the northwest-trending structures were deflected by later and recurrent horizontal movement along the west-northwest belts. The large component of horizontal displacement along the west-northwest-trending belts contrasts with the apparent vertical displacement along most other large faults in the Cordilleran foreland, such as the fault beneath the northwest-trending Cedar Creek anticline.

Most of the intermediate- and small-scale folds and faults in the Lake Basin fault zone, Cat Creek fault zone, and Blood Creek syncline tectonic unit trend northwest or northeast, though west-northwest trends are common near some of the large-scale belts. A few intermediate- to large-scale faults in northeastern Montana trend northeast. The most important of these are the Weldon fault (Montana structure 9) and the Brockton-Froid fault zone (Montana structure 6). The Weldon fault is probably much longer than shown on the map; subsurface data indicate that the fault was active during Paleozoic time (W. L. Dockery, oral communication, 1955) because the zero isopach contour line of Ordovician rocks is parallel and adjacent to the Weldon fault. The northwest- and northeast-trending faults were probably formed by repeated deformation along trends established during Precambrian time.

The dominant joints throughout most of the Lake Basin fault zone, Cat Creek fault zone, and Blood Creek syncline tectonic unit trend nearly northwest, parallel to most larger structures. The parallelism of the joints, folds, and faults with small valleys and ridges probably related to regional glaciation (R. B. Colton, oral communication, 1955) suggests that the tectonic trend may have influenced the direction of glacial movement, the flow of melt water, or directions of cracking within the ice. Some of these ridges and valleys are parallel to and alined with the Brockton-Froid fault zone (Swenson, 1955, pl. 1). The inferred tectonic control of the preglacial geomorphic development of the region is strengthened by the fact that tributaries to the Missouri River from the south flow northwest, at an acute angle to the eastward flow of the river, whereas those tributaries to the north flow southeast (Osterwald and Dean, 1957).

A few small dikes and other intrusions crop out 11 miles north of Hysham, Treasure County, Mont., and near the crest and flanks of Porcupine dome (Montana structure 26), and about 8 miles west of Jordan, Garfield County, Mont.

BIGHORN BASIN, BIGHORN MOUNTAINS-PRYOR MOUNTAINS UPLIFT, AND POWDER RIVER BASIN

The Bighorn Basin is a sharply asymmetric trough southwest of the Bighorn Mountains-Pryor Mountains-uplift. The basin is bordered by belts of parallel asymmetric northwest-trending intermediate- and small-scale folds and faults; others not yet known may be found in the central part of the basin. These northwest-trending belts and zones of northeast-trending faults are intimately associated, particularly in northwestern Big Horn and Park Counties, Wyo. The basin trough is near the southwestern margin of the basin in eastern Park County, Wyo., where the basin is very deep; depths from the surface to the top of the Madison limestone of Mississippian age are estimated to be at least 20,000 feet (P. L. Gooldy, oral communication, 1953).

The North Oregon Basin dome (Wyoming structure 47) and the South Oregon Basin dome (Wyoming structure 48) in the Bighorn Basin are parts of a large asymmetric anticline which is bordered on the east by a north- to northwest-trending subsurface fault of great displacement. Other similar subsurface faults trend north-northeast in northern Park County. Two small outliers of rocks of Paleozoic age rest on rocks of Cretaceous and Tertiary age in central Park County, Wyo. These outliers are either remnants of an extensive overthrust sheet that moved eastward from the Absaroka Mountains (Pierce, 1941), or they are local thrusts related to the volcanic activity in the Absaroka Mountains (Bucher, 1947).

The Pryor Mountains uplift, though structurally separate from the Bighorn Mountains uplift (Blackstone, 1940), contains many analogous structures; the two uplifts are here considered a single tectonic unit. The trends of some north-trending folds and faults within the Pryor Mountains uplift turn sharply and are almost east-west near a major west-northwest trending belt of structures, the Nye-Bowler zone.

The structure of the Bighorn-Pryor uplift is the result of differential movement of a series of blocks of relatively resistant Precambrian rocks, over which the weaker sedimentary rocks were draped into a series of folds. Many of the sedimentary rocks are faulted (Blackstone, 1947; Osterwald, 1949), indicating recurrent movement along previously established zones of deformation in the Precambrian rocks. The raised blocks are bordered partly by monoclines and partly by faults; some of these monoclines overlie faults at depth. Curving asymmetric anticlines, at or near the margins of some of the blocks, pass laterally and vertically into steeply dipping normal or reverse faults. At least part of the folds bordering the uplift are in zones arranged in echelon, in which individual folds are oblique to the trend of the uplift; these zones are most common in southwestern Johnson County, Wyo., and the folds are most abundant on the west side of the uplift. The Lake Basin fault zone probably is the northern limit of the uplift.

The Tensleep-Horn normal fault (Wyoming structure 136), of large displacement, trends west-northwest across the Bighorn-Pryor uplift in northeastern Washakie County and western Johnson County, Wyo. North of this fault, the Precambrian rocks are considerably elevated with respect to the Precambrian rocks south of the fault. A large-scale anticline extends southeastward from the south end of the uplift to a point about 12 miles west of Casper, Wyo.

The structures of Precambrian age within the Bighorn Mountains part of the uplift have two principal trends: an early trend which is approximately northeast and a later one which is approximately northwest. The general trend of the uplift is approximately parallel to the later Precambrian trend.

The Powder River Basin is a large-scale elongate structural depression between the Bighorn Mountains uplift and the Black Hills uplift. The basin is markedly asymmetric; the deepest part is only a few miles east of the Bighorn Mountains front. Eastward from the trough (Wyoming structure 152), the basin floor slopes upward gently until it joins the monoclines bounding the Black Hills uplift.

Several broad intermediate-scale anticlines and synclines trend approximately southwest in the southern part of the basin. The folds are not prominent in the rocks of Tertiary age at the surface, but become increasingly prominent with increasing depth and pass into strong folds and faults in rocks of Paleozoic age (W. N. Zakis, oral communication, 1954). These ridges and depressions probably reflect considerable and recurrent deformation along structures of Precambrian age. Some of the small-scale structures visible at the surface in the Powder River Basin do reflect the underlying intermediate-scale structures in a subtle way, as shown by the trends of the surface and subsurface structures in southwestern Campbell County and southeastern Johnson County, Wyo. (W. N. Sharp, written communication, 1955).

Northwest-trending joints, parallel to the primary joint set in granites of Precambrian age in the Bighorn Mountains, are common in the northern part of the Powder River Basin, but are most abundant in a large area in northeastern Johnson County. In this area the upper surface of the Precambrian rocks is virtually flat (Osterwald, 1956, fig. 2 or 109).

The eastward extension of the Nye-Bowler zone of structures forms the northern boundary of the Powder River Basin in southern Montana; this zone probably extends as far east as the northwestern part of the Black Hills uplift (J. R. Lynn, oral communication, 1954). It is possible, however, that the Tongue River syncline (Montana structure 24) is a northern continuation of the Powder River Basin beyond the Nye-Bowler zone.

As a result of geophysical investigations by private companies a subsurface intrusion was detected in southeastern Big Horn County, Mont., in T. 8 S., R. 43 E.; other subsurface intrusions were detected in northeastern Sheridan County and in Campbell County, Wyo., in T. 49 N., R. 70 W.

CHADRON ARCH UPLIFT

The general position of the large-scale Chadron arch uplift (Nebraska-Kansas structure 2) is indicated on the map by the approximate position of its crestline drawn on top of the rocks of Precambrian age. The arch is the central part of a long subsurface uplift that extends northwest into South Dakota as the Black Hills uplift and southeast into Kansas as the central Kansas uplift. That part of the anticline in south-central Nebraska is called the Cambridge arch. The uplift was raised before Mississippian time, again after the Mississippian (probably during the Pennsylvanian), and at least the Chadron arch part of the uplift was raised during Late Cretaceous or early Tertiary time (King, 1951, p. 49). The

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Chadron arch uplift is bordered on the southwest and northeast by large-scale synclines (Fuenning, 1942). Although the dips of sedimentary rocks at the surface throughout much of western Nebraska, northwestern Kansas, and southwestern South Dakota are less than 10°, the dips of Paleozoic rocks at depth along the Chadron arch uplift exceed 10° in some places.

ABSAROKA MOUNTAINS UPLIFT

The Absaroka Mountains uplift is composed largely of different kinds of volcanic rocks of early Tertiary age (Rouse, 1947), though extrusives of probable late Tertiary age were recently discovered (Blackstone, oral communication, 1956). The volcanic rocks, both pyroclastic and flow, grade southeastward into rocks clearly of sedimentary origin, though containing a large proportion of pyroclastic material (W. H. Wilson, oral communication, 1956). The contacts between sedimentary and volcanic rocks of Tertiary age shown on the tectonic map were taken from the State geologic map of Wyoming (Love and others, 1955) and from a few scattered localities where detailed information is available. The contacts of the Tertiary rocks shown on the tectonic map are only approximate and have been inferred.

The geologic structure beneath the volcanic rocks is not known; however, the tectonic trends shown by intermediate-scale folds and faults along the margins of the volcanic rocks probably extend beneath the volcanic rocks. Most of these structures trend approximately northwest, but a few smaller ones trend northeast. In the southern part of the Absaroka Mountains uplift, a few structures trend approximately east-west; these are probably related to the structures of the Owl Creek Mountains uplift where east-west trends are conspicuous.

OWL CREEK MOUNTAINS UPLIFT, WIND RIVER BASIN, SWEETWATER ARCH UPLIFT, AND NORTHERN LARAMIE MOUNTAINS UPLIFT

Large-scale east-west-trending structures, locally bordered by zones of smaller structures arranged in echelon, are common in the Owl Creek Mountains uplift, the Wind River Basin (Wyoming structure 101), and the Sweetwater arch uplift. Reverse faults either at the surface or in the subsurface border many of the large- and intermediate-scale anticlines.

Most of the large-scale Wind River Basin trends east-west, but the eastern end trends southeast and becomes parallel to the large-scale broad anticline extending southeastward from the Bighorn Mountains uplift.

Numerous volcanic plugs and dikes of middle Eocene age (Carey, 1954, p. 33) have intruded rocks of Precambrian to early Eocene age along the north flank of the large-scale Sweetwater arch uplift in western Natrona County, Wyo. These volcanic rocks, many of which contain much sodium, were intruded along the crest of the subordinate Rattlesnake anticline (Wyoming structure 201), one of a series of northwest-trending intermediate-scale structures arranged in echelon along the north flank of the east-west-trending Sweetwater arch uplift.

WIND RIVER MOUNTAINS UPLIFT

The Wind River Mountains uplift is a large-scale elongate block of rocks of Precambrian age trending northwest in west-central Wyoming. The internal structure of the rocks of Precambrian age is virtually unknown, except for small areas near the southern end of the uplift (Trumbull, 1913; Armstrong, 1948), and for the north end where numerous faults have been mapped (Richmond, 1945; Baker, 1946). The southern end of the uplift is separated from the Sweetwater arch uplift by east-northeast-trending intermediate- to small-scale faults and folds. The northwestern end of the Wind River Mountains uplift merges with the Absaroka Mountains uplift and with the overthrust belt of the Cordilleran geanticline. The Wind River fault (Wyoming structure 237), a large-scale reverse fault of considerable throw, separates the uplift from the adjacent Green River basin (Coffin, 1946, p. 2031–2032). Parallel to this fault is the intermediate-scale Pinedale anticline (Wyoming structure 238) and several subordinate smaller faults and folds.

GREEN RIVER BASIN AND ROCK SPRINGS UPLIFT

The Green River basin is south and west of the Wind River Mountains uplift. The structure of the basin is little known because of extensive cover of rocks of early Tertiary age which are deformed only locally; the results of subsurface exploration by private industry were not available at the time of the present investigation. The western margin of the basin is the belt of thrust faults and long asymmetric folds, including the Meridian anticline (Wyoming structure 307) and the thrust fault east of it. The exact eastern limit of this belt of folds and thrust faults is not known; eastward extension beneath the sedimentary rocks of early Tertiary age within the basin is suggested by the folds and faults in the subsurface at Barrel Springs anticline (Wyoming structure 306).

The eastern margin of the Green River basin is the Rock Springs uplift (Wyoming structure 245). The trend of this uplift is almost north-south, though there are several bends in the crestal line. The

Green River basin and Rock Springs uplift are bounded on the south by the east-west-trending Uinta Mountains uplift and related structures. A belt of east-northeast-trending intermediate-scale faults crosses the uplift near its central part, and may extend to the east as the Wamsutter arch (Wyoming structure 246), the structural division between the Great Divide Basin and the Washakie basin.

The Leucite Hills, a cluster of flows, blister cones, and cinder cones of potassium-rich volcanic rocks, are in the northern part of the Rock Springs uplift. Some of the flows and blister cones are probably of early Tertiary age (Schultz and Cross, 1912; Kemp and Knight, 1903), but the cinder cones are probably much younger.

UINTA MOUNTAINS UPLIFT

The general trend of the Uinta Mountains uplift is east-west (Colorado-Utah structure 2), except at its eastern end where the tectonic trend changes to southeast at the intersection with a series of northwest-trending structures. The crestal part of the uplift is broad and gently folded; the flanks are intensely folded and faulted. The approximate parallelism in the trend of the Uinta Mountains uplift with that of the Owl Creek Mountains uplift and with the west northwest-trending structural belts in central and southern Montana, such as the Nye-Bowler zone and the Lake Basin and Cat Creek fault zones, suggests that all these structures may be tectonically similar (Blackstone, 1955).

GREAT DIVIDE BASIN, WASHAKIE BASIN, AND UPLIFT AND BASIN COMPLEX

The Great Divide Basin and Washakie basin are two large-scale structural depressions east of the Rock Springs uplift; they are separated from each other by a northeast-trending intermediate- to large-scale structure, the Wamsutter arch (Wyoming structure 246) (G. N. Pipiringos, oral communication, 1955). The structure of most of both basins is unknown. The north-south trend of the Rock Springs uplift to the west of the two basins is paralleled to the east by several other intermediate-scale geologic structures in the uplift and basin complex in Carbon and Albany Counties, Wyo.; an example is the Bell Springs fault (Wyoming structure 258), north and slightly west of Rawlins, Wyo.

Some of the basins in the Great Divide Basin, Washakie basin, and uplift and basin complex tectonic unit are deep, though their lateral extent is not great; the difference in elevation between rocks of Precambrian age in the subsurface of the Hanna basin in Carbon County and the exposed rocks of Precambrian age 20 miles to the south is about 40,000 feet (Knight, 1951, p. 46). A belt of northwest-trending discontinuous intermediate-scale structures separates the uplift and basin complex from the Sweetwater arch uplift to the north. Along the southern margin of Wyoming large- to intermediate-scale structures which trend approximately east-west are common from south-central Sweetwater County to the southeastern part of Carbon County. As shown on the tectonic map, the north-south, northeast, and east-west trends in rocks as young as Tertiary age are approximately parallel to trends established in Precambrian time.

SAND WASH BASIN, AXIAL BASIN UPLIFT, AND WHITE RIVER UPLIFT

The tectonic unit including the Sand Wash basin, Axial Basin uplift, and White River uplift is characterized predominantly by intermediate- to large-scale northwest-trending folds and faults. Locally, both northwest- and northeast-trending structures are present. Some of the folds have a few thousands of feet of structural relief, but most are much smaller. Post-Miocene subsidence along some of the northwest-trending anticlines has produced superposed synclines in rocks of Miocene age and zones of anticlines, synclines, and small faults arranged in echelon (Sears, 1924).

Volcanic flows, dikes, sills, and plugs characterize the eastern part of the area, particularly the White River uplift and the eastern part of the Sand Wash basin. Most of these volcanic rocks are of late Tertiary age, except for a few intrusives along the eastern margin of the Sand Wash basin that are of early Tertiary age. Other subsurface intrusions are present in the Sand Wash basin; an example is Slater dome (Colorado-Utah structure 12; R. E. Wells, oral communication, 1956).

The Sand Wash basin is separated from the Washakie basin to the north by the east-west-trending structures of Cherokee Ridge (Wyoming structure 298).

FRONT RANGE-PARK RANGE-SOUTHERN LARAMIE MOUNTAINS UPLIFT

The Front Range-Park Range-southern Laramie Mountains uplift forms a large tectonic unit, the orientation of which is approximately north-south. The smaller structures within the subordinate uplifts and basins trend northwest or northeast at angles oblique to the trend of the tectonic unit. In the northern parts of this tectonic unit, particularly along the eastern margin of the Laramie Mountains uplift, some large-scale structures trend approximately north-south parallel to the orientation of the unit.

The uplift is bounded on the east by the Denver basin and on the west by the Sand Wash basin and the White River uplift. Numerous northwest-trending intermediate-scale faults and folds characterize the east flank of the uplift; these faults and folds, though caused by recurrent movement along structures of Precambrian age (Hudson, 1955), involve rocks as young as Cretaceous age. The northern boundary of the uplift, though irregular, is marked by a belt of northeast-trending folds in southeastern Wyoming.

The trends of structures of Precambrian age, such as foliation, folds, joints, and trends of lithologic units, are in general approximately northwest, northeast, and east-west. In many local areas Tertiary structural trends diverge from Precambrian structural trends, but the general coincidence of the two patterns on a regional basis suggests that the younger structures are controlled, at least in part, by the older ones (Lovering and Goddard, 1950, p. 57–59). Most of the intermediate- and small-scale faults of Tertiary age within the uplift are high-angle normal or reverse types. The Williams Range thrust fault (Colorado-Utah structure 113) and a few other low-angle thrust faults are exceptions and probably are the result of local compressive components of strain during deformation that was largely the result of differential vertical movements.

Folds within the subordinate uplifts have as much as a few thousands of feet of structural relief. Extensive flows of Tertiary age and a few intrusions of early Tertiary age in the central part of the mountainous areas are shown on the tectonic map. A northeast-trending line of intrusions of early Tertiary age (Lovering and Goddard, 1950, p. 43), in the southern part of the mountainous area, marks the trend of the Front Range mineral belt. This line of stocks is parallel to other large-scale northeast-trending structures in the Cordilleran foreland (Osterwald, 1956).

Numerous northwest-trending high-angle faults, including many reverse faults with large components of horizontal movement, are common along the eastern part of the uplift. The faults, and their related subsidiary fractures, provided openings along which many veins and dikes were emplaced. Folds along the mountain front are related to movement along these faults. In northern Albany County and western Platte County, Wyo., northeast-trending intermediate-scale structures separate the north-south-trending part of the Laramie Mountains uplift from the northern part which trends northwest.

DENVER BASIN AND HARTVILLE UPLIFT

Most of eastern Colorado, southeastern Wyoming, and adjacent parts of Nebraska and Kansas are included in the Denver basin; it is sometimes referred to as the Julesburg basin. The trough of this large-scale basin trends north-south in northern Colorado and passes beneath Cheyenne, Wyo.; a few miles north of Cheyenne the trend changes to northeast, and to the south of the mapped area the trend changes to southeast.

Numerous small-scale folds modify the structure of the Denver basin throughout much of eastern Colorado. Although the trends of these folds vary, northwest and northeast trends are most common; some folds trend approximately east-west and a few trend almost north-south. Most of these small folds have only a few tens of feet of structural relief. Parallel to the northeast-trending part of the Denver basin in Wyoming, are numerous intermediate- to small-scale faults in Platte and Goshen Counties, which cut rocks as young as Miocene age. At least some of the intermediate- and small-scale structures of Precambrian age in the northern part of the Laramie Mountains uplift also trend northeast; the northeast trend of structures of post-Miocene age and of the Denver basin probably was established by recurrent movement along older structures of Precambrian age. The north-south trend of the Denver basin trough near Denver, Colo., is parallel to the trend of the Front Range-Park Range-Laramie Mountains uplift west of Denver, Boulder, and Fort Collins, Colo., but is oblique to most of the northeast- and northwest-trending structures within the uplift, though a few structures in the uplift parallel the basin trough.

A conspicuous belt of gentle west-plunging anticlines and synclines is in southwestern Nebraska, south of the North Platte River. North and south of this fold belt the trends of anticlines and synclines are northwest, north, and northeast. The northwest- and northeast-trending folds parallel a widespread regional joint and fold pattern, shown by numerous joints in southern Scotts Bluff County and northern Banner County, Nebr. The divergence of the west-trending folds from this regional pattern suggests that these folds are the result of deep-seated disturbances unrelated to the cause of the northwest- and northeast-trending joints and that these folds are perhaps analogous to other nearly west-trending structures in Montana, Wyoming, and Utah. These suggestions are strengthened by the fact that a saddle in the long Chadron arch-Cambridge arch uplift, just east of the area of the tectonic map, is directly east of and in line with the belt of west-trending folds (Reed, 1956).

The Hartville uplift (Wyoming structure 161) is an elongate large-scale structural ridge extending north-northeast from northwestern Platte County, Wyo., almost to the southwestern part of the Black Hills uplift. Within the Hartville uplift, a series of north-northeast-trending intermediate-scale folds and faults deform rocks of Oligocene age and possibly rocks of Miocene age (Love and others, 1949). A less pronounced northwest structural trend in the

Hartville uplift is indicated by a few folds, such as the Spanish Diggings anticline (Wyoming structure 166) and the Magoon dome (Wyoming structure 162). A steep northeast-trending monocline that dips northwest, delimits the Hartville uplift from the southeastern end of the Powder River Basin. Locally, intermediate-scale folds parallel this monocline, and probable faults in the rocks of Precambrian age are associated with some of the folds, such as the Lance Creek anticline (Wyoming structure 159).

No outcrops of igneous rocks of Tertiary age are known in the Denver basin or the Hartville uplift, except for a few flows and a dike west of Denver, Colo., and a few dikes east and north of Boulder, Colo., near the western margin of the basin. At two places, however, airborne magnetometer surveys have detected anomalies, which may represent igneous rocks at depth. Both of these anomalies are along the western margin of Nebraska: one is in western Kimball County, Nebr., and the adjacent part of Wyoming; the other is along the North Platte River in western Scotts Bluff County, Nebr. According to W. J. Dempsey (written communication, 1954), the source of the anomaly in western Kimball County is 6,500 to 9,000 feet below the ground surface. At this place the top of the rocks of Precambrian age is at a depth of about 9,500 feet; hence, the source of the anomaly may be an intrusion in rocks above those of Precambrian age. The anomaly in western Scotts Bluff County, Nebr., is not amenable to a depth analysis (Dempsey, written communication, 1954).

RELATION OF URANIUM DEPOSITS TO STRUCTURE

Many uranium deposits or groups of deposits in the central Cordilleran foreland are close to structures. This relationship was established by evaluating the spatial distribution of about 1,200 deposits in the structural framework of about 260,100 square miles. The deposits and structures in the overall area are sufficiently numerous and varied to warrant broad generalizations concerning the relation between deposits and structures, but such generalizations are limited by several inherent factors. First, the scale of presentation prohibits showing the small and intimate structural details that might control individual deposits. Second, structures shown on the tectonic map include both surface and subsurface features; some subsurface structures have little or no surface expression. Third, the age of structures shown on the map is indicated only within very wide limits by indicating the general age of the rocks as Precambrian, Cambrian to Eocene, and post-Eocene; where data on the relative ages of deposits and structures are scanty, structures may predate or postdate deposits by sufficient time intervals to make an apparently close spatial relationship misleading. Where data were available, such limitations were considered even though it has not been possible to so indicate in the text and on the tectonic map; all quoted examples of structural relationship are supported by reasonably adequate geologic data.

Because the tectonic map is complex and because the prime objective was to determine structural relationships, lithologic types of host rocks favorable for the deposition of uranium could not be shown. The distribution of such lithologic types in relation to uranium deposits has been shown by Finnell and Parrish (1957). The tectonic map and the map by Finnell and Parrish are basic and companion documents for further evaluation of the structural and stratigraphic environments of uranium deposits.

The distribution of uranium deposits may have been influenced by igneous intrusions and also by structures and distribution of favorable host rocks. Vein deposits of uranium in the northern Black Hills uplift are near many intrusions in the subsurface and at the surface. Some uranium deposits in Slope County, N. Dak., are near the surface projection of a buried intrusion. Igneous rocks of Tertiary age crop out along the north margin of the Sweetwater arch, a short distance east of many uranium deposits. The vein deposits of uranium in the Front Range uplift are near many intrusions of early Tertiary age. Other intrusions that do not crop out, as, for example, the ones in Big Horn County, Mont., and Kimball County, Nebr., influenced the distribution of uranium in surface waters.

RELATIONS OF DEPOSITS TO LARGE-SCALE STRUCTURES

Within the 15 tectonic units defined above and shown on figure 28, deposits can be related by first-order discrimination to the following large-scale structural environments, although by themselves, large-scale structures are too coarse to define clearly the exact position and dimensions of districts favorable for uranium deposits:

1. Crests of large-scale anticlines, as shown by deposits along the Yellowjacket anticline (Colorado-Utah structure 102) and along the Chadron arch uplift;
2. Troughs of major basins, as shown by deposits in the Williston basin, in the eastern part of the Wind River Basin, and in the Great Divide Basin;
3. Flanks of large-scale uplifts where smaller structures are arranged in echelon, as shown by deposits along the south flank of the Owl Creek Mountains uplift, along the north flank of the Sweetwater arch, and along the east flank of the Front Range uplift;

4. Flanks of large-scale uplifts where subordinate structures are parallel to the major structure, as shown by deposits along small- to intermediate-scale folds and faults on the north flank of the Uinta Mountains uplift, along the intermediate-scale Old Woman anticline (Wyoming structure 157) in the Hartville uplift, and along the north flank of the Axial Basin uplift where intermediate-scale structures, genetically related to a syncline of post-Miocene age overlying the uplift, are parallel to the uplift;
5. Conjunctions of major structures where trends intersect or merge with loss of identity of some or all trends, as shown by deposits where the northeast-trending Hartville uplift and the northwest-trending northern Laramie Mountains uplift merge, where a large-scale northeast-trending fault zone (Osterwald, 1956, fig. 1 or 108) intersects the northwest-trending Powder River Basin trough;
6. Conjunctions of major structures where trends intersect or merge with loss of identity of one or all trends and where subordinate structures are parallel to, or in echelon with, the trend of one or all major structures, as shown by deposits in the Pryor Mountains where north-trending, intermediate-scale anticlines and faults are in echelon to the northwest-trending large-scale Bighorn Mountains-Pryor Mountains uplift and to the west-northwest-trending Nye-Bowler zone.

Uranium deposits or groups of deposits related to large-scale structures are at varying distances from the crest, trough, or central trend of the such structures. Although a group of deposits in the White River uplift is close to the crest of the large-scale Yellowjacket anticline (Colorado-Utah structure 102), deposits in the Williston basin are not close to the basin trough but are all between 10 and 30 miles from the trough. Many deposits, however, including most of those related by first-order discrimination to large-scale structures, can be more closely related by second-order discrimination to small- to intermediate-scale structures.

RELATIONS OF DEPOSITS TO STRUCTURAL PATTERNS

In general, deposits are related to large, intermediate-, and small-scale structures forming a characteristic pattern within areas of variable size. Repetitions of the patterns outlined above may provide clues to areas containing presently unknown uranium deposits, provided suitable host rocks are present. Patterns in which northwest-trending intermediate-scale structures are in echelon along the flanks of north-, northwest-, or west-northwest-trending large-scale structures are found in the western part of the Owl Creek

Mountains uplift and on the western side of the Bighorn Basin. Patterns in which northwest-trending intermediate-scale structures intersect or merge with northeast-trending intermediate-scale to small-scale structures are in northwestern Big Horn County, northeastern Park County, and Natrona County, Wyo. Patterns in which northwest-trending large-scale structures intersect or merge with northeast-trending structures are in the northeastern part of the Williston basin and in the Lemmon syncline. Patterns consisting of large-scale anticlines, synclines, and fault zones are in the Green River basin, the Cedar Creek anticline, and the Lake Basin fault zone. Within the areas containing these structural patterns, individual small-scale structures or groups of structures may serve as guides to uranium deposits; echelon or parallel belts of small-scale fractures and folds, subordinate to intermediate-scale structures, are particularly favorable.

REFERENCES CITED

Armstrong, F. C., 1948, Preliminary report on the geology of the Atlantic City–South Pass mining district, Wyoming: U.S. Geol. Survey open-file report, 65 p.

Baker, C. L., 1946, Geology of the northwestern Wind River Mountains, Wyoming: Geol. Soc. America Bull., v. 57, p. 565–596; repr., Wyoming Geol. Survey Bull. 35, p. 565–596.

Ballard, W. N., 1942, Regional geology of Dakota basin: Am. Assoc. Petroleum Geologists Bull., v. 26, p. 1557–1584.

Blackstone, D. L., Jr., 1940, Structure of the Pryor Mountains: Jour. Geology, v. 48, p. 590–618.

——— 1947, Structural relationships of the Pryor Mountains, *in* Wyoming Geol. Assoc. Guidebook [2d Ann.] Field Conf., Bighorn Basin, 1947, p. 182–188.

——— 1955, Notes on a tectonic map of parts of southwestern Wyoming and adjoining States, *in* Wyoming Geol. Assoc. Guidebook 10th Ann. Field Conf., Green River basin, 1955, p. 122–124.

Bucher, W. H., 1947, Heart Mountain problem, *in* Wyoming Geol. Assoc. Guidebook [2d Ann.] Field Conf., Bighorn Basin, 1947, p. 189–197.

Burbank, W. S., and Lovering, T. S., 1933, Relation of stratigraphy, structure, and igneous activity to ore deposition of Colorado and southern Wyoming, *in* Ore deposits of the Western States (Lindgren volume): New York, Am. Inst. Mining Metall. Engineers, p. 272–316.

Carey, B. D., Jr., 1954, A brief sketch of the geology of the Rattlesnake Hills, *in* Wyoming Geol. Assoc. Guidebook 9th Ann. Field Conf., Casper area, 1954, p. 32–36.

Chamberlin, R. T., 1919, A peculiar belt of oblique faulting: Jour. Geology, v. 27, p. 606–613.

——— 1945, Basement control in Rocky Mountain deformation: Am. Jour. Sci., v. 243–A, Daly volume, p. 98–116.

Cloos, Ernest, and Cloos, Hans, 1934, Precambrian structure of the Beartooth, the Big Horn, and the Black Hills uplifts and its coincidence with Tertiary uplifting [abs.]: Geol. Soc. America Proc., 1933, p. 56.

Coffin, R. C., 1946, Recent trends in geological-geophysical exploration: Am. Assoc. Petroleum Geologists Bull., v. 30, p. 2013–2033.

Curry, W. H., Jr., and Curry, W. H., III, 1954, South Glenrock, a Wyoming stratigraphic oil field: Am. Assoc. Petroleum Geologists Bull., v. 38, p. 2119–2156.

Darton, N. H., 1951, Geologic map of South Dakota: U.S. Geol. Survey.

Darton, N. H., and Paige, Sydney, 1925, Description of the central Black Hills: U.S. Geol. Survey Geol. Atlas, Folio 219, 34 p.

Eardley, A. J., 1951, Structural geology of North America: New York, Harper & Bros.

Finnell, T. L., and Parrish, I. S., 1957, Uranium deposits and principal ore-bearing formations of the central Cordilleran foreland region: U.S. Geol. Survey Field Studies Map MF–120.

Fuenning, Paul, 1942, Thickness and structural study of major divisions of Cretaceous system in Nebraska: Am. Assoc. Petroleum Geologists Bull., v. 26, p. 1517–1536.

Gill, J. R., and Moore, G. W., 1955, Carnotite-bearing sandstone in Cedar Canyon, Slim Buttes, Harding County, South Dakota: U.S. Geol. Survey Bull. 1009–I, p. 249–264.

Hares, C. J., 1928, Geology and lignite resources of the Marmarth field, southwestern North Dakota: U.S. Geol. Survey Bull. 775, 107 p.

Hennen, R. V., 1943, Tertiary geology and oil and gas prospects in Dakota basin of North Dakota: Am. Assoc. Petroleum Geologists Bull., v. 27, p. 1567–1594.

Hiestand, T. C., 1935, Regional investigations, Oklahoma and Kansas: Am. Assoc. Petroleum Geologists Bull., v. 19, p. 948–970.

Horberg, Leland, Nelson, Vincent, and Church, Victor, 1949, Structural trends in central western Wyoming: Geol. Soc. America Bull., v. 60, p. 183–215.

Hudson, F. S., 1955, Folding of unmetamorphosed strata superjacent to massive basement rocks: Am. Assoc. Petroleum Geologists Bull., v. 39, p. 2038–2052.

Kemp, J. F., and Knight, W. C., 1903, Leucite Hills of Wyoming: Geol. Soc. America Bull., v. 14, p. 305–336.

King, P. B., 1951, The tectonics of middle North America—middle north America east of the Cordilleran system: Princeton, N.J., Princeton Univ. Press, 203 p.

Knight, S. H., 1951, The late Cretaceous-Tertiary history of the northern portion of the Hanna basin, Carbon County, Wyoming, *in* Wyoming Geol. Assoc. Guidebook, 6th Ann. Field Conf., South-Central Wyoming, 1951, p. 45–53.

Kunkel, R. P., 1954, Structure contour map of the base of Mississippian rocks in the Williston basin and adjoining areas of Montana, North Dakota, South Dakota, and Wyoming: U.S. Geol. Survey Oil and Gas Inv. Map OM–165.

Love, J. D., Denson, N. M., and Botinelly, Theodore, 1949, Geology of the Glendo area, Wyoming: U.S. Geol. Survey Oil and Gas Inv. Prelim. Map 92.

Love, J. D., Weitz, J. L., and Hose, R. K., 1955, Geologic map of Wyoming: U.S. Geol. Survey.

Lovering, T. S., and Goddard, E. N., 1950, Geology and ore deposits of the Front Range, Colorado: U.S. Geol. Survey Prof. Paper 223, 319 p.

Lyons, P .L., 1950, A gravity map of the United States: Tulsa Geol. Soc. Digest, v. 18, p. 33–43.

Noble, J. A., 1952, Structural features of the Black Hills and adjacent areas developed since Precambrian time: Billings Geol. Soc. Guidebook, 3d Ann. Field Conf., p. 31–37.

Osterwald, F. W., 1949, Structure of the Tongue River area, Bighorn Mountains, Wyoming, *in* Wyoming Geol. Assoc. Guidebook, 4th Ann. Field Conf., Powder River Basin, 1949, p. 37–39.

——— 1956, Relation of tectonic elements in Precambrian rocks to uranium deposits in the Cordilleran foreland of the Western United States, *in* Proceedings of the International Conference on the Peaceful Uses of Atomic Energy, v. 6, Geology of uranium and thorium, p. 293–298: New York, United Nations; U.S. Geol. Survey Prof. Paper 300, p. 329–335.

Osterwald, F. W., and Dean, B. G., 1957, Preliminary tectonic map of eastern Montana, showing the distribution of uranium deposits: U.S. Geol. Survey Mineral Inv. Map MF–126.

Petsch, B. C., and Carlson, L. A., 1950, Magnetic observations in South Dakota: South Dakota Geol. Survey Rept. Inv. 66, 35 p.

Pierce, W. G., 1941, Heart Mountain and South Fork thrusts, Park County, Wyoming: Am. Assoc. Petroleum Geologists Bull., v. 25, p. 2021–2045.

Reed, E. C., 1955, Structure contour map of Nebraska, *in* Finch, W. C., and others, eds., The oil and gas fields of Nebraska: Denver, Colo., Rocky Mtn. Assoc. Geologists, in pocket [1956].

Richmond, G. M., 1945, Geology of northwest end of the Wind River Mountains, Sublette County, Wyoming: U.S. Geol. Survey Oil and Gas Inv. Prelim. Map 31.

Rouse, J. T., 1947, The Absaroka volcanic field, *in* Wyoming Geol. Assoc. Guidebook [2d Ann.] Field Conf., Bighorn Basin, 1947, p. 165–172.

Russell, W. L., 1925, The possibilities of oil in western Ziebach County: South Dakota Geol. Nat. History Survey Circ. 20, 25 p.

Sawatzky, H. B., compiler, 1956a, Regional gravity map of south Saskatchewan: Regina, Saskatchewan Dept. Mineral Resources.

——— 1956b, Regional gravity map of north Saskatchewan: Regina, Saskatchewan Dept. Mineral Resources.

——— 1956c, Composite seismic map of south Saskatchewan: Regina, Saskatchewan Dept. Mineral Resources.

Schultz, A. R., and Cross, Whitman, 1912, Potash-bearing rocks of the Leucite Hills, Sweetwater County, Wyo.: U.S. Geol. Survey Bull. 512, 39 p.

Sears, J. D., 1942, Relations of the Browns Park formation and the Bishop conglomerate, and their role in the origin of Green and Yampa Rivers: Geol. Soc. America Bull., v. 35, p. 279–304.

Swenson, F. A., 1955, Geology and ground-water resources of the Missouri River valley in northeastern Montana: U.S. Geol. Survey Water-Supply Paper 1263, 128 p.

Thome, W. T., Jr., 1923, The relation of deep-seated faults to the surface structural features of central Montana: Am. Assoc. Petroleum Geologists Bull., v. 7, p. 1–13.

——— 1947, Structural features of the Bighorn Basin rim, *in* Wyoming Geol. Assoc. Guidebook [2d Ann.] Field Conf., Bighorn Basin, 1947, p. 173–177.

Townsend, R. C., 1954, Geology of the Portal quadrangle, North Dakota: U.S. Geol. Survey Geol. Quad. Map GQ–47.

Townsend, R. C., and Jenke, A. L., 1951, The problem of the origin of the Max moraine of North Dakota and Canada: Am. Jour. Sci., v. 249, p. 842–858.

Trumbull, L. W., 1913 [map] Atlantic City mining district, Fremont County, Wyoming: Cheyenne, Wyo., Office of the State Geologist.

Winchester, B. E., Hares, C. J., Lloyd, E. R., and Parks, E. M., 1916, The lignite field of northwestern South Dakota: U.S. Geol. Survey Bull 627, 169 p.

SOURCES OF DATA FOR INDEX MAPS

EASTERN MONTANA

No. on pl. 29

1 Andrews, D. A., Pierce, W. G., and Eargle, D. H., 1947, Geologic map of the Big Horn Basin, Wyoming and Montana, showing terrace deposits and physiographic features: U.S. Geol. Survey Oil and Gas Inv. Prelim. Map 71.

2 Baker, A. A., 1929, The northward extension of the Sheridan coal field, Big Horn and Rosebud Counties, Montana: U.S. Geol. Survey Bull. 806–B, p. 15–67.

3 Bass, N. W., 1932, The Ashland coal field, Rosebud, Powder River, and Custer Counties, Montana: U.S. Geol. Survey Bull. 831–B, p. 19–105.

4 Blackstone, D. L., Jr., 1940, Structure of the Pryor Mountains, Montana: Jour. Geology, v. 48, p. 590–618.

5 Brady, F. H., 1955, written communication.

6 Bryson, R. P., 1952, The Coalwood coal field, Powder River County, Montana: U.S. Geol. Survey Bull. 973–B, p. 23–106.

7 Collier, A. J., 1925, The Scobey lignite field, Valley, Daniels, and Sheridan Counties, Montana: U.S. Geol. Survey Bull. 751–E, p. 157–230.

8 Collier, A. J., and Knechtel, M. M., 1939, The coal resources of McCone County, Montana: U.S. Geol. Survey Bull. 905, 80 p.

9 Colton, R. B., 1951, Geology of the Oswego quadrangle: U.S. Geol. Survey open-file report, 45 p.

10 ——— 1951, Geology of the Otter Creek quadrangle, Montana: U.S. Geol. Survey open-file report, 32 p.

11 ——— 1955, written communication.

12 Colton, R. B., and Bateman, A. F., Jr., 1956, Geologic and structure contour map of the Fort Peck Indian Reservation and vicinity, Montana: U.S. Geol. Survey Misc. Geol. Inv. Map I–225.

13 Dobbin, C. E., 1930, The Forsyth coal field, Rosebud, Treasure, and Big Horn Counties, Montana: U.S. Geol. Survey Bull. 821–A, p. 1–55.

*14 Dobbin, C. E., and Erdmann, C. E., 1935, Structure contour map of the Montana plains: (Revised ed.) U.S. Geol. Survey.

*15 ——— 1955, Structure contour map of the Montana plains: U.S. Geol. Survey Oil and Gas Inv. Map OM–178A.

16 Dobbin, C. E., and Larsen, R. M., 1934, Geologic and structure contour map of the southern half of the Cedar Creek anticline, Fallon County, Montana, and Bowman County, North Dakota: U.S. Geol. Survey.

17 Erdmann, C. E., and Larsen, R. M., 1934, Geologic and structure contour map of the northern half of the Cedar Creek anticline, Dawson, Prairie, Wibaux, and Fallon Counties, Montana: U.S. Geol. Survey.

18 Fisher, S. P., 1953, Geology of west central McKenzie County, North Dakota: North Dakota Geol. Survey Rept. Inv. 11, pt. 1.

19 Hancock, E. T., 1919, Geology and oil and gas prospects of the Lake Basin field, Montana: U.S. Geol. Survey Bull. 691–D, p. 101–147.

* indicates source data that apply to all of eastern Montana.

No. on pl. 29

20 Hancock, E. T., 1920, Geology and oil and gas prospects of the Huntley field, Montana: U.S. Geol. Survey Bull. 711–G, p. 105–148.

21 Heald, K. C., 1926, The geology of the Ingomar anticline, Treasure and Rosebud Counties, Montana: U.S. Geol. Survey Bull. 786–A, p. 1–37.

22 Knappen, R. S., and Moulton, G. J., 1931, Geology and mineral resources of parts of Carbon, Big Horn, Yellowstone, and Stillwater Counties, Montana: U.S. Geol. Survey Bull. 822–A, p. 1–70.

23 Knechtel, M. M., and Patterson, S. H., 1955, Bentonite deposits of the northern Black Hills district, Montana, Wyoming, and South Dakota: U.S. Geol. Survey Mineral Inv. Field Studies Map MF–36.

24 ——— 1956, Bentonite deposits in marine Cretaceous formations, Hardin district, Montana and Wyoming: U.S. Geol. Survey Bull. 1023, 116 p.

*25 Kunkel, R. P., 1954, Structure contour map of the base of Mississippian rocks in the Williston basin and adjoining areas of Montana, North Dakota, South Dakota, and Wyoming: U.S. Geol. Survey Oil and Gas Inv. Map OM–165.

** Lyons, P. L., 1950, A gravity map of the United States: Tulsa Geol. Soc. Digest, v. 18, p. 33–43.

26 Moulton, G. J., and Bass, N. W., 1922, Oil and gas prospects in the Cedar Creek anticline and vicinity in Montana, North Dakota, and South Dakota: U.S. Geol. Survey Press Bull. 12051, with map.

27 Noble, J. A., 1952, Structural features of the Black Hills and adjacent areas developed since Precambrian time, *in* Billings Geol. Soc. Guidebook 3d Ann. Field Conf., Black Hills–Williston basin, 1952: p. 31–37.

28 Parker, F. S., 1936, The Richey–Lambert coal field, Richland and Dawson Counties, Montana: U.S. Geol. Survey Bull. 847–C, p. 121–174.

29 Parker, F. S., and Andrews, D. A., 1940, the Mizpah coal field, Custer County, Montana: U.S. Geol. Survey Bull. 906–C, p. 85–133.

30 Pierce, W. G., 1936, The Rosebud coal field, Rosebud and Custer Counties, Montana: U.S. Geol. Survey Bull. 847–B, p. 43–120.

31 Pierce, W. G., Andrews, D. A., and Keroher, J. K., 1947, Structure contour map of the Big Horn Basin, Wyoming and Montana: U.S. Geol. Survey Oil and Gas Inv. Prelim. Map 74.

32 Prichard, G. E., and Landis, E. R., 1955, Geology of the northern part of the Girard coal field, Richland County, Montana: U.S. Geol. Survey Coal Inv. Map C–24.

33 Renick, B. C., 1929, Geology and ground-water resources of central and southern Rosebud County, Montana: U.S. Geol. Survey Water-Supply Paper 600, 140 p.

34 Richards, P. W., 1955, Geology of the Bighorn Canyon–Hardin area, Montana and Wyoming: U.S. Geol. Survey Bull. 1026, 93 p.

35 Rogers, G. S., 1913, The Little Sheep Mountain coal field, Dawson, Custer, and Rosebud Counties, Montana: U.S. Geol. Survey Bull. 531–F, p. 159–227.

36 ——— 1914, Geology and coal resources of the area southwest of Custer, Yellowstone, and Big Horn Counties, Montana: U.S. Geol. Survey Bull. 541–H, p. 316–328.

* Indicates source data that apply to all of eastern Montana.
** Indicate source data obtained from text only.

No. on pl. 29

37 Rogers, G. S., and Lee, Wallace, 1923, Geology of the Tullock Creek coal field, Rosebud and Big Horn Counties, Montana: U.S. Geol. Survey Bull. 749, 181 p.

*38 Ross, C. P., Andrews, D. A., and Witkind, I. J., 1955, Geologic map of Montana: U.S. Geol. Survey.

39 Rubey, W. W., 1925, written communication.

40 Sonnenberg, F. P., 1956, Tectonic patterns of central Montana, *in* Billings Geol. Soc. Guidebook 7th Ann. Field Conf., 1956: p. 73–81.

41 Stebinger, Eugene, 1912, The Sidney lignite field, Dawson County, Montana: U.S. Geol. Survey Bull. 471–D, p. 284–318.

42 Thom, W. T., Jr., and Dobbin, C. H., 1921, Possible new oil field in central Montana—the Alice dome, a promising anticlinal structure: U.S. Geol. Survey press notice, with map.

43 Thom, W. T., Jr., Hall, G. M., Wegemann, C. H., and Moulton, G. F., 1935, Geology of Big Horn County and the Crow Indian Reservation, Montana: U.S. Geol. Survey Bull. 856, 200 p.

44 Wilson, C. W., Jr., 1938, Revision of the stratigraphy of Dry Creek and Golden structures, Carbon County, Montana: Am. Assoc. Petroleum Geologists Bull., v. 22, p. 106–108.

45 Woolsey, L. H., Richards, R. W., and Lupton, C. T., 1917, The Bull Mountain coal field, Musselshell and Yellowstone Counties, Montana: U.S. Geol. Survey Bull. 647, 218 p.

*46 Vine, J. D., and Erdmann, C. E., 1952, Map of Montana showing oil and gas fields and test wells for oil and gas: U.S. Geol. Survey Oil and Gas Inv. Map OM–130.

47 Zapp, A. D., 1952, Structure contour map of the Powder River Basin, Wyoming and Montana: U.S. Geol. Survey Oil and Gas Inv. Map OM–133.

* indicates source data that apply to all of eastern Montana.

WESTERN NORTH DAKOTA

No. on pl. 30

1 Andrews, D. A., 1939, Geology and coal resources of the Minot region, North Dakota: U.S. Geol. Survey Bull. 906–B, p. 43–84.

*2 Ballard, W. N., 1942, Regional geology of Dakota basin: Am. Assoc. Petroleum Geologists Bull., v. 26, p. 1557–1584.

3 Bateman, A. F., Jr., 1957, Structure contour map of the Nesson anticline, Williston basin, North Dakota: U.S. Geol. Survey open-file map.

4 Bauer, C. M., and Herald, F. A., 1921, Lignite in the western part of the Fort Berthold Indian Reservation south of Missouri River, North Dakota: U.S. Geol. Survey Bull. 726, p. 109–172.

5 Benson, W. E., 1951, Geologic map of North Dakota southwest of the Missouri River: U.S. Geol. Survey Prelim. Map.

6 Caldwell, J. W., 1954, Surface structure of western Stark County and adjacent areas of North Dakota: North Dakota Geol. Survey Rept. Inv. 14.

* indicates source data that apply to all of western North Dakota.

No. on pl. 30

7 Collier, A. J., 1918, The Nesson anticline, Williams County, North Dakota: U.S. Geol. Survey Bull. 691–G, p. 211–217.

8 Dingman, R. J., and Gordan, E. D., 1952, Geology and ground-water resources of the Fort Berthold Indian Reservation, North Dakota; with a section on the chemical quality of the ground water by H. A. Swenson: U.S. Geol. Survey open-file report, 196 p.

9 Dobbin, C. E., and Larsen, R. M., 1934, Geologic and structure-contour map of the southern half of the Cedar Creek anticline, Fallon County, Montana, and Bowman County, North Dakota: U.S. Geol. Survey.

** Fisher, S. P., 1952, The geology of Emmons County, North Dakota: North Dakota Geol. Survey Bull. 26, 47 p.

10 ——— 1953, Geology of west central McKenzie County, North Dakota: North Dakota Geol. Survey Rept. Inv. 11.

11 ——— 1954, Structural geology of the Skaar-Trotters area, McKenzie and Golden Valley Counties, North Dakota: North Dakota Geol. Survey Rept. Inv. 15.

12 Hancock, E. T., 1921, New Salem lignite field, Morton County, North Dakota: U.S. Geol. Survey Bull. 726, p. 1–39.

** Hansen, Miller, 1954, Structural interpretations in southwestern North Dakota, *in* North Dakota Geol. Soc., Guidebook Southwestern North Dakota Field Conf.: p. 16–17.

13 Hanson, B. M., 1955, Geology of the Elkhorn Ranch area, Billings and Golden Valley Counties, North Dakota: North Dakota Geol. Survey Rept. Inv. 18.

14 Hares, C. J., 1928, Geology and lignite resources of the Marmarth field, southwestern North Dakota: U.S. Geol. Survey Bull. 775, 107 p.

*15 Hennen, R. V., 1943, Tertiary geology and oil and gas prospects in Dakota basin of North Dakota: Am. Assoc. Petroleum Geologists Bull., v. 27, p. 1567–1594.

16 Herald, F. A., 1913, Williston lignite field, Williams County, North Dakota: U.S. Geol. Survey Bull. 531, p. 91–157.

17 Johnson, W. D., Jr., and Kunkel, R. P., 1954, Geologic map of the Square Buttes district, Oliver and Mercer Counties, North Dakota: U.S. Geol. Survey Oil and Gas Inv. Map OM–148.

** Kohanowski, N. N., 1951, Geomagnetic survey of Rolette and Towner Counties, North Dakota: North Dakota Geol. Survey Rept. Inv. 6, 4 p.

*18 Kunkel, R. P., 1954, Structure contour map of the base of Mississippian rocks in the Williston basin and adjoining areas of Montana, North Dakota, South Dakota, and Wyoming: U.S. Geol. Survey Oil and Gas Inv. Map OM–165.

*19 Laird, W. M., 1944, Stratigraphy and structure of North Dakota: North Dakota Geol. Survey Bull. 18, 11 p.

*20 ——— 1949, Stratigraphy of North Dakota with reference to oil possibilities: North Dakota Geol. Survey Rept. Inv. 2.

*21 ——— 1952, The Williston basin, North Dakota: Oil in Canada, v. 4, no. 20, p. 18–30.

* Indicates source data that apply to all of western North Dakota.
** Indicate source data obtained from text only.

No. on pl. 30

22 Laird, W. M., and Mitchell, R. H., 1942, The geology of the southern part of Morton County, North Dakota: North Dakota Geol. Survey Bull. 14, 42 p.

23 Leonard, A. G., and Eaton, H. N., 1925, Divide and Burke Counties, *in* Leonard, A. G., Babcock, E. J., and Dove, L. P., The lignite deposits of North Dakota: North Dakota Geol. Survey Bull. 4, 240 p.

24 Leonard, A. G., and Smith, C. D., 1909, Sentinel Butte lignite field, North Dakota and Montana: U.S. Geol. Survey Bull. 341, p. 15–35.

25 Lloyd, E. R., 1914, Cannonball River lignite field, North Dakota: U.S. Geol. Survey Bull. 541, p. 243–291.

*26 Lyons, P. L., 1950, A gravity map of the United States: Tulsa Geol. Soc. Digest, v. 18, p. 33–43.

27 Meldahl, E. G., 1956, The geology of the Grassy Butte area, McKenzie County, North Dakota: North Dakota Geol. Survey Rept. Inv. 26.

28 Nevin, C. N., 1946, The Keene dome, northeast McKenzie County, North Dakota: North Dakota Geol. Survey Bull. 21, pt. 1, p. 1–10.

29 Pishel, M. A., 1912, Lignite in the Fort Berthold Indian Reservation, North Dakota, north of Missouri River: U.S. Geol. Survey Bull. 471, p. 170–186.

30 Roth, K. W., 1954, Fryburg field, Billings County, North Dakota, *in* North Dakota Geol. Soc., Guidebook Southwestern North Dakota Field Conf.: p. 22–24.

31 Smith, C. D., 1910, Fort Berthold Indian Reservation lignite field, North Dakota: U.S. Geol. Survey Bull. 381, p. 30–39.

32 Tisdale, E. E., 1941, The geology of the Heart Butte quadrangle: North Dakota Geol. Survey Bull. 13, 32 p.

33 Townsend, R. C., 1950, Deformation of Fort Union near Lignite, North Dakota: Am. Assoc. Petroleum Geologists Bull., v. 34, p. 1552–1564.

34 ——— 1954, Geology of the Portal quadrangle, North Dakota: U.S. Geol. Survey Geol. Quad. Map GQ–47.

35 Townsend, R. C., and Jenke, A. L., 1951, The problem of the origin of the Max moraine of North Dakota and Canada: Am. Jour. Sci., v. 249, p. 842–858.

* indicates source data that apply to all of western North Dakota.

WESTERN SOUTH DAKOTA

No. on pl. 31

1 Balk, Robert, 1931, Inclusions and foliation of the Harney Peak granite, Black Hills, South Dakota: Jour. Geology, v. 39, p. 736–748.

2 Bell, Henry, and Bales, W. E., 1955, Uranium deposits in Fall River County, South Dakota: U.S. Geol. Survey Bull. 1009–G, p. 211–233.

3 Berg, R. J., 1946, Pre-Cambrian geology of the Galena-Roubaix district, Black Hills, South Dakota: South Dakota Geol. Survey Rept. Inv. 52, 50 p.

*4 Blackstone, D. L., Jr., 1954, written communication.

5 Braddock, W. A., 1954, written communication.

6 Darton, N. H., 1902, Description of the Oelrichs quadrangle [South Dakota-Nebraska]: U.S. Geol. Survey Geol. Atlas, Folio 85, 6 p.

* indicates source data that apply to all of western South Dakota.

No. on pl. 31

7 Darton, N. H., 1904, Description of the Newcastle quadrangle [Wyoming-South Dakota]: U.S. Geol. Survey Geol. Atlas, Folio 107, 9 p.

8 ——— 1905, Description of the Sundance quadrangle [Wyoming-South Dakota]: U.S. Geol. Survey Geol. Atlas, Folio 127, 12 p.

9 ——— 1918, The structure of parts of the central Great Plains: U.S. Geol. Survey Bull. 691–A, 26 p.

10 ——— 1918, Artesian waters in the vicinity of the Black Hills, South Dakota: U.S. Geol. Survey Water-Supply Paper 428, 64 p.

11 ——— 1919, Description of the Newell quadrangle, South Dakota: U.S. Geol. Survey Geol. Atlas, Folio 209, 7 p.

*12 ——— 1951, Geologic map of South Dakota: U.S. Geol. Survey.

13 Darton, N. H., and O'Harra, C. C., 1909, Description of the Belle Fourche quadrangle, South Dakota: U.S. Geol. Survey Geol. Atlas, Folio 164, 9 p.

14 Darton, N. H., and Paige, Sydney, 1925, Description of the central Black Hills: U.S. Geol. Survey Geol. Atlas, Folio 219, 34 p.

15 Denson, N. M., Bachman, G. O., and Zeller, H. D., 1955, Geologic map of the Slim Buttes area, Harding County, South Dakota: U.S. Geol. Survey Coal Inv. Map C–35.

16 Gill, J. R., 1954, written communication.

17 ——— 1955, Geologic map of Reva Gap area, Slim Buttes, Harding County, South Dakota, *in* Geologic investigations of radioactive deposits—Semiannual progress report, Dec. 1, 1954, to May 31, 1955: U.S. Geol. Survey TEI–540, p. 157, issued by U.S. Atomic Energy Comm. Tech. Inf. Service Ext., Oak Ridge, Tenn.

18 Gill, J. R., and Denson, N. M., 1955, Lignite investigations; regional synthesis, eastern Montana and North and South Dakota, *in* Geologic investigations of radioactive deposits—Semiannual progress report, June 1 to Nov. 30, 1955: U.S. Geol. Survey TEI–590, p. 233–240, isued by U.S. Atomic Energy Comm. Tech. Inf. Service Ext., Oak Ridge, Tenn.

** Gill, J. R., and Moore, G. W., 1955, Carnotite-bearing sandstone in Cedar Canyon, Slim Buttes, Harding County, South Dakota: U.S. Geol. Survey Bull. 1009–I, p. 249–264.

** Gries, J. P., 1940, A structural survey of northeastern Stanley County, South Dakota: South Dakota Geol. Survey Rept. Inv. 34, 52 p.

19 Irving, J. D., and Emmons, S. F., 1904, Economic resources of the northern Black Hills, Part 2, Mining geology: U.S. Geol. Survey Prof. Paper 26, p. 43–215.

20 Kepferle, R. C., 1954, Geology of a portion of the White River Badlands, Pennington County, South Dakota: M.A. thesis, South Dakota School Mines and Technology.

21 Kepferle, R. C., and Chisholm, W. A., 1955, Lignite investigations, Cave Hills, Harding County, South Dakota, *in* Geologic investigations of radioactive deposits—Semiannual progress report, June 1 to Nov. 30, 1955: U.S. Geol. Survey TEI–590, p. 240–247, issued by U.S. Atomic Energy Comm. Tech. Inf. Service Ext., Oak Ridge, Tenn.

* indicates source data that apply to all of western South Dakota.
** indicate source data obtained from text only.

No. on pl. 31

22 Knechtel, M. M., and Patterson, S. H., 1955, Bentonite deposits of the northern Black Hills district, Montana, Wyoming, and South Dakota: U.S. Geol. Survey Mineral Inv. Field Studies Map MF-36.

23 Kunkel, R. P., 1954, Structure contour map of the base of Mississippian rocks in the Williston basin and adjoining areas of Montana, North Dakota, South Dakota, and Wyoming: U.S. Geol. Survey Oil and Gas Inv. Map OM-165.

24 Kupfer, D. H., and Langen, R. E., 1949, written communication.

25 Lang, A. J., Jr., and Redden, J. A., 1953, Geology and pegmatites of part of the Fourmile area, Custer County, South Dakota: U.S. Geol. Survey Circ. 245, 20 p.

26 Moore, G. W., and Gill, J. R., 1955, Geologic map of the southern part of the Slim Buttes area, Harding County, South Dakota: U.S. Geol. Survey Coal Inv. Map C-36.

27 Morgan, R. E., and Petsch, B. C., 1945, A geological survey in Dewey and Corson Counties, South Dakota: South Dakota Geol. Survey Rept. Inv. 49, 53 p.

28 Moulton, G. F., 1923, Oil and gas prospects in southern Perkins County: South Dakota Geol. Nat. Hist. Survey Circ. 14, 12 p.

29 Noble, J. A., 1947, written communication.

30 ——— 1952, Structural features of the Black Hills and adjacent areas developed since Precambrian time, *in* Billings Geol. Soc., Guidebook 3d Ann. Field Conf., Black Hills-Williston basin, 1952: p. 31–37.

31 Norton, J. J., 1956, written communication.

32 Paige, Sydney, 1924, Geology of the region around Lead, South Dakota, and its bearing on the Homestake ore body: U.S. Geol. Survey Bull. 765, 58 p.

*33 Petsch, B. C., 1955, Structure map, State of South Dakota: Rocky Mountain Oil Reporter, v. 12, p. 17.

*34 ——— 1955, Map of Precambrian surface, the State of South Dakota: Rocky Mountain Oil Reporter, v. 12, p. 18.

35 Petsch, B. C., and Carlson, L. A., 1950, Magnetic observations in South Dakota: South Dakota Geol. Survey Rept. Inv. 66, 35 p.

36 Redden, J. A., 1956, written communication.

37 Rothrock, E. P., 1930, The Fairburn structure: South Dakota Geol. Survey Rept. Inv. 6, 12 p. (1950 revisions).

38 ——— 1931, The Cascade anticline: South Dakota Geol. Survey Rept. Inv. 8, 19 p.

39 ——— 1931, The Chilson anticline: South Dakota Geol. Survey Rept. Inv. 9, 2d ed., 26 p.

40 ——— 1937, Structural conditions in Harding County [South Dakota]: South Dakota Geol. Survey Rept. Inv. 28, 30 p.; repr. 1946.

41 Rothrock, E. P., and Robinson, T. R., 1936, Artesian conditions in west-central South Dakota: South Dakota Geol. Survey Rept. Inv. 26, 92 p.

42 Runner, J. J., 1934, Pre-Cambrian Geology of the Nemo district, Black Hills, South Dakota: Am. Jour. Sci., 5th ser., v. 28, p. 353–372.

43 ——— 1943, Structure and origin of Black Hills pre-Cambrian granite domes: Jour. Geology, v. 51, p. 431–457.

* Indicates source data that apply to all of western South Dakota.

No. on pl. 31

44 Russell, W. L., 1925, The possibilities of oil in western Ziebach County: South Dakota Geol. Nat. Hist. Survey Circ. 20, 25 p.

45 ——— 1926, The possibilities of oil in western Corson County: South Dakota Geol. Nat. Hist. Survey Circ. 27, 18 p.

46 ——— 1926, Structures in western Haakon and eastern Pennington Counties: South Dakota Geol. Nat. Hist. Survey Circ. 28, 24 p.

47 Smith, K. G., 1952, Structure plan of clastic dikes: Am. Geophys. Union Trans., v. 33, p. 889–892.

48 Smith, W. C., and Page, L. R., 1941, Tin-bearing pegmatites of the Tinton district, Lawrence County, South Dakota: U.S. Geol. Survey Bull. 922–T, p. 595–630.

49 Stevenson, R. E., 1952, Structures and stratigraphy of southwestern Butte County: South Dakota Geol. Survey Rept. Inv. 69, 32 p.

50 Toepelman, W. C., 1923, The possibilities of oil in eastern Harding County: South Dakota Geol. Nat. Hist. Survey Circ. 12, 12 p.

51 Ward, Freeman, 1922, The geology of a portion of the Badlands: South Dakota Geol. Nat. Hist. Survey Bull. 11, 80 p.

52 ——— 1925, Structures in northern Haakon County: South Dakota Geol. Nat. Hist. Survey Circ. 22, 15 p.

*53 ——— 1925, The structure of western South Dakota: South Dakota Geol. Nat. Hist. Survey Circ. 25, 7 p.

54 Ward, Freeman, and Wilson, R. A., 1922, The possibilities of oil in western Dewey County: South Dakota Geol. Nat. Hist. Survey Circ. 9, 10 p.

55 Wilson, R. A., 1922, The possibilities of oil in northern Dewey County: South Dakota Geol. Nat. Hist. Survey Circ. 10, 6 p.

*56 ——— 1923, The bearing of geologic features in South Dakota upon oil possibilities: Am. Assoc. Petroleum Geologists Bull., v. 7, p. 507–516.

57 ——— 1925, Oil and gas possibilities in northeastern Meade County: South Dakota Geol. Nat. Hist. Survey Circ. 23, 14 p.

58 ——— 1925, The Ragged Butte structure [in southwestern Dewey County, South Dakota]: South Dakota Geol. Nat. Hist. Survey Circ. 24, 7 p.

59 Winchester, D. E., 1913, Cross-bedding in the White River formation of northwestern South Dakota: Jour. Geology, v. 21, p. 550–556.

60 Winchester, D. E., Hares, C. J., Lloyd, E. R., and Parks, E. M., 1916, The lignite field of northwestern South Dakota: U.S. Geol. Survey Bull. 627, 169 p.

61 Zeller, H. D., 1955, Geologic map of the Bar H area, Slim Buttes, Harding County, South Dakota: U.S. Geol. Survey Coal Inv. Map C–37.

* indicates source data that apply to all of western South Dakota.

WYOMING, EAST OF THE OVERTHRUST BELT

No. on pl. 32

1 Albanese, John, 1954, Boone dome gas field, *in* Wyoming Geol. Assoc. Guidebook 9th Ann. Field Conf., Casper area, 1954: p. 69–72.

2 Andrews, D. A., 1944, Geologic and structure contour map of the Maverick Springs area, Fremont County, Wyoming: U.S. Geol. Survey Oil and Gas Inv. Prelim. Map 13.

No. on pl. 32

3 Andrews, D. A., Pierce, W. G., and Eargle, D. H., 1947, Geologic map of the Bighorn Basin, Wyoming and Montana, showing terrace deposits and physiographic features: U.S. Geol. Survey Oil and Gas Inv. Prelim. Map 71.

4 Armstrong, F. C., 1948, Preliminary report on the geology of the Atlantic City-South Pass Mining district, Wyoming: U.S. Geol. Survey open-file report, 65 p.

* Bailey, T. F., 1951, Deep Creek-Dad area, Carbon County, Wyoming, *in* Wyoming Geol. Assoc. Guidebook 6th Ann. Field Conf., South-Central Wyoming, 1951: p. 115.

5 Baker, C. L., 1946, Geology of the Northwestern Wind River Mountains, Wyoming: Wyoming Geol. Survey Bull. 35; Geol. Soc. America Bull., v. 57, p. 565–596.

6 Ball, S. H., 1906, The Hartville Iron-ore range, Wyoming: U.S. Geol. Survey Bull. 315, pt. 1, p. 190–205.
Assoc. Guidebook 8th Ann. Field Conf., Laramie Basin, Wyoming, and North Park, Colorado, 1953: p. 147–149.

* Barlow, J. A., Jr., 1953, East Allen Lake dome, *in* Wyoming Geol. Assoc. Guidebook 8th Ann. Field Conf., Laramie Basin, Wyoming, and North Park, Colorado, 1953: p. 147–149.

• 7 ——— 1953, Rex Lake anticline, *in* Wyoming Geol. Assoc. Guidebook 8th Ann. Field Conf., Laramie Basin, Wyoming, and North Park, Colorado, 1953: p. 159–160.

8 ——— 1955, Structure of the Rawlins uplift, Carbon County, Wyoming, *in* Wyoming Geol. Assoc. Guidebook 10th Ann. Field Conf., Green River basin, 1955: p. 138–139.

9 ——— 1955, written communication.

10 Beasley, H. F., 1954, Pine Mountain and West Poison Spider structures, *in* Wyoming Geol. Assoc. Guidebook 9th Ann. Field Conf., Casper area, 1954: p. 64–68.

11 Beckwith, R. H., 1941, Structure of the Elk Mountain district, Carbon County, Wyoming: Geol. Soc. America Bull., v. 52, p. 1445–1486.

12 Beer, William, and Repp, H. E., 1955, Savery anticline, Carbon County, Wyoming, *in* Wyoming Geol. Assoc. Guidebook 10th Ann. Field Conf., Green River basin, 1955: p. 165–167.

13 Bell, W. G., 1955, The geology of the southeastern flank of the Wind River Mountains, Fremont County, Wyoming: Ph.D. dissertation, Wyoming Univ., 204 p.

14 Berry, R. G., Jr., 1952, The geology of the Bonanza pool, Big Horn County, Wyoming, *in* Wyoming Geol. Assoc. Guidebook 7th Ann. Field Conf., Southern Big Horn Basin, Wyoming, 1952: p. 120–122.

15 Berta, J. Q., 1951, The Hanna coal field, *in* Wyoming Geol. Assoc. Guidebook 6th Ann. Field Conf., South-Central Wyoming, 1951: p. 88–91.

16 Blackstone, D. L., Jr., 1948, Tectonic map of Wind River Basin, Wyoming, *in* Wyoming Geol. Assoc. Guidebook 3d Ann. Field Conf., Wind River Basin, Wyoming, 1948: p. 71.

17 ——— 1951, Tectonic map of south-central Wyoming, *in* Wyoming Geol. Assoc. Guidebook 6th Ann. Field Conf., South-Central Wyoming, 1951: pl. 4, in pocket.

18 ——— 1953, Tectonic map of portions of southern Wyoming and northern Colorado, *in* Wyoming Geol. Assoc. Guidebook 8th Ann. Field Conf., Laramie Basin, Wyoming, and North Park, Colorado, 1953.

*indicates source data obtained from text only.

No. on pl. 32

19 Blackstone, D. L., Jr., 1954, written communication.

20 ——— 1955, Tectonic map of parts of southwestern Wyoming and adjoining States, *in* Wyoming Geol. Assoc. Guidebook 10th Ann. Field Conf., Green River basin, 1955.

21 Bogrett, J. W., 1954, Geologic map and structure sections of the northwestern end of the Rattlesnake Hills, Natrona County, Wyoming, *in* Wyoming Geol. Assoc. Guidebook 9th Ann. Field Conf., Casper area, 1954, in pocket.

22 Bradley, W. H., 1945, Geology of the Washakie basin, Sweetwater and Carbon Counties, Wyoming, and Moffat County, Colorado: U.S. Geol. Survey Oil and Gas Inv. Prelim. Map 32.

23 ——— 1955, written communication.

24 Brady, F. H., 1952, written communication.

25 Brady, F. H., and Elmgren, C. B., 1948, written communication.

26 ——— 1949, written communication.

27 ——— 1949, written communication.

28 ——— 1949, written communication.

29 Carey, B. D., Jr., 1954, A brief sketch of the geology of the Rattlesnake Hills, *in* Wyoming Geol. Assoc. Guidebook 9th Ann. Field Conf., Casper area, 1954: p. 32–36.

30 Christensen, H. E., and Marshall, John, 1950, La Barge field, Sublette and Lincoln Counties, Wyoming, *in* Wyoming Geol. Assoc. Guidebook 5th Ann. Field Conf., Southwest Wyoming, 1950: p. 105–108.

31 Cochran, K. L., and Bertagnolli, A. J., 1950, Surface geologic map, old and new Aspen-Altamont tunnels, Uinta County, Wyoming, *in* Wyoming Geol. Assoc. Guidebook 5th Ann. Field Conf., Southwest Wyoming, 1950: p. [120].

* Coffin, R. C., 1946, Recent trends in geological-geophysical exploration: Am. Assoc. Petroleum Geologists Bull., v. 30, p. 2013–2033.

32 Curry, W. H., 1954, The South Glenrock oil field, *in* Wyoming Geol. Assoc. Guidebook 9th Ann. Field Conf., Casper area, 1954: p. 49–53.

33 Curry, W. H., Jr., and Curry, W. H., 3d, 1954, South Glenrock, a Wyoming stratigraphic oil field: Am. Assoc. Petroleum Geologists Bull., v. 38, p. 2119–2156.

34 Curtis, B. F., 1950, Structure of the north flank of the Uinta Mountains, *in* Wyoming Geol. Assoc. Guidebook 5th Ann. Field Conf., Southwest Wyoming, 1950: p. 93–94 and map.

35 Darton, N. H., 1905, Description of the Sundance quadrangle: U.S. Geol. Survey Geol. Atlas, Folio 127, 12 p.

36 Darton, N. H., and O'Harra, C. C., 1905, Description of the Aladdin quadrangle: U.S. Geol. Survey Geol. Atlas, Folio 125, 8 p.

37 DeChadenedes, J. F., 1953, Dutton Creek and Cooper Cove fields, Carbon and Albany Counties, Wyoming, *in* Wyoming Geol. Assoc. Guidebook 8th Ann. Field Conf., Laramie Basin, Wyoming, and North Park, Colorado, 1953: p. 144–146.

38 Denson, N. M., and Botinelly, Theodore, 1949, Geology of the Hartville uplift, eastern Wyoming: U.S. Geol. Survey Oil and Gas Inv. Prelim. Map 102.

39 Dobbin, C. E., 1955, written communication.

40 ——— 1955, written communication.

* indicates source data obtained from text only.

No. on pl. 32

41 Dobbin, C. E., and Horn, G. H., 1949, Geology of the Mush Creek and Osage oil fields and vicinity, Weston County, Wyoming: U.S. Geol. Survey Oil and Gas Inv. Prelim. Map 103.

42 Eardley, A. J., 1950, Snake River region of western Wyoming, *in* Wyoming Geol. Assoc. Guidebook 5th Ann. Field Conf., Southwest Wyoming, 1950: p. 88–92.

43 Espach, R. H., and Biggs, Paul, 1953, The Rock River oil field, *in* Wyoming Geol. Assoc. Guidebook 8th Ann. Field Conf., Laramie Basin, Wyoming, and North Park, Colorado, 1953: p. 161–164.

44 Fenwick, W. H., 1949, A discussion of the application of the gravitational and magnetic methods of exploration to the Powder River Basin, *in* Wyoming Geol. Assoc. Guidebook 4th Ann. Field Conf., Powder River Basin, 1949: p. 53–62.

45 Fidlar, M. M., 1950, Structural features of the Green River Basin, *in* Wyoming Geol. Assoc. Guidebook 5th Ann. Field Conf., Southwest Wyoming, 1950: p. 86–87.

46 ——— 1950, Church Buttes gas field, Sweetwater and Uinta Counties, Wyoming, *in* Wyoming Geol. Assoc. Guidebook 5th Ann. Field Conf., Southwest Wyoming, 1950: p. 111–113.

47 ——— 1950, Baxter Basin gas fields, Sweetwater County, Wyoming, *in* Wyoming Geol. Assoc. Guidebook 5th Ann. Field Conf., Southwest Wyoming, 1950: p. 109–110.

48 Gras, V. B., 1955, Vermillion Creek basin area, Sweetwater County, Wyoming, and Moffat County, Colorado, *in* Wyoming Geol. Assoc. Guidebook 10th Ann. Field Conf., Green River basin, 1955: p. 177–181.

49 Hagner, A. F., 1953, Mineral deposits of the Laramie Range, Wyoming, *in* Wyoming Geol. Assoc. Guidebook 8th Ann. Field Conf., Laramie Basin, Wyoming, and North Park, Colorado, 1953: p. 111–118.

50 Hale, L. A., 1950, Geologic map, Rock Springs uplift, Wyoming; geology by A. R. Schultz and J. D. Sears, *in* Wyoming Geol. Assoc. Guidebook 5th Ann. Field Conf., Southwest Wyoming, 1950, in pocket.

51 Hares, C. J., and others, 1946, Geologic map of the southeastern part of the Wind River Basin and adjacent areas in central Wyoming: U.S. Geol. Survey Oil and Gas Inv. Prelim. Map 51.

52 ——— 1946, Geologic map of the southern part of the Wind River Basin and adjacent areas in central Wyoming: U.S. Geol. Survey Oil and Gas Inv. Prelim. Map 60.

53 Harris, L. E., 1952, Sand Creek field, Washakie County, Wyoming, *in* Wyoming Geol. Assoc. Guidebook 7th Ann. Field Conf., Southern Big Horn Basin, Wyoming, 1952: p. 123–125.

54 ——— 1952, Slick Creek oil field, Washakie County, Wyoming, *in* Wyoming Geol. Assoc. Guidebook 7th Ann. Field Conf., Southern Big Horn Basin, Wyoming, 1952: p. 114–116.

55 Hart, L. T., and McCulloch, J. C., 1950, Idealized N.W.–S.E. cross section through Little Round Mounain well, *in* Wyoming Geol. Assoc. Guidebook 5th Ann. Field Conf., Southwest Wyoming, 1950: p. [119].

56 Heissey, E. L., 1951, Geology of the Ferris Mountains-Muddy Gap area, *in* Wyoming Geol. Assoc. Guidebook 6th Ann. Field Conf., South-Central Wyoming, 1951: p. 71–76.

No. on pl. 32

57 Horn, G. H., 1955, Geologic and structure map of the Sussex and Meadow Creek oil fields and vicinity, Johnson and Natrona Counties, Wyoming: U.S. Geol. Survey Oil and Gas Inv. Map OM-164.

58 Horn, G. H., and Alliger, Jerald, 1947, Geologic and structure contour map of the Mush Creek area, Weston County, Wyoming: U.S. Geol. Survey.

59 Hose, R. K., 1954, Geology of the Crazy Woman Creek area, Johnson County, Wyoming: U.S. Geol. Survey Oil and Gas Inv. Map OM-142.

60 ——— 1955, Geology of the Crazy Woman Creek area, Johnson County, Wyoming: U.S. Geol. Survey Bull. 1027-B, 118 p.

61 House, Eldon, 1955, Salt Wells gas field, Sweetwater County, Wyoming, *in* Wyoming Geol. Assoc. Guidebook 10th Ann. Field Conf., Green River basin, 1955: p. 161-164.

62 Howe, R. A., 1955, Tip Top field, Wyoming, *in* Wyoming Geol. Assoc. Guidebook 10th Ann. Field Conf., Green River basin, 1955: p. 172-176.

63 Hubley, M. D., 1948, The Beaver Creek field, Fremont County, Wyoming, *in* Wyoming Geol. Assoc. Guidebook 3d Ann. Field Conf., Wind River Basin, Wyoming, 1948: p. 160-165.

64 Hunter, W. S., Jr., 1950, The Kemmerer coal field, *in* Wyoming Geol. Assoc. Guidebook 5th Ann. Field Conf., Southwest Wyoming, 1950: p. 123-132.

65 Jenkins, C. E., 1951, Grenville dome, Carbon County, Wyoming, *in* Wyoming Geol. Assoc. Guidebook 6th Ann. Field Conf., South-Central Wyoming, 1951: p. 58-59.

66 ——— 1955, Pinedale anticline, Sublette County, Wyoming, *in* Wyoming Geol. Assoc, Guidebook 10th Ann. Field Conf., Green River basin, 1955: p. 155-156.

67 Keefer, W. R., 1955, Geologic map of the Du Noir area, Fremont County, Wyoming: U.S. Geol. Survey Oil and Gas Inv. Map OM-166.

68 ——— 1955, written communication.

69 Ketterer, W. P., and Swirczynski, R. P., 1952, Preliminary lithofacies study of Phosphoria formation, Big Horn Basin, Wyoming, *in* Wyoming Geol. Assoc. Guidebook 7th Ann. Field Conf., Southern Big Horn Basin, Wyoming, 1952: p. 53-54.

70 Knechtel, M. M., and Patterson, S. H., 1955, Bentonite deposits of the northern Black Hills district, Montana, Wyoming, and South Dakota: U.S. Geol. Survey Mineral Inv. Field Studies Map MF-36.

71 Knight, S. H., 1951, The Late Cretaceous-Tertiary history of the northern portion of the Hanna basin, Carbon County, Wyoming, *in* Wyoming Geol. Assoc. Guidebook 6th Ann. Field Conf., South-Central Wyoming, 1951: p. 45-53.

72 ——— 1953, Summary of the Cenozoic history of the Medicine Bow Mountains, Wyoming, *in* Wyoming Geol. Assoc. Guidebook 8th Ann. Field Conf., Laramie Basin, Wyoming, and North Park, Colorado, 1953: p. 65-76.

73 Kramer, W. B., Cattermole, J. M., and Curtis, B. F., 1943, Geologic map and sections of the Oregon Basin anticline, Park County, Wyoming: U.S. Geol. Survey.

No. on pl. 32

74 Krampert, E. W., 1948, The Lander-Hudson oil field, Fremont County, Wyoming, *in* Wyoming Geol. Assoc. Guidebook 3d Ann. Field Conf., Wind River Basin, Wyoming, 1948: p. 148–152.

75 ——— 1948, Dallas field, Fremont County, Wyoming, *in* Wyoming Geol. Assoc. Guidebook 3d Ann. Field Conf., Wind River Basin, Wyoming, 1948: p. 153–155.

* ——— 1951, Bunker Hill field, *in* Wyoming Geol. Assoc. Guidebook 6th Ann. Field Conf., South-Central Wyoming, 1951: p. 117.

76 Krueger, M. L., 1955, Preliminary geological report, Big Piney gas field, Sublette County, Wyoming, *in* Wyoming Geol. Assoc. Guidebook 10th Ann. Field Conf., Green River basin, 1955: p. 142–144.

77 Larson, T. G., and Vieux, D. G., 1951, Miller Hill area, Carbon County, Wyoming, *in* Wyoming Geol. Assoc. Guidebook 6th Ann. Field Conf., South-Central Wyoming, 1951: p. 124–125.

78 Lawson, D. E., 1954, Poison Spider field, *in* Wyoming Geol. Assoc. Guidebook 9th Ann. Field Conf., Casper area, 1954: p. 77–79.

79 Love, J. D., 1953, Preliminary report on uranium deposits in the Miller Hill area, Carbon County, Wyoming: U.S. Geol. Survey Circ. 278, 10 p.

80 Love, J. D., Denson, N. M., and Botinelly, Theodore, 1949, Geology of the Glendo area, Wyoming: U.S. Geol. Survey Oil and Gas Inv. Prelim. Map 92.

81 Love, J. D., Keefer, W. R., Duncan, D. C., Berquist, H. R., and Hose, R. K., 1951, Geologic map of the Spread Creek-Gros Ventre River area, Teton County, Wyoming: U.S. Geol. Survey Oil and Gas Inv. Map OM–118, fig. 6, Tectonic map of Teton County and adjacent areas.

82 Love, J. D., and Weitz, J. L., 1951, Geologic map of the Powder River Basin and adjacent areas, Wyoming: U.S. Geol. Survey Oil and Gas Inv. Map OM–122.

83 ——— 1953, Geologic map of Albany County, Wyoming: Geol. Survey Wyoming.

** Love, J. D., Weitz, J. L., and Hose, R. K., 1955, Geologic map of Wyoming: U.S. Geol. Survey.

84 McCabe, W. S., and Walker, C. L., 1948, Winkleman dome, Fremont County, Wyoming, *in* Wyoming Geol. Assoc. Guidebook 3d Ann. Field Conf., Wind River Basin, Wyoming, 1948: p. 167–173.

85 McCanne, R. W., 1947, Grass Creek oil field, Hot Springs County, Wyoming, *in* Wyoming Univ., Wyoming Geol. Assoc., Yellowstone-Bighorn Research Assoc. Guidebook [2d Ann.] Field Conf., Bighorn Basin, 1947: p. 223–228.

86 ——— 1949, Structural map of Lance Creek-East Lance Creek-Little Buck Creek, Niobrara County, Wyoming, *in* Wyoming Geol. Assoc. Guidebook 4th Ann. Field Conf., Powder River Basin, 1949: facing p. 85.

* McCoy, J. H., 1951, The Mahoney-Ferris oil and gas fields, *in* Wyoming Geol. Assoc. Guidebook 6th Ann. Field Conf., South-Central Wyoming, 1951: p. 118.

87 McDonald, R. E., 1955, Morrow Creek unit, Sweetwater County, Wyoming, *in* Wyoming Geol. Assoc. Guidebook 10th Ann. Field Conf., Green River basin, 1955: p. 150–152.

* Indicates source data obtained from text only.
** Indicates source data that apply to all of Wyoming.

No. on
pl. 32

**88 McGrew, L. W., 1955, Map of Wyoming showing test wells for oil and gas, anticlines, oil and gas fields, and pipelines: U.S. Geol. Survey Oil and Gas Inv. Map OM–175.

89 McGrew, P. O., and Berman, J. E., 1955, Geology of the Tabernacle Butte area, Sublette County, Wyoming, *in* Wyoming Geol. Assoc. Guidebook 10th Ann. Field Conf., Green River basin, 1955: p. 108–111.

90 Mapel, W. J., 1954, Geology and coal resources of the Lake De Smet area, Johnson County, Wyoming: U.S. Geol. Survey Coal Inv. Map C–23.

91 Masursky, Harold, 1949–50, Geology of the western Owl Creek Mountains, *in* Wyoming Geol. Assoc. Guidebook 7th Ann. Field Conf., Southern Big Horn Basin, Wyoming, 1952, in pocket.

92 Mazzola, J. R., and Pederson, S. L., 1955, Structure contour map of Church Buttes gas field, Uinta and Sweetwater Counties, Wyoming, *in* Wyoming Geol. Assoc. Guidebook 10th Ann. Field Conf., Green River basin, 1955: p. 145.

93 Mees, E. C., and Bowers, G. F., 1952, Gebo field, Hot Springs County, Wyoming, *in* Wyoming Geol. Assoc. Guidebook 7th Ann. Field Conf., Southern Big Horn Basin, Wyoming, 1952: p. 110–113.

94 Montagne, John de la, 1953, Late Tertiary normal faults along the east flank of the Park Range, Wyoming and Colorado, *in* Wyoming Geol. Assoc. Guidebook 8th Ann. Field Conf., Laramie Basin, Wyoming, and North Park, Colorado, 1953: p. 103–105.

95 Murphy, J. H., 1955, written communication.

96 Murphy, J. H., and Roberts, R. W., 1954, Geology of the Steamboat Butte-Pilot Butte area, Fremont County, Wyoming: U.S. Geol. Survey Oil and Gas Inv. Map OM–151.

97 Murray, H. F., 1954, written communication.

98 Nace, R. L., 1939, Geology of the northwest part of the Red Desert, Sweetwater and Fremont Counties, Wyoming: Wyoming Geol. Survey Bull. 27, 48 p.

99 Newhouse, W. H., and Hagner, A. F., 1955, written communication.

100 Noble, J. A., 1947, written communication.

101 Olson, R. B., 1955, Middle Mountain field, Sweetwater County, Wyoming, *in* Wyoming Geol. Assoc. Guidebook 10th Ann. Field Conf., Green River basin, 1955: p. 148–149.

102 Olson, W. G., 1948, Circle Ridge and Maverick Springs oil fields, Fremont County, Wyoming, *in* Wyoming Geol. Assoc. Guidebook 3d Ann. Field Conf., Wind River Basin, Wyoming, 1948: p. 178–184.

103 ——— 1949, Big Muddy field, *in* Wyoming Geol. Assoc. Guidebook 4th Ann. Field Conf., Powder River Basin, 1949: p. 87–88.

104 Osterwald, F. W., 1946, Wyoming Geol. Survey open-file map.

105 ——— 1949, Structure of the Tongue River area, Bighorn Mountains, Wyoming, *in* Wyoming Geol. Assoc. Guidebook 4th Ann. Field Conf., Powder River Basin, 1949: p. 37–39.

106 ——— 1956, Relation of tectonic elements in Precambrian rocks to uranium deposits in the Cordilleran foreland of the Western United States: U.S. Geol. Survey Prof. Paper 300, p. 329–335.

107 ——— 1959, Structure and petrology of the northern Bighorn Mountains, Wyoming: Wyoming Geol. Survey Bull. 48, 47 p.

** indicate source data that apply to all of Wyoming.

No. on pl. 32

* Osterwald, F. W., and Osterwald, D. B., 1952, Wyoming mineral resources: Wyoming Geol. Survey Bull. 45, 215 p.

108 Pierce, W. G., 1948, Geologic and structure contour map of the Basin-Greybull area, Big Horn County, Wyoming: U.S. Geol. Survey Oil and Gas Inv. Prelim. Map 77.

109 Pierce, W. G., and Andrews, D. A., 1941, Geology and oil and coal resources of the region south of Cody, Park County, Wyoming: U.S. Geol. Survey Bull. 921-B, 180 p.

110 Pierce, W. G., Andrews, D. A., and Keroher, J. K., 1947, Structure contour map of the Big Horn Basin, Wyoming and Montana: U.S. Geol. Survey Oil and Gas Inv. Prelim. Map 74.

111 Pierce, W. G., and Girard, R. M., 1952, Structure contour map of the Powder River Basin, Wyoming and Montana: U.S. Geol. Survey Oil and Gas Inv. Map OM-133; revised by A. D. Zapp, 1951, from map published in 1945.

112 Pipiringos, G. N., 1956, Uranium-bearing coal in the central part of the Great Divide Basin, Sweetwater County, Wyoming: U.S. Geol. Survey TEI-477, 124 p., open-file report.

113 Pipiringos, G. N., and Masursky, Harold, 1955, written communication.

114 Post, J. D., 1955, The geology of the east Washakie basin, *in* Wyoming Geol. Assoc. Guidebook 10th Ann. Field Conf., Green River basin, 1955: p. 182–185.

115 Pott, R. L., and DeVore, S. F., 1951, The Lost Soldier field, Sweetwater County, Wyoming, *in* Wyoming Geol. Assoc. Guidebook 6th Ann. Field Conf., South-Central Wyoming, 1951: p. 103–107.

116 Redman, L. E., 1954, The Notches oil field, *in* Wyoming Geol. Assoc. Guidebook 9th Ann. Field Conf., Casper area, 1954: p. 73–75.

117 Richmond, G. M., 1945, Geology of northwest end of the Wind River Mountains, Sublette County, Wyoming: U.S. Geol. Survey Oil and Gas Inv. Prelim. Map 31.

118 Robinson, C. S., Mapel, W. J., and Bergendahl, M. H., 1955, written communication.

119 Rogers, C. P., Richards, P. W., Conant, L. C., Vine, J. D., and Notley, D. F., 1948, Geology of the Worland-Hyattville area, Big Horn and Washakie Counties, Wyoming: U.S. Geol. Survey Oil and Gas Inv. Prelim. Map 84.

120 Schultz, A. R., 1920, Oil possibilities in and around Baxter Basin, in the Rock Springs uplift, Sweetwater County, Wyoming: U.S. Geol. Survey Bull. 702, 107 p.

121 Sears, J. D., 1924, Relations of the Browns Park formation and the Bishop conglomerate, and their role in the origin of Green and Yampa Rivers: Geol. Soc. America Bull., v. 35, p. 279–304.

122 Sears, J. D., and Bradley, W. H., 1925, Relations between the Wasatch and Green River formations in northwestern Colorado and southern Wyoming, with notes on oil shale in the Green River formation: U.S. Geol. Survey Prof. Paper 132, p. 93–107.

123 Sears, W. A., and Sims, F. C., 1954, Structural geology of the Casper Mountain area, *in* Wyoming Geol. Assoc. Guidebook 9th Ann. Field Conf., Casper area, 1954: p. 27–31.

* Indicates source data obtained from text only.

No. on pl. 32

124 Sharkey, H. H. R., Zapp, A. D., and Johnson, C. O., 1946, Geologic and structure contour map of Sage Creek dome, Fremont County, Wyoming: U.S. Geol. Survey Oil and Gas Inv. Prelim. Map 53.

125 Sharp, W. N., 1956, written communication.

126 Stephens, J. G., and Bergin, M. J., 1955, written communication.

127 Stiteler, C. C., 1954, Emigrant Gap anticline, *in* Wyoming Geol. Assoc. Guidebook 9th Ann. Field Conf., Casper area, 1954: p. 58–63.

128 Summerford, H. E., 1948, Résumé of the oil and gas structures immediately adjacent to the southeastern margin of the Wind River Basin, *in* Wyoming Geol. Assoc. Guidebook 3d Ann. Field Conf., Wind River Basin, 1948: p. 186–194.

129 ——— 1952, Hamilton dome field, Hot Springs County, Wyoming, *in* Wyoming Geol. Assoc. Guidebook 7th Ann. Field Conf., Southern Big Horn Basin, Wyoming, 1952: p. 101.

130 ——— 1952, Murphy dome field, Hot Springs County, Wyoming, *in* Wyoming Geol. Assoc. Guidebook 7th Ann. Field Conf., Southern Big Horn Basin, Wyoming, 1952: p. 100.

131 ——— 1952, Lake Creek field, Hot Springs County, Wyoming, *in* Wyoming Geol. Assoc. Guidebook 7th Ann. Field Conf., Southern Big Horn Basin, Wyoming, 1952: p. 99.

132 Thompson, R. M., Troyer, M. L., and Pipiringos, G. N., 1950, Geology of the Lander area, central Wyoming: U.S. Geol. Survey Oil and Gas Inv. Map OM–112.

133 Thompson, R. M., and White, V. L., 1954, Geology of the Riverton area, central Wyoming: U.S. Geol. Survey Oil and Gas Inv. Map OM–127.

134 Tourtelot, H. A., 1953, Geology of the Badwater area, central Wyoming: U.S. Geol. Survey Oil and Gas Inv. Map OM–124.

135 Truchot, J. F., Jr., 1954, The South Cole Creek field, *in* Wyoming Geol. Assoc. Guidebook 9th Ann. Field Conf., Casper area, 1954: p. 54–57.

136 Trumbull, L. W., 1913, Atlantic City mining district, Fremont County, Wyoming: Cheyenne, Wyo., Office of State Geologist, published map.

137 Tudor, M. S., 1953, Structural geology of west-central flank of the Laramie Range, *in* Wyoming Geol. Assoc. Guidebook 8th Ann. Field Conf., Laramie Basin, Wyoming, and North Park, Colorado, 1953: p. 101–102.

138 Veronda, G. R., 1951, Summary report on the geology of the Hatfield structure, Carbon County, Wyoming, *in* Wyoming Geol. Assoc. Guidebook 6th Ann. Field Conf., South-Central Wyoming, 1951: p. 100–102.

139 ——— 1951, Summary report on the geology of the Big Medicine Bow field, Carbon County, Wyoming, *in* Wyoming Geol. Assoc. Guidebook 6th Ann. Field Conf., South-Central Wyoming, 1951: p. 97–99.

140 Veronda, G. R., and Crowley, C. J., 1951, Composite geologic map of Separation basin area, Carbon and Sweetwater Counties, Wyoming, *in* Wyoming Geol. Assoc. Guidebook 6th Ann. Field Conf., South-Central Wyoming, 1951, in pocket.

141 Van Houten, F. B., 1954, Geology of the Long Creek-Beaver Divide area, Fremont County, Wyoming: U.S. Geol. Survey Oil and Gas Inv. Map OM–140.

No. on pl. 32

142 Vine, J. D., Prichard, G. E., Murany, E. E., and McDowell, J. P., 1954, written communication.

143 Walton, P. T., 1947, Oregon Basin oil field, *in* Wyoming Univ., Wyoming Geol. Assoc., Yellowstone-Bighorn Research Assoc. Guidebook [2d Ann.] Field Conf., Bighorn Basin, 1947: p. 210–222; pl. 2, p. [102c].

144 Weitz, J. L., and Love, J. D., 1952, Geologic map of Carbon County, Wyoming: Wyoming Geol. Survey.

145 West, W. E., Jr., 1953, The Quealy oil field, Albany County, Wyoming, *in* Wyoming Geol. Assoc. Guidebook 8th Ann. Field Conf., Laramie Basin, Wyoming, and North Park, Colorado, 1953: p. 165–169.

146 ——— 1953, The Herrick and Little Laramie oil fields, Albany County, Wyoming, *in* Wyoming Geol. Assoc. Guidebook 8th Ann. Field Conf., Laramie Basin, Wyoming, and North Park, Colorado, 1953: p. 150–152.

147 White, V. L., 1955, Table Rock and Southwest Table Rock gas fields, *in* Wyoming Geol. Assoc. Guidebook 10th Ann. Field Conf., Green River basin, 1955: p. 170–171.

148 Williams, M. D., and Sharkey, H. H. R., 1946, Geology of the Bargee area, Fremont County, Wyoming: U.S. Geol. Survey Oil and Gas Inv. Prelim. Map 56.

149 Wilson, W. H., 1953, written communication.

150 Wold, J. S., 1952, Report on Worland field, Wyoming, *in* Wyoming Geol. Assoc. Guidebook 7th Ann. Field Conf., Southern Big Horn Basin, Wyoming, 1952: p. 117–119.

151 Woodbury, H. O., 1950, West-east cross-section, Snider basin area, Sublette County, Wyoming, *in* Wyoming Geol. Assoc. Guidebook 5th Ann. Field Conf., Southwest Wyoming, 1950: between p. [120] and [121].

152 Woodward, T. C., 1955, Geology of Deadman Butte area, Natrona County, Wyoming: Ph.D. dissertation, Texas Univ., 185 p.

153 Wyoming Geological Association, 1948, Steamboat Butte oil field, *in* Wyoming Geol. Assoc. Guidebook 3d Ann. Field Conf., Wind River Basin, Wyoming, 1948: p. 173–177.

154 ——— 1950, Photo map of the Fossil NE quadrangle, *in* Wyoming Geol. Assoc. Guidebook 5th Ann. Field Conf., Southwest Wyoming, 1950, in pocket.

155 ——— 1952, Little Sand Draw anticline, T. 44, 45 N., R. 96 W., *in* Wyoming Geol. Assoc. Guidebook 7th Ann. Field Conf., Southern Big Horn Basin, Wyoming, 1952: p. 4.

156 ——— 1952, Hamilton dome field, Hot Springs County, Wyoming, *in* Wyoming Geol. Assoc. Guidebook 7th Ann. Field Conf., Southern Big Horn Basin, Wyoming, 1952: p. 104–106.

157 ——— 1952, Mahogany Butte and Chabot anticlines, T. 42, 43 N., R. 87, 88, 89 W., Washakie County, Wyoming, *in* Wyoming Geol. Assoc. Guidebook 7th Ann. Field Conf., Southern Big Horn Basin, Wyoming, 1952: p. 145.

158 ——— 1953, Structure map of the Laramie Basin, Albany and Carbon Counties, Wyoming, *in* Wyoming Geol. Assoc. Guidebook 8th Ann. Field Conf., Laramie Basin, Wyoming, and North Park, Colorado, 1953.

No. on pl. 32

159 Wyoming Geological Association 1954, Geological map of South Casper Creek, Poison Spider, Oil Mountain, and Iron Creek, Natrona County, Wyoming, *in* Wyoming Geol. Assoc. Guidebook 9th Ann. Field Conf., Casper area, 1954, in pocket.

160 Zeller, H. D., Soister, P. E., and Hyden, H. J., 1956, Preliminary map of the Gas Hills uranium district, Fremont and Natrona Counties, Wyoming: U.S. Geol. Survey Mineral Inv. Map MF-83.

WESTERN NEBRASKA AND NORTHWESTERN KANSAS

No. on pl. 33

1 Brady, F. H., 1957, written communication.

2 Condra, G. E., 1907, Geology and water resources of the Republic River valley and adjacent areas, Nebraska: U.S. Geol. Survey Water-Supply Paper 216, 71 p.

*3 Condra, G. E., and Reed, E. C., 1943, The geological section of Nebraska: Nebraska Geol. Survey Bull. 14, 82 p.

**4 Lee, Wallace, and Merriam, D. F., 1954, Preliminary study of the structure of western Kansas: Kansas Geol. Survey Oil and Gas Inv. 11, 23 p.

5 Lugn, A. L., 1939, Classification of the Tertiary system in Nebraska: Geol. Soc. America Bull., v. 50, p. 1245–1275.

**6 Moore, R. C., and Landes, K. K., 1937, Geologic map of Kansas: Kansas Geol. Survey.

7 Murray, H. F., 1954, written communication.

8 Noble, J. A., 1948, written communication.

*9 Reed, E. C., 1956, Structure contour map of Nebraska, *in* Finch, W. C., ed., The oil and gas fields of Nebraska: Denver, Colo., Rocky Mtn. Assoc. Geologists.

*** Stose, G. W., and Ljungstedt, O. A., 1932, Geologic map of the United States: U.S. Geol. Survey.

*10 Tulsa Geological Society, 1951, Mid-Continent region, *in* Ball, M. W., ed., Possible future petroleum provinces of North America: Am. Assoc. Petroleum Geologists Bull., v. 35, p. 318–322.

11 Wenzel, L. K., and Waite, H. A., 1941, Ground water in Keith County, Nebraska: U.S. Geol. Survey Water-Supply Paper 848, 68 p.

* indicates source data that apply to all of western Nebraska.
** indicate source data that apply to all of northwestern Kansas.
*** indicate source data that apply to all of map area.

NORTHERN COLORADO AND NORTHEASTERN UTAH

No. on pl. 34

1 Abrassart, C. P., and Clough, G. A., Jr., 1955, Juniper Mountain area, Colorado, *in* Intermountain Assoc. Petroleum Geologists and Rocky Mtn. Assoc. Geologists, Guidebook to the geology of northwest Colorado, 6th Ann. Field Conf., 1955: p. 86–87.

2 Alpha, A. G., 1954, Structure contour map of the Pawnee Creek field, T. 7–8 N., R. 54 W., Logan County, Colorado, *in* Jensen, F. S., and others, eds., The oil and gas fields of Colorado: Denver, Colo., Rocky Mtn. Assoc. Geologists, p. 244.

No. on pl. 34

3 Anderman, G. G., 1955, Tertiary deformational history of a portion of the north flank of the Uinta Mountains in the vicinity of Manila, Utah, *in* Wyoming Geol. Assoc. Guidebook 10th Ann. Field Conf., Green River basin, 1955: p. 130–134.

*4 Andrews, D. A., and Hunt, C. B., 1948, Geologic map of eastern and southern Utah: U.S. Geol. Survey Oil and Gas Inv. Prelim. Map 70.

5 Ashburn, N. L., 1954, Structure contour map of the Atwood field, T. 7 N., R. 53 W., Logan County, Colorado, *in* Jensen, F. S., and others, eds., The oil and gas fields of Colorado: Denver, Colo., Rocky Mtn. Assoc. Geologists, p. 86.

6 Ashburn, N. L., 1954, Structure contour map of the Armstrong field, T. 11 N., R. 53 W., Logan County, Colorado, *in* Jensen, F. S., and others, eds., The oil and gas fields of Colorado: Denver, Colo., Rocky Mtn. Assoc. Geologists, p. 80.

7 Ball, M. W., and Stebinger, Eugene, 1910, Eastern part of the Little Snake River coal field, Wyoming: U.S. Geol. Survey Bull. 381, p. 186–213.

8 Barnwell, W. W., 1955, The geology of the South Hahns Peak district, Routt County, Colorado, *in* Intermountain Assoc. Petroleum Geologists and Rocky Mtn. Assoc. Geologists, Guidebook to the geology of northwest Colorado, 6th Ann. Field Conf., 1955: p. 73–74.

9 Bass, N. W., Eby, J. B., and Campbell, M. R., 1955, Geology and mineral fuels of parts of Routt and Moffat Counties, Colorado: U.S. Geol. Survey Bull. 1027–D, 250 p.

10 Beckett, R. L., 1955, Geology of the Red Canyon area, Eagle County, Colorado: M.A. thesis, Colorado Univ., 36 p.

11 Beckwith, R. H., 1942, Structure of the upper Laramie River Valley Colorado-Wyoming: Geol. Soc. America Bull., v. 53, p. 1491–1532.

12 Beekly, A. L., 1915, Geology and coal resources of North Park, Colorado: U.S. Geol. Survey Bull. 596, 121 p.

13 Bergman, D. R., 1954, Structure contour map of the Moffat field, T. 4–5 N., R. 91 W., Moffat County, Colorado, *in* Jensen, F. S., and others, eds., The oil and gas fields of Colorado: Denver, Colo., Rocky Mtn. Assoc. Geologists, p. 224.

14 Bergren, A. L., 1954, Structure contour map of the Little Beaver field, T. 1–2 S., R. 56–57 W., Adams and Washington Counties, Colorado, *in* Jensen, F. S., and others, eds., The oil and gas fields of Colorado: Denver, Colo., Rocky Mtn. Assoc. Geologists, p. 192.

15 Blackstone, D. L., Jr., 1953, Tectonic map of a portion of southern Wyoming and northern Colorado, *in* Wyoming Geol. Assoc. Guidebook 8th Ann. Field Conf., Laramie Basin, Wyoming and North Park, Colorado, 1953: p. 85–86.

16 ——— 1955, Tectonic map of parts of southwestern Wyoming and adjoining States, *in* Wyoming Geol. Assoc. Guidebook 10th Ann. Field Conf., Green River basin, 1955, in pocket.

17 Boos, M. F., 1954, Genesis of Precambrian granitic pegmatites in the Denver Mountain Parks area, Colorado: Geol. Soc. America Bull., v. 65, p. 115–141.

18 Bradley, W. H., 1931, Origin and microfossils of the oil shale of the Green River formation of Colorado and Utah: U.S. Geol. Survey Prof. Paper 168, 58 p.

* indicates source data that apply to all of northeastern Utah.

No. on pl. 34

19 Bradley, W. H., 1935, Anticlines between Hiawatha gas field and Baggs, Wyoming: Am. Assoc. Petroleum Geologists Bull., v. 19, j. 537–543.

20 ——— 1936, Geomorphology of the north flank of the Uinta Mountains: U.S. Geol. Survey Prof. Paper 185, p. 163–205.

21 ——— 1945, Geology of the Washakie basin, Sweetwater and Carbon Counties, Wyoming, and Moffat County, Colorado: U.S. Geol. Survey Oil and Gas Inv. Prelim. Map 32.

22 ——— 1955, written communication.

23 Brady, F. H., and Elmgren, C. B., 1950, written communication.

24 Brown, H. H., 1954, Structure contour map of the Iles dome field, T. 4 N., R. 92 W., Moffat County, Colorado, *in* Jensen, F. S., and others, eds., The oil and gas fields of Colorado: Denver, Colo., Rocky Mtn. Assoc. Geologists, p. 173–174.

25 Brunton, A. F., 1954, Structure contour map of the Greasewood field, T. 6 N., R. 60–61 W., Morgan and Weld Counties, Colorado, *in* Jensen, F. S., and others, eds., The oil and gas fields of Colorado: Denver, Colo., Rocky Mtn. Assoc. Geologists, p. 154.

**26 Burbank, W. S., Lovering, T. S., Goddard, E. N., and Eckel, E. B., 1935, Geologic map of Colorado: U.S. Geol. Survey

27 Burns, T B., 1954, Structure contour map of the Buckingham field, T. 8 N., R. 59 W., Weld County, Colorado, *in* Jensen, F. S., and others, eds., The oil and gas fields of Colorado: Denver, Colo., Rocky Mtn. Assoc. Geologists, p. 114.

28 Campbell, M. R., 1922, Guidebook of the Western United States, Part E, The Denver & Rio Grande Western Route: U.S. Geol. Survey Bull. 707, 266 p.

29 ——— 1923, Twentymile Park district of the Yampa coal field, Routt County, Colorado: U.S. Geol. Survey Bull. 748, 82 p.

*** Carey, B. D., Jr., 1955, The Elkhead Mountains volcanic field, northwestern Colorado, *in* Intermountain Assoc. Petroleum Geologists and Rocky Mtn. Assoc. Geologists, Guidebook to the geology of northwest Colorado, 6th Ann. Field Conf., 1955: p. 44–45.

30 Chapman, E. P., 1935, Quartz monzonite batholithic intrusions of Twin Lakes and Clear Creek districts, Lake and Chaffee Counties: Colorado Sci. Soc. Proc., v. 13, no. 8, p. 481–493.

31 Childs, O. E., 1950, Geologic history of the Uinta Basin, Utah, *in* Petroleum geology of the Uinta Basin: Utah Geol. and Mineralog. Survery Guidebook to the geology of Utah, no. 5, p. 49–59.

32 Coffin, R. C., Perini, V. C., Jr., and Collins, M. J., 1920, Some anticlines of western Colorado: Colorado Geol. Survey Bull. 24, 61 p.

33 Crawford, R. D., Wilson, K. M., and Perini, V. C., Jr., 1920, Some anticlines of Routt County: Colorado Geol. Survey Bull. 23, 61 p.

*** Crittenden, M. D., Jr., 1955, Precambrian rocks west and south of the Green River basin [Utah], *in* Wyoming Geol. Assoc. Guidebook 10th Ann. Field Conf., Green River basin, 1955: p. 20–22.

*** Crowley, A. J., 1955, A structural history of northwestern Colorado and parts of northeastern Utah, *in* Intermountain Assoc. Petroleum Geologists and Rocky Mtn. Assoc. Geologists, Guidebook to the geology of northwest Colorado, 6th Ann. Field Conf., 1955: p. 53–55.

** indicate source data that apply to all of northern Colorado.
*** indicate source data obtained from text only.

No. on pl. 34

34 Cullen, A. W., and Forcade, K. C., 1954, Structure contour map of the Adena field, T. 1–2 N., R. 57–58 W., Morgan County, Colorado, *in* Jensen, F. S., and others, eds., The oil and gas fields of Colorado: Denver, Colo., Rocky Mtn. Assoc. Geologists, p. 73–76.

35 Curtis, B. F., 1950, Structure of the north flank of the Uinta Mountains, *in* Wyoming Geol. Assoc. Guidebook 5th Ann. Field Conf., Southwest Wyoming, 1950: p. 93–94.

36 Denny, C. C., 1954, Structure contour map of the Black Hollow field, T. 7–8 N., R. 66–67 W., Weld County, Colorado, *in* Jensen, F. S., and others, eds., The oil and gas fields of Colorado: Denver, Colo., Rocky Mtn. Assoc. Geologists, p. 102.

37 Deuth, John, 1954, Structure map of the Boulder field, T. 1 N., R. 70 W., Boulder County, Colorado, *in* Jensen, F. S., and others, eds., The oil and gas fields of Colorado: Denver, Colo., Rocky Mtn. Assoc. Geologists, p. 110.

38 Dobbin, C. E., 1950, The petroleum geology of Colorado, *in* Applied geology, a symposium: Colorado School Mines Quart., v. 45, no. 1B, p. 1–28.

39 Dobbin, C. E., and Davison, Robert, 1945, Geologic and structure contour map of the Clay Basin gas field and vicinity, Daggett County, Utah, and Sweetwater County, Wyoming: U.S. Geol. Survey.

40 Donner, H. F., 1949, Geology of the McCoy area, Eagle and Routt Counties, Colorado: Geol. Soc. America Bull., v. 60, p. 1215–1247.

41 Eldridge, G. H., 1896, Uintaite (gilsonite) deposits of Utah: U.S. Geol. Survey 17th Ann. Rept., pt. 1, p. 909–949.

42 Erdmann, C .E., 1944, Geology of the Coalmont district: U.S. Geol. Survey open-file report.

43 Fenneman, N. M., and Gale, H. S., 1906, Yampa coal field, Routt County: U.S. Geol. Survey Bull. 297, 96 p.

44 Finley, E. A., Dobbin, C. E., and Richardson, E. E., 1955, Preliminary structure contour map of the Colorado Plains: U.S. Geol. Survey Oil and Gas Inv. Map OM–176.

45 Folsom, L. W., 1955, Powder Wash-Ace field, Moffat County, Colorado, *in* Intermountain Assoc. Petroleum Geologists and Rocky Mtn. Assoc. Geologists, Guidebook to the geology of northwest Colorado, 6th Ann. Field Conf., 1955: p. 94–98.

46 Forrester, J. D., 1937, Structure of the Uinta Mountains: Geol. Soc. America Bull., v. 48, p. 631–666.

47 Frey, J. E., 1954, Structure contour map of the Tow Creek field, T. 6 N., R. 86 W., Routt County, Colorado, *in* Jensen, F. S., and others, eds., The oil and gas fields of Colorado: Denver, Colo., Rocky Mtn. Assoc. Geologists, p. 274.

48 Gale, H. S., 1906, Hahns Peak gold field: U.S. Geol. Survey Bull. 285, p. 28–34.

49 ——— 1909, Coal fields of northwestern Colorado and northeastern Utah: U.S. Geol. Survey Bull. 341, p. 283–315.

50 ——— 1910, Coal fields of northwestern Colorado and northeastern Utah: U.S. Geol. Survey Bull. 415, 265 p.

51 Gallagher, W. G., 1954, Structure contour map of the Fort Collins field, T. 8 N., R. 68–69 W., Larimer County, Colorado, *in* Jensen, F. S., and others, eds., The oil and gas fields of Colorado: Denver, Colo., Rocky Mtn. Assoc. Geologists, p. 138.

No. on
pl. 34

52 Gallagher, W. G., 1954, Structure contour map of the Wellington field, T. 9–10 N., R. 68–69 W., Larimer County, Colorado, *in* Jensen, F. S., and others, eds., The oil and gas field of Colorado: Denver, Colo., Rocky Mtn. Assoc. Geologists, p. 282.

53 George, R. D., and Crawford, R. D., 1909, Hahns Peak region, Routt County: Colorado Geol. Survey 1st Rept., p. 189–229.

54 Gras, V. B., 1955, Vermillion Creek basin area, Sweetwater County, Wyoming, and Moffat County, Colorado, *in* Intermountain Assoc. Petroleum Geologists and Rocky Mtn. Assoc. Geologists, Guidebook to the geology of northwest Colorado, 6th Ann. Field Conf., 1955: p. 78–83.

55 Griffith, E. G., 1954, Structure contour map of the Goodrich-Masters fields, T. 5 N., R. 60–61 W., Weld and Morgan Counties, Colorado, *in* Jensen, F. S., and others, eds., The oil and gas fields of Colorado: Denver, Colo., Rocky Mtn. Assoc. Geologists, p. 144.

56 ——— 1954, Structure contour map of the Roggen and S. Roggen fields, T. 2 N., R. 63 W., Weld County, Colorado, *in* Jensen, F. S., and others, eds., The oil and gas fields of Colorado: Denver, Colo., Rocky Mtn. Assoc. Geologists, p. 258.

57 Grout, F. F., Worcester, P. G., and Henderson, Junius, 1913, Reconnaissance of the geology of the Rabbit Ears region, Routt, Grand, and Jackson Counties, Colorado: Colorado Geol. Survey Bull. 5, pt. 1, 57 p.

58 Hale, L. A., 1950, Geologic map, Rock Springs uplift, Wyoming; geology by A. R. Schultz and J. D. Sears *in* Wyoming Geol. Assoc. Guidebook 5th Ann. Field Conf., southwest Wyoming, 1950, in pocket.

59 Hancock, E. T., 1915, History of a portion of the Yampa River and its possible bearing on Green River: U.S. Geol. Survey Prof. Paper 90, p. 183–189.

60 ——— 1925, Geology and coal resources of the Axial and Monument Butte quadrangles, Moffat County, Colorado: U.S. Geol. Survey Bull. 757, 134 p.

61 Hancock, E. T., and Eby, J. B., 1930, Geology and coal resources of the Meeker quadrangle, Moffat and Rio Blanco Counties: U.S. Geol. Survey Bull. 812, p. 191–242.

62 Hansen, W. R., 1955, Precambrian geology of the area between Clay Basin and Browns Park in Utah and Colorado, *in* Wyoming Geol. Assoc. Guidebook 10th Ann. Field Conf., Green River basin, 1955: p. 23–28.

63 ——— 1955, written communication.

64 ——— 1955, written communication.

65 ——— 1955, written communication.

66 ——— 1955, written communication.

67 ——— 1957, Geology of Clay Basin quadrangle, Utah: U.S. Geol. Survey Geol. Quad. Map GQ–101.

*68 ——— 1957, Structural features of the Uinta arch, *in* Intermountain Assoc. Petroleum Geologists Guidebook to the geology of the Uinta Basin: p. 35–39.

* Indicates source data that apply to all of northeastern Utah.

No. on pl. 34

69 Hansen, W. R., and Bonilla, M. G., 1954, Laramide faulting and orogeny on the North Flank of the Uinta Mountains in eastern Daggett County, Utah: Colorado Sci. Soc. Proc., v. 17, no. 1, 29 p.

70 ——— 1956, Geology of the Manila quadrangle, Utah and Wyoming: U.S. Geol. Survey Misc. Geol. Inv. Map I–156.

71 Heaton, R. L., 1940, Geological aspects of the Colorado-Big Thompson project: Mines Mag. [Colorado], v. 30, no. 5, p. 257–264.

72 Hillis, Don, 1954, Structure contour map of the Battle Canyon field, T. 11 N., R. 56 W., Weld County, Colorado, *in* Jensen, F. S., and others, eds., The oil and gas fields of Colorado: Denver, Colo., Rocky Mtn. Assoc. Geologists, p. 96.

73 Hubert, J. F., 1954, Structure and stratigraphy of an area east of Brush Creek, Eagle County, Colorado: M.A. thesis, Colorado Univ., 104 p.

74 Huddle, J. W., and McCann, F. T., 1947, Geologic map of Duchesne River area, Wasatch and Duchesne Counties, Utah: U.S. Geol. Survey Oil and Gas Inv. Prelim. Map 75.

75 Huddle, J. W., Mapel, W. J., and McCann, F. T., 1951, Geology of the Moon Lake area, Duchesne County, Utah: U.S. Geol. Survey Oil and Gas Inv. Map OM–115.

76 Hula, C. W., 1954, Structure contour map of the Long field (Colorado portion) T. 12 N., R. 56 W., Weld County, Colorado, *in* Jensen, F. S., and others, eds., The oil and gas fields of Colorado: Denver, Colo., Rocky Mtn. Assoc. Geologists, p. 198.

77 Hunter, J. M., 1955, Geology of the North Hahns Peak area, Routt County, Colorado, *in* Intermountain Assoc. Petroleum Geologists and Rocky Mtn. Assoc. Geologists, Guidebook to the geology of northwest Colorado, 6th Ann. Field Conf., 1955: p. 71–72.

78 Hunter, Z. M., 1956, Areal geology of the foothills of the Front Range, in northern Colorado: Denver, Colo., Rocky Mtn. Assoc. Geologists map.

79 Intermountain Association Petroleum Geologists and Rocky Mountain Association Geologists, 1955, Tectonic map of northwest Colorado, *in* Intermountain Assoc. Petroleum Geologists and Rocky Mtn. Assoc. Geologists, Guidebook to the geology of northwest Colorado, 6th Ann. Field Conf., 1955: facing p. 52.

80 ——— 1955, Thornburg dome, Moffat County, Colorado, *in* Intermountain Assoc. Petroleum Geologists and Rocky Mtn. Assoc. Geologists, Guidebook to the geology of northwest Colorado, 6th Ann. Field Conf., 1955: p. 108–109.

81 Jackson, J. W., 1954, Structure contour map of the Badger Creek field, T. 2 S., R. 57 W., Adams County, Colorado, *in* Jensen, F. S., and others, eds., The oil and gas fields of Colorado: Denver, Colo., Rocky Mtn. Assoc. Geologists, p. 88.

82 ——— 1954, Structure contour map of the West Padroni field, T. 9–10 N., R. 52 W., Logan County, Colorado, *in* Jensen, F. S., and others, eds., The oil and gas fields of Colorado: Denver, Colo., Rocky Mtn. Assoc. Geologists, p. 242.

83 Jacober, G. E., 1954, Structure contour map of the Elk Springs field, T. 5 N., R. 98 W., Moffat County, Colorado, *in* Jensen, F. S., and others, eds., The oil and gas fields of Colorado: Denver, Colo., Rocky Mtn. Assoc. Geologists, p. 130.

No. on pl. 34

84 Johnson, A. E., 1954, Structure contour map of the Bonham field, T. 8 N., R. 55 W., Logan County, Colorado, *in* Jensen, F. S., and others, eds., The oil and gas fields of Colorado: Denver, Colo., Rocky Mtn. Assoc. Geologists, p. 106.

85 Kanizay, S. P., 1955, Geology of Cross Mountain, Moffat County, Colorado, *in* Intermountain Assoc. Petroleum Geologists and Rocky Mtn. Assoc. Geologists, Guidebook to the geology of northwest Colorado, 6th Ann. Field Conf., 1955: p. 60–62.

86 Keebler, W. E., 1954, Structure contour map of the Messex field, T. 5–6 N., R. 55 W., Morgan County, Colorado, *in* Jensen, F. S., and others, eds., The oil and gas fields of Colorado: Denver, Colo., Rocky Mtn. Assoc. Geologists, p. 218.

87 ——— 1954, Structure contour map of the Merino field, T. 6 N., R. 54 W., Logan County, Colorado, *in* Jensen, F. S., and others, eds., The oil and gas fields of Colorado: Denver, Colo., Rocky Mtn. Assoc. Geologists, p. 216.

88 Kelley, V. C., 1954, Tectonic map of western Colorado, *in* Jensen, F. S., and others, eds., The oil and gas fields of Colorado: Denver, Colo., Rocky Mtn. Assoc. Geologists, p. 50.

**** King, P. B., and others, 1944, Tectonic map of the United States: Am. Assoc. Petroleum Geologists, prepared under the direction of the Committee on Tectonics, Div. Geology and Geography, Natl. Research Council.

89 Kinney, D. M., 1951, Geology of the Uinta River and Brush Creek-Diamond Mountain areas, Duchesne and Uintah Counties, Utah: U.S. Geol. Survey Oil and Gas Inv. Map OM–123.

90 Kinney, D. M., 1955, Geology of the Uinta River-Brush Creek area, Duchesne and Uintah Counties, Utah: U.S. Geol. Survey Bull. 1007, 185 p.

91 Kinney, D. M., and Rominger, J. F., 1947, Geology of the Whiterocks River-Ashley Creek area, Uintah County, Utah: U.S. Geol. Survey Oil and Gas Inv. Prelim. Map 82.

92 Kramer, W. B., 1939, Geologic map of Powder Wash dome, Moffat County [Colorado]: U.S. Geol. Survey.

93 ——— 1939, Geologic map of Wilson Creek dome, Rio Blanco and Moffat Counties [Colorado]: U.S. Geol. Survey.

94 Larsen, W. N., 1954, Precambrian geology of the western Uinta Mountains, Utah: Ph. D. dissertation, Utah Univ.

95 Lavington, C. H., and Bachrach, R., 1954, Structure contour map of the Thornburg field, T. 3 N., R. 91 W., Moffat and Rio Blanco Counties, Colorado, *in* Jensen, F. S., and others, eds., The oil and gas fields of Colorado: Denver, Colo., Rocky Mtn. Assoc. Geologists, p. 270.

96 Lavington, C. S., 1954, Structure contour map of the Berthoud field, T. 4 N., R. 69 W., Larimer County, Colorado, *in* Jensen, F. S., and others, eds., The oil and gas fields of Colorado: Denver, Colo., Rocky Mtn. Assoc. Geologists, p. 98.

97 Lee, A. T., 1954, Structure contour map of the Yenter field, T. 8–9 N., R. 54 W., Logan County, Colorado, *in* Jensen, F. S., and others, eds., The oil and gas fields of Colorado: Denver, Colo., Rocky Mtn. Assoc. Geologists, p. 296.

**** indicate source data that apply to entire tectonic map area.

No. on pl. 34

98 Lippitt, W. S., 1954, Structure contour map of the Fleming field, T. 8 N., R. 50 W., Logan County, Colorado, *in* Jensen, F. S., and others, eds., The oil and gas fields of Colorado: Denver, Colo., Rocky Mtn. Assoc. Geologists, p. 132.

99 Lovering, T. S., 1931, The Granby anticline, Grand County, Colorado: U.S. Geol. Survey Bull. 822–B, p. 71–76.

100 ——— 1935, Geology and ore deposits of the Montezuma quadrangle, Colorado: U.S. Geol. Survey Prof. Paper 178, 119 p.

101 Lovering, T. S., and Goddard, E. N., 1950, Geology and ore deposits of the Front Range, Colorado: U.S. Geol. Survey Prof. Paper 223, 319 p.

102 Lovering, T. S., and Tweto, Ogden, 1944, Areal geology of the Minturn quadrangle: U.S. Geol. Survey open-file map.

103 McCue, J. J., 1955, Slater dome, Moffat and Routt Counties, Colorado: Wyoming Geol. Assoc. Guidebook 10th Ann. Field Conf., Green River basin, 1955: p. 168–169.

104 McElroy, J. R., 1953, Geology of the Derby Creek area, Eagle, Routt, and Garfield Counties, Colorado: M.A. thesis, Colorado Univ., 78 p.

105 McGregor, A. A., 1954, Structure contour map of the Bobcat field, T. 1 S., R. 56 W., Washington County, Colorado, *in* Jensen, F. S., and others, eds., The oil and gas fields of Colorado: Denver, Colo., Rocky Mtn. Assoc. Geologists, p. 104.

106 MacQuown, W. C., Jr., 1945, Structure of the White River Plateau near Glenwood Springs: Geol. Soc. America Bull., v. 56, p. 877–892.

107 Mather, K. F., Gilluly, James, and Lusk, R. G., 1928, Geology and oil and gas prospects of northeastern Colorado: U.S. Geol. Survey Bull. 796, p. 65–124.

108 Mickelson, G. O., 1954, Structure contour map of the Padroni field, T. 9 N., R. 52 W., Logan County, Colorado, *in* Jensen, F. S., and others, eds., The oil and gas fields of Colorado: Denver, Colo., Rocky Mtn. Assoc. Geologists, p. 238.

109 Montagne, J. M. de la, 1953, Late Tertiary normal faults along the east flank of the Park Range, Wyoming and Colorado, *in* Wyoming Geol. Assoc. Guidebook 8th Ann. Field Conf., Laramie Basin, Wyoming, and North Park, Colorado, 1953: p. 103–105.

110 Murray, H. F., 1954, written communication.

111 Nelson, Erik, 1955, Iles dome, Moffat County, Colorado, *in* Intermountain Assoc. Petroleum Geologists and Rocky Mtn. Assoc. Geologists, Guidebook to the geology of northwest Colorado, 6th Ann. Field Conf., 1955: p. 90–91.

112 Newton, W. A., 1954, Structure contour map of the South Springdale field, T. 8 N., R. 53 W., Logan County, Colorado, *in* Jensen, F. S., and others, eds., The oil and gas fields of Colorado: Denver, Colo., Rocky Mtn. Assoc. Geologists, p. 264.

113 Nightingale, W. T., 1930, Geology of Vermillion Creek gas area in southwest Wyoming and northwest Colorado: Am. Assoc. Petroleum Geologists Bull., v. 14, p. 1013–1040.

*** ——— 1938, Petroleum and natural gas in nonmarine sediments of Powder Wash field in northwest Colorado: Am. Assoc. Petroleum Geologists Bull., v. 22, p. 1020–1047.

*** indicate source data obtained from text only.

No. on pl. 34

114 Nightingale, W. T., 1954, Structure contour map of Powder Wash oil and gas field, Moffat County, Colorado, *in* Jensen, F. S., and others, eds., The oil and gas fields of Colorado: Denver, Colo., Rocky Mtn. Assoc. Geologists, p. 250.

115 ——— 1954, Structure contour map of Hiawatha oil and gas field, Moffat County, Colorado and Sweetwater County, Wyoming, *in* Jensen, F. S., and others, eds., The oil and gas fields of Colorado: Denver, Colo., Rocky Mtn. Assoc. Geologists, p. 163.

116 Nolte, C. J., and Lair, Lee, 1954, Structure contour map of the Johnson Hill and Liberty fields, T. 8 N., R. 54 W., Logan County, Colorado, *in* Jensen, F. S., and others, eds., The oil and gas fields of Colorado: Denver, Colo., Rocky Mtn. Assoc. Geologists, p. 178.

117 Oriel, S. S., and others, 1954, Tectonic map of Colorado, in Jensen, F. S., and others, eds., The oil and gas fields of Colorado: Denver, Colo., Rocky Mtn. Assoc. Geologists.

118 Parkinson, L. J., 1956, Geology of an area east of Boulder, Boulder County, Colorado: M.A. thesis, Colorado Univ., 49 p.

119 Pott, R. L., 1954, Structure contour map of the East Woodrow field, T. 1 S., R. 55 W., Washington County, Colorado, *in* Jensen, F. S., and others, eds., The oil and gas fields of Colorado: Denver, Colo., Rocky Mtn. Assoc. Geologists, p. 292.

120 ——— 1954, Structure contour map of the West Woodrow field, T. 1 S., R. 57 W., Adams County, Colorado, *in* Jensen, F. S., and others, eds., The oil and gas fields of Colorado: Denver, Colo., Rocky Mtn. Assoc. Geologists, p. 294.

121 Powell, J. W., 1876, Report on the geology of the eastern portion of the Uinta Mountains and a region of country adjacent thereto: U.S. Geol. and Geog. Survey Terr., Atlas.

122 Quam, L. O., 1938, Rock type and geologic structure map of the Estes Park area, Colorado, *in* Guidebook 12th Ann. Field Conf. along the Front Range of the Rocky Mountains, Colorado: Kansas Geol. Soc., p. 70.

123 Riley, P. E., 1949, Geology of an area along the Colorado River, T. 3 S., R. 85 W., Eagle County, Colorado: M.A. thesis, Colorado Univ., 24 p.

124 Sandberg, G. W., 1954, Structure contour map of the Minto field, T. 8 N., R. 52 W., Logan County, Colorado, *in* Jensen, F. S., and others, eds., The oil and gas fields of Colorado: Denver, Colo., Rocky Mtn. Assoc. Geologists, p. 222.

125 Sanford, W. G., 1954, Structure contour map of the Frenchmans Creek gas field, T. 8 N., R. 50 W., Logan County, Colorado, *in* Jensen, F. S., and others, eds., The oil and gas fields of Colorado: Denver, Colo., Rocky Mtn. Assoc. Geologists, p. 142.

126 Saterdal, A., 1955, Tow Creek oil field, Routt County, Colorado, *in* Intermountain Assoc. Petroleum Geologists and Rocky Mtn. Assoc. Geologists, Guidebook to the geology of northwest Colorado: p. 110–112.

127 Schultz, A. R., 1920, Oil possibilities in and around Baxter Basin in the Rock Springs uplift, Sweetwater County, Wyoming: U.S. Geol. Survey Bull. 702, 107 p.

128 Sears, J. D., 1924, Relations of the Browns Park formation and the Bishop conglomerate and their role in the origin of Green and Yampa Rivers: Geol. Soc. America Bull., v. 35, p. 279–304.

No. on pl. 34

129 Sears, J. D., 1925, Geology and oil and gas prospects of part of Moffat County, Colorado, and southern Sweetwater County, Wyoming: U.S. Geol. Survey Bull. 751, p. 269–319.

130 Sears, J. D., and Bradley, W. H., 1925, Relations of the Wasatch and Green River formations in northwestern Colorado and southern Wyoming: U.S. Geol. Survey Prof. Paper 132, p. 93–107.

131 Severy, C. L., 1955, Geology of the Williams Park-Fish Creek anticlines, Routt County, Colorado, in Intermountain Assoc. Petroleum Geologists and Rocky Mtn. Assoc. Geologists, Guidebook to the geology of northwest Colorado: p. 116–118.

132 Severy, C. L., and Deane, W. R., 1954, Structure contour map of the West Peetz field, T. 11–12 N., R. 52–53 W., Logan County, Colorado, *in* Jensen, F. S., and others, eds., The oil and gas fields of Colorado: Denver, Colo., Rocky Mtn. Assoc. Geologists, p. 246.

133 ——— 1954, Structure contour map of the McRae field, T. 1 N., R. 55 W., Morgan County, Colorado, *in* Jensen, F. S., and others, eds., The oil and gas fields of Colorado: Denver, Colo., Rocky Mtn. Assoc. Geologists, p. 214.

134 Shearer, E. M., 1951, Geology of Red Dirt Creek area, Eagle County, Colorado: M. A. thesis, Colorado Univ., 46 p.

135 Sheldon, T. D., 1954, Structure contour map of the Stoneham field, T. 9 N., R. 56 W., Weld County, Colorado, *in* Jensen, F. S., and others, eds., The oil and gas fields of Colorado: Denver, Colo., Rocky Mtn. Assoc. Geologists, p. 266.

136 ——— 1954, Structure contour map of the South Stoneham field, T. 8 N., R. 56 W., Weld County, Colorado, *in* Jensen, F. S., and others, eds., The oil and gas fields of Colorado: Denver, Colo., Rocky Mtn. Assoc. Geologists, p. 268.

137 Shelton, J. W., 1954, Structure contour map of the Mount Hope field, T. 9 N., R. 53–54 W., Logan County, Colorado, *in* Jensen, F. S., and others, eds., The oil and gas fields of Colorado: Denver, Colo., Rocky Mtn. Assoc. Geologists, p. 232.

138 Souder, W. J., 1954, Structure contour map of the Walker field, T. 9 N., R. 53 W., Logan County, Colorado, *in* Jensen, F. S., and others, eds., The oil and gas fields of Colorado: Denver, Colo., Rocky Mtn. Assoc. Geologists, p. 280.

139 Spencer, A. C., 1904, Copper deposits of the Encampment district, Wyoming: U.S. Geol. Survey Prof. Paper 25, 107 p.

140 Stark, J. T., 1934, Reverse faulting in the Sawatch Range: Geol. Soc. America Bull., v. 45, p. 1001–1015.

141 Stauffer, J. E., 1953, Geology of an area west of Wolcott, Eagle County, Colorado: M. A. thesis, Colorado Univ., 56 p.

142 Sternberg, C. W., 1954, Structure contour map of the Lee field, T. 2 N., R. 57 W., Morgan County, Colorado, *in* Jensen, F. S., and others, eds., The oil and gas fields of Colorado: Denver, Colo., Rocky Mtn. Assoc. Geologists, p. 186.

143 Steven, T. A., 1954, Geology of the Northgate fluorspar district, Colorado: U.S. Geol. Survey Mineral Inv. Map MF–13.

144 Taylor, J. M., and Kirkpatrick, H. M., 1954, Structure contour map of the Dale-Springdale fields, T. 8 N., R. 53 W., Logan County, Colorado, *in* Jensen, F. S., and others, eds., The oil and gas fields of Colorado: Denver, Colo., Rocky Mtn. Assoc. Geologists, p. 122.

No. on pl. 34

145 Thurston, W. R., 1954, Structure contour map of the Abbott field, T. 2 S., R. 54 W., Washington County, Colorado, *in* Jensen, F. S., and others, eds., The oil and gas fields of Colorado: Denver, Colo., Rocky Mtn. Assoc. Geologists, p. 70.

146 Tollefson, O. W., 1955, Geology of central Middle Park, Colorado: Ph. D. dissertation, Colorado Univ., 148 p.

147 Van Horn, Richard, 1957, Bedrock geology of the Golden quadrangle, Colorado: U.S. Geol. Survey Geol. Quad. Map GQ–103.

148 Volk, G. D., 1954, Structure contour map of the Logan field, T. 8 N., R. 54 W., Logan County, Colorado, in Jensen, F. S., and others, eds., The oil and gas fields of Colorado: Denver, Colo., Rocky Mtn. Assoc. Geologists, p. 196.

149 Wahlstrom, E. E., 1944, Structure and petrology of Specimen Mountain, Colorado: Geol. Soc. America Bull., v. 55, p. 77–89.

150 ——— 1956, Petrology and weathering of the Iron Dike, Boulder and Larimer Counties, Colorado: Geol. Soc. America Bull., v. 67, p. 147–163.

151 Wakefield, Lawrence, 1952, Geology of the Boetcher Ridge-Sheep Mountain Delanos Butte area, North Park, Colorado: M.A. thesis, Colorado Univ., 74 p.

152 Walton, P. T., 1944, Geology of the Cretaceous of the Uinta Basin, Utah: Geol. Soc. America Bull., v. 55, p. 91–130.

153 Wanek, L. J., 1953, Geology of an area east of Wolcott, Eagle County, Colorado: M.A. thesis, Colorado Univ., 62 p.

154 Welsh, J. E., 1953, Geology of the Sheep Mountain-Delaney Butte area, North Park, Colorado, *in* Wyoming Geol. Assoc. Guidebook 8th Ann. Field Conf., Laramie Basin, Wyoming and North Park, Colorado, 1953: p. 99–100.

155 White, C. A., 1889, On the geology and physiography of a portion of northwestern Colorado and adjacent parts of Utah and Wyoming: U.S. Geol. Survey 9th Ann. Rept., p. 677–712.

156 Williams, N. C., 1953, Late Precambrian and early Paleozoic geology of western Uinta Mountains, Utah: Am. Assoc. Petroleum Geologists, v. 37, p. 2734–2742.

157 Williamson, N. H., 1954, Structure contour map of the Lewis Creek field, T. 11 N., R. 52–53 W., Logan County, Colorado, *in* Jensen, F. S., and others, eds., The oil and gas fields of Colorado: Denver, Colo., Rocky Mtn. Assoc. Geologists, p. 188.

158 ——— 1954, Structure contour map of the N. W. Graylin field, T. 8–9 N., R. 53–54W., Logan County, Colorado, *in* Jensen, F. S., and others, eds., The oil and gas fields of Colorado: Denver, Colo., Rocky Mtn. Assoc. Geologists, p. 152.

159 ——— 1954, Structure contour map of the Graylin field, T. 8 N., R. 53 W., Logan County, Colorado, *in* Jensen, F. S., and others, eds., The oil and gas fields of Colorado: Denver, Colo., Rocky Mtn. Assoc. Geologists, p. 148.

160 Wilmarth, V. R., 1953, Yellow Canary uranium deposits, Daggett County, Utah: U.S. Geol. Survey Circ. 312, 8 p.

161 Wolfe, R. L., 1954, Structure contour map of the Willard field, T. 7 N., R. 54–55 W., Logan County, Colorado, in Jensen, F. S., and others, eds., The oil and gas fields of Colorado: Denver, Colo., Rocky Mtn. Assoc. Geologists, p. 286.

No. on pl. 34

162 Wyeth, J. C., 1955, Craig dome, Moffat County, Colorado, *in* Intermountain Assoc. Petroleum Geologists and Rocky Mtn. Assoc. Geologists, Guidebook to the geology of northwest Colorado, 6th Ann. Field Conf., 1955: p. 86–87.

163 ——— 1955, Bell Rock dome, Moffat County, Colorado, *in* Intermountain Assoc. Petroleum Geologists and Rocky Mtn. Assoc. Geologists, Guidebook to the geology of northwest Colorado, 6th Ann. Field Conf., 1955: p. 84–85.