Geology and Coal Resources of the Henryetta Mining District, Okmulgee County, Oklahoma

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By R. J. DUNHAM *and* J. V. A. TRUMBULL

A CONTRIBUTION TO ECONOMIC GEOLOGY

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GEOLOGY AND COAL RESOURCES OF THE HENRYETTA MINING DISTRICT, OKMULGEE COUNTY, OKLAHOMA

By R. J. DUNHAM and J. V. A. TRUMBULL

ABSTRACT

The mapped area of the Henryetta mining district includes about 168 square miles in Okmulgee County in the east-central part of Oklahoma. The rocks in this district consist of sandstone, silty shale, and shale, and are divided into the Senora formation and the overlying Calvin sandstone of Pennsylvanian age.

Coal occurs in the Senora formation in two minable beds: the Morris bed and the overlying Henryetta bed. The Morris bed averages about 16 inches in thickness. Mining of this bed has been restricted for the most part to strip mining in the northeastern section of the mapped area, where the strata have a gentle westward dip of about 1 degree. The Henryetta coal bed averages about 25 to 36 inches in thickness and has been mined extensively to the east, west, and south of the north-trending Henryetta-Schulter anticline, the only important structural feature in the district. Although this anticline is locally faulted, displacements of the faults are small. At present, the large operating coal mines are on the western side of the anticline.

The coal in the Henryetta and Morris beds is of high volatile A and B bituminous ranks. Coal from the Henryetta bed was being used in 1952 in blends for the manufacture of coke at the Sheffield steel plant at Houston, Tex.

The total remaining coal reserves in the Henryetta district are estimated to be 275 million tons. Of this total, 271 million tons is in the Henryetta bed and 4 million tons is in the Morris bed.

INTRODUCTION

In the course of re-estimating the coal reserves of the State of Oklahoma, the U. S. Geological Survey and the Oklahoma Geological Survey recognized the need for a detailed investigation of the Henryetta coal bed in southern Okmulgee County in the vicinity of the town of Henryetta, the center of one of the most productive coal-mining districts in the State. The resulting investigation had as important associated objectives the determination of whether the coal mined at Morris, a town 13 miles to the northeast, should be correlated with the Henryetta coal bed, and whether the area contains any other beds of minable coal.

Field work extended over a period of 4 months in the summer and fall of 1951, and additional field work occupied about 2 weeks in the spring of 1952. Aerial photographs at the scale of 1 : 20,000 were studied stereoscopically in the office and in the field, and field data were recorded directly upon them. The geologic data, drainage, and culture on the photographs were assembled by tracing them directly onto transparent cellulose acetate sheets, which were used, together with township plats of the Bureau of Land Management, in the final compilation of the geologic map. The area is well suited to this method of compilation because a rectangular system of section-line roads marks the land survey lines clearly, and the topographic relief of most of the area is not great enough to cause serious distortion. Stratigraphic sections were measured by hand level and tape and by aneroid traverse. Mines and mined-out areas were located from company and other mine maps and insofar as possible were investigated in the field.

PREVIOUS PUBLICATIONS

The geology of the Henryetta area was described by Taff in 1905 in a report that dealt mainly with the coal-mining districts to the south, but included a small-scale map and brief description of the Henryetta coal bed and its outcrop. Clarke and Bauer (1921) and Clarke (1926) reported on the geology of Okmulgee County with reference to oil and gas. Shannon (1926) presented a summary description of Oklahoma's coal resources, in which he included outcrop maps of the Henryetta coal bed and the data from six deep-core holes drilled to determine the westward extent of the coal.

ACKNOWLEDGMENTS

The writers are indebted to Malcolm C. Oakes of the Oklahoma Geological Survey for cooperation throughout the investigation, for tracing the Senora formation and the Calvin sandstone from their type localities northward into the Henryetta district, and for spending several days in field conference. John T. Cole, mining engineer, of Okmulgee, generously provided maps of coal prospect openings and mines around Henryetta and Morris, in addition to supplying a great deal of background information, particularly about mines now abandoned. For other mine maps and data, and particularly for their friendly cooperation, thanks are extended to M. A. Berman, Starr Coal Co.; Gene Taylor and Ned Wilson, Ben Hur Coal Co.; Fred Steckelberg, Atlas Coal Corp.; S. E. Grafe and Frank Whitaker, McGinnis and Grafe Coal Co.; Cecil Arnold and Fred Burkhardt, Sinclair Coal Co.; and John M. Malloy, chief mine inspector, State of Oklahoma.

GEOGRAPHY

The mapped area lies in east-central Oklahoma about 45 miles south of Tulsa (fig. 29). It includes 168 square miles lying largely in southern Okmulgee County, but including, in its southeastern corner, 4 square miles of McIntosh County (pl. 21). Altitudes range from a little less than 600 feet in Deep Fork valley, which receives the runoff from most of the area, to a little more than 900 feet on the hills in the southwestern part of the area. The broad alluvial plain of Deep Fork separates the moderately hilly land in the southwest from the flat or gently rolling land in the northeast.

The largest town in the area is Okmulgee, the former capital of the Creek Indian Nation and present-day county seat, which had in 1950

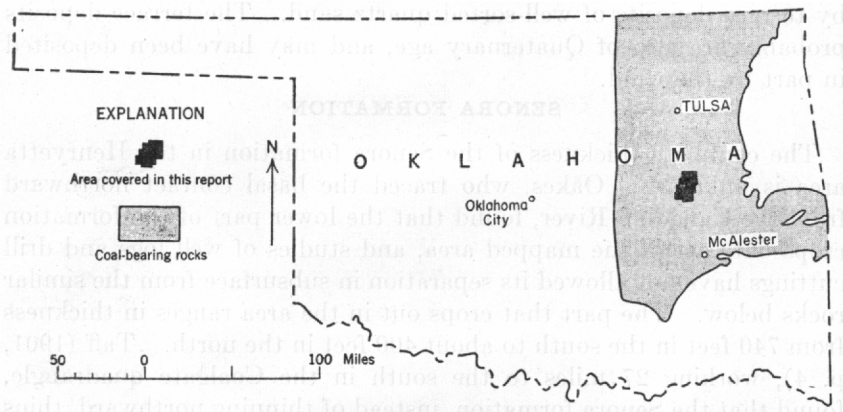

FIGURE 29.—Index map showing area investigated and extent of coal-bearing rocks in Oklahoma.

a population of 18,317. Henryetta, the next largest town, had in the same year a population of 7,987. Morris, the third largest town, with a 1950 population of 1,122, was a center of large-scale strip mining until operations were abandoned in 1951. The St. Louis–San Francisco; the Kansas, Oklahoma & Gulf; and the Okmulgee Northern railroads serve the area, together with 3 paved highways, U. S. Routes 62, 75, and 266. Many improved dirt roads provide easy access to all parts of the area.

STRATIGRAPHY

The rocks exposed at the surface in the Henryetta district are of Pennsylvanian age, and are correlated with a part of the Des Moines sequence of Kansas and Iowa. They have been divided into the Senora formation and the overlying Calvin sandstone, both of which consist largely of shale, silty shale, and fine-grained and very fine-grained sandstone. Coal is found only in the Senora formation. The sandstone beds are rather well exposed and are expressed in the

topography by cuestas and stony ledges overlooking shale prairies and valleys. The distribution of sandstone is shown on the geologic map (pl. 21). The stratigraphic diagram, plate 22, illustrates the interrelations of the rock units, and shows the relative positions of sections measured during the field work.

Taff (1901, p. 4) named and first described the Senora formation and the Calvin sandstone in his report on the Coalgate quadrangle. He did not designate type localities, but presumably the former was named for the long-abandoned village of Senora in the SE¼SE¼ sec. 22, T. 11 N., R. 13 E., Okmulgee County, and the latter for the town of Calvin in the Coalgate quadrangle.

The bedrock is obscured over large areas by Recent alluvium, as much as 40 feet thick in the SW¼SE¼ sec. 16, T. 13 N., R. 13 E, and by terrace deposits of well-sorted quartz sand. The terrace deposits probably are also of Quaternary age, and may have been deposited in part by the wind.

SENORA FORMATION

The complete thickness of the Senora formation in the Henryetta area is unknown. Oakes, who traced the basal contact northward from the Canadian River, found that the lower part of the formation crops out east of the mapped area, and studies of well logs and drill cuttings have not allowed its separation in subsurface from the similar rocks below. The part that crops out in the area ranges in thickness from 740 feet in the south to about 400 feet in the north. Taff (1901, p. 4), working 27 miles to the south in the Coalgate quadrangle, found that the Senora formation, instead of thinning northward, thins southwestward from 500 feet to 150 feet. The maximum thickness of the formation thus would seem to lie between the two areas.

Taff described the Senora formation as being composed of a lower sandstone and an upper shale. No such characterization can be applied to the area of the present investigation. Here, except for the area north of the latitude of Schulter, the Senora formation is a monotonous sequence of sandstone regularly alternated with thicker beds of shale and silty shale, the sandstone to shale ratio being almost 1:4.

North of the latitude of Schulter the two sandstones next above the Henryetta coal bed and the two next below it thicken and coalesce to form a mass of current-marked sandstone about 200 feet thick, through the middle of which passes a zone of highly carbonaceous shaly sandstone equivalent to the Henryetta coal. (See pl. 22.) The outcrop of the coalesced mass is centered in sec. 35, T. 13 N., R. 13 E., and covers 5 square miles. At this latitude the Senora sandstone to shale ratio is almost 1:1. Farther to the north all the sandstone mapped in the Senora formation changes abruptly to shale and silty

shale. None of the sandstone beds recognized in the south extends north of Morris more than a mile. (See pl. 21.)

The sandstone in the mapped part of the Senora formation is commonly crossbedded and ripple marked and locally contains many fossil plant remains, many of which are casts of pieces of scale-trees the size of stovewood. As a general rule, the grains making up the sandstone are appreciably finer than those of the Calvin sandstone, falling in the "very fine" division of the Wentworth scale. These sandstone beds of the Senora formation grade laterally and vertically into silty shale, which is generally micaceous, commonly sandy and carbonaceous, and in many exposures ripple marked. In the spillway below the Lake Henryetta dam, well-developed ripple marks are excellently exposed in the silty shale below the horizon of the Morris coal. The nonsilty or clay shale of the mapped area is gray, locally calcareous, and generally contains nodules and stringers of sideritic ironstone distributed along bedding planes. The few beds of limestone found in the Senora formation are thin and very shaly, and bear an abundance of marine fossils.

Many of the stratigraphic sections which were measured during the field work are printed at the end of this report, and much of the Senora formation is described in greater lithologic detail there.

About 200 feet below the base of the lower continuous sandstone of the Calvin sandstone is the Henryetta coal bed, which is by far the thicker, more extensive, and more valuable of the two minable coal beds in the area. Its outcrop extends the length of the mapped area (pl. 23), but through the sandstone mass in the southeast corner of T. 13 N., R. 13 E., it is present only as a 4-foot bed of very carbonaceous shaly sandstone. Immediately to the north and south of this sandstone mass the coal is too impure to be mined profitably, but further south, in the area where it has been extensively mined by underground methods in the general vicinity of Henryetta and Schulter, it averages 36 inches in thickness and has few or no partings. Through most of this mining area the coal is overlain by gray clay shale, but northward from Coalton the shale becomes increasingly silty and sandy. Northward from the sandstone mass, the Henryetta coal again becomes of minable purity, and where it has been strip mined, from the south side of sec. 14, T. 13 N., R. 13 E. northward to a point 1 mile beyond the north boundary of the map, it averages 25 inches in thickness and has an overburden of silty shale. About 50 feet above the Henryetta coal a stringer of coal 2 to 5 inches thick was observed at two localities in the northern part of T. 13 N., R. 13 E.

A more detailed description of the nature, distribution, and mining of the Henryetta coal bed is given on page 194.

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A second coal bed has been strip mined near the town of Morris, in the northeastern part of the area. This bed averages 16 inches in thickness in that area and lies about 125 feet below the Henryetta coal. It is designated in this report as the Morris coal bed. Its outcrop has been traced to a point 5 miles south of Morris, where the interval between it and the overlying Henryetta coal has increased to about 180 feet. Through this distance its thickness changes erratically, ranging from 2 to 15 inches and even to 36 inches in one extremely small area (see pls. 23 and 24, section nos. 96–114). The Morris coal bed is underlain by silty and sandy shale, and is overlain by clay shale, though in a few localities a few inches of silty limestone intervene immediately above the coal. A coal stringer from ½ to 5 inches thick, overlying 4 feet of shale containing thin lenses of coal, is exposed north of Lake Henryetta in the southern part of the area. It lies about 200 feet below the Henryetta coal bed, and since it is in the stratigraphic position of the Morris coal, it is considered to be an extension of that bed.

The nature, extent, and mining of the Morris coal bed is discussed in more detail on page 197.

The presence of marine fossils, plant remains, coal, and current-marked sandstone beds of irregular thickness and extent suggests that the Senora formation was deposited in coastal swamps, deltas, and near-shore waters of a shallow sea, the margin of which migrated back and forth across the bordering lowland. The 200-foot mass of current-marked sandstone between Schulter and Morris seems to indicate strongly the existence there in Pennsylvanian time of a delta.

CALVIN SANDSTONE

Taff (1901, p. 4) described the Calvin sandstone in the Coalgate quadrangle as a deposit of massive and thin-bedded sandstone thinning southwestward from 240 feet to 140 feet and containing some shaly beds in the upper part. In the area of the present investigation, the formation is divisible into three parts: an upper sandstone; a lower sandstone, which intertongues with the underlying Senora formation; and a middle shale. Excluding the intertonguing part, the Calvin sandstone maintains a fairly uniform thickness of about 200 feet as far north as Schulter, beyond which the middle shale thins until at Okmulgee the formation is but 100 feet thick. The sandstone units are very prominent in the topography south of Okmulgee, but northward they become shaly and their outcrop is difficult to distinguish from that of the middle shale or the shale in the Senora formation.

The upper sandstone ranges in thickness from 40 to 50 feet and, though somewhat changeable, is the most lithologically uniform and

topographically resistant unit in the mapped area. It is light yellow-brown, generally massive, and fine grained. The middle shale ranges in thickness from 140 feet to 24 feet. It is gray and generally free of silt and sand grains, and locally contains as many as three 1-foot beds of hard crystalline limestone carrying numerous pelecypods, brachiopods, and other fossils. The limestone beds are lenticular and cannot be correlated from hill to hill. The lower sandstone ranges in thickness from 15 feet to 80 feet, exclusive of the tongue at the base. For the most part, the lower sandstone, like the upper, is light yellow-brown and generally massive, resistant, and fine grained; in some places, however, it is shaly, weak, and very fine grained, like that in the Senora formation, and exhibits plant impressions. Details of the lithology of the Calvin sandstone are given in measured sections nos. 5 and 11, and in the upper parts of nos. 30 and 44, at the end of this report.

The massive, relatively coarse-grained phase of the lower sandstone of the Calvin locally exhibits intricately contorted bedding planes. The contortions are probably due to movements induced by gravity while the sand deposit was still loose and filled with water. Present-day quicksand "flows" in the same manner. Upon weathering, the contorted bodies of sandstone break along bedding planes and produce a litter of strongly curved plates several feet in diameter. The sandstone plates are particularly well exposed on top of the hill immediately northwest of Coalton, and contorted sandstone in place is excellently exposed on the cliffs near the south quarter corner of sec. 32, T. 12 N., R. 13 E.

Between the town of Henryetta and Deep Fork, a long tongue (shown as unit 1a on pl. 22) about 15 feet thick projects northward from the lower sandstone of the Calvin down into the shale of the Senora formation. The shale separating the tongue from the rest of the Calvin sandstone is thin south of the latitude of Coalton and could reasonably be left unmapped. But northward from Coalton the shale thickens and the tongue rapidly descends in the section, until in sec. 10, T. 12 N., R. 13 E., the shale is about 120 feet thick and the tongue is but 70 feet above the Henryetta coal bed, a descent of 100 feet in 3 miles. The rocks are sufficiently well exposed so that the intertonguing is convincingly demonstrated. This is particularly true on the dip-slope hill northwest of Coalton. At the top of the dip slope the tongue is 170 feet above the coal, and at the bottom of the dip slope, in sec. 17, T. 12 N., R. 13 E., at the Sun mine, the tongue is about 100 feet above the coal.

At these northern localities the tongue occurs on about the same stratigraphic level as the uppermost part of the sandstone mass in the Senora formation on the north side of Deep Fork. Silty and sandy

shale, laterally gradational with the sandstone mass, join the tongue to the underlying sandstone of the Senora formation on the south side of Deep Fork. Both of these facts suggest that the basal tongue of the Calvin sandstone is continuous with the sandstone mass in the Senora formation; however, Quaternary alluvium and terrace deposits obscure the bedrock in the critical area. For convenience in mapping, the tongue is shown to pinch out beneath the alluvium of Deep Fork.

It is evident from the intertonguing of the two formations that part of the upper shale of the Senora formation and part of the lower Calvin sandstone were deposited contemporaneously. At no place in the area of investigation is there evidence of an erosional or nondepositional break between the two formations, nor have they been reported by workers in other areas.

The Calvin sandstone underlies the Wetumka shale. The contact was examined only at the excellent exposure in Okmulgee Creek, just north of the south quarter section corner of sec. 6, T. 13 N., R. 13 E., where it appears conformable. The presence in the Calvin sandstone of both plant impressions and marine limestones suggests that the nearshore environment of the Senora continued during the deposition of the Calvin. The scarcity of plant impressions and the absence of coal suggest further that the influence of the sea dominated deposition more strongly than before.

STRUCTURE

Considered regionally, the rocks on the surface in this part of Oklahoma strike about 15° east of north and dip about 1° toward the west. This gentle westward dip is interrupted in the mapped area by only a few structural features, of which the Henryetta-Schulter anticline is by far the most important. Only those measurements that show deviation from the regional dip have been shown by symbols on the geologic map.

HENRYETTA-SCHULTER ANTICLINE

The structural feature most important to coal miners is a locally faulted, asymmetric anticlinal flexure that extends through T. 12 N., R. 13 E., from Henryetta to Schulter, and changes the elevation of the coal a maximum amount of 135 feet in an east-west distance of less than half a mile. Shannon (1926, p. 38 and pl. 22) proposed the name "Henryetta anticline" for the flexure, but Clarke (1926, p. 9) referred to it later as the "Schulter anticline." Cole and most of the miners follow Clarke's usage. The two names have been linked in this report.

The flexure is expressed at the surface by a belt of eastward-dipping rocks, 1,000 to 2,500 feet wide, that stretches from the SE¼ sec. 8,

T. 12 N., R. 13 E., to the SE¼ sec. 31. Throughout the belt the rocks dip toward the east more steeply than 2°, attaining 25° locally and probably averaging about 5°. In several places rather well-defined crop lines can be traced part or all the way from the area of normal westward dip, into and across the belt of reverse dip, then into the area of normal westward dip on the opposite side of the flexure. As would be expected, the crop lines gradually rise toward the west. This is best exhibited by sandstone unit 5 of the Senora formation, which rises progressively northwestward from an altitude of about 640 feet at the Geary and Martin mine in the NE¼SW¼ sec. 32 to about 690 feet in the gully near the drifts of the Atlas No. 2 mine and the Blackstone No. 3 mine in the SE¼SE¼ sec. 30. From the latter location the bed descends northeastward to an altitude of about 650 feet at the shaft of the abandoned Atlas No. 1 mine in the SW¼ sec. 29. Along both these traverses the sandstone is unfaulted and rather well exposed.

The mines near the east side of this belt of eastward dipping rocks open the Henryetta coal bed by slopes and shafts 50 to 100 feet deep; those at the west side of the belt open the coal by drifts (see pl. 23). The only large mines presently active are those on the west side of the flexure, and the predecessor of each mined partly or completely across the flexure. In secs. 29 and 30, T. 12 N., R. 13 E., near the southern end of the flexure, the workings of the Atlas No. 1 shaft mine extend without interruption into those of the Atlas No. 2 drift mine. A detailed map of these combined workings, prepared in 1920 by C. E. Schurch, shows that the coal dips smoothly eastward from the drift to the shaft, descending 60 feet in 2,000 feet. A half mile to the south, the Blackstone slope mines, Nos. 1 and 2, mined the eastward-dipping coal until they almost merged with, and were abandoned in favor of, the No. 3 drift mine. Neither of these operations met with faults having displacements of more than a few feet.

In the abandoned Starr (old No. 2) shaft mine in sec. 29, where the flexure is most strongly developed, the east dip of the coal increases from 3° at the shaft to 10° 500 feet west of the shaft. Rather than mine coal of such steep dip, the operators drilled a series of test holes across the flexure and opened the No. 2 drift, where they found the coal about 135 feet higher than that in the bottom of the shaft. The new mine reached a local, intensely faulted anticline about 2,000 feet in from the portal, but mined through it into undisturbed beds, and has continued operating without further difficulty.

The abandoned and now inaccessible Whitehead No. 4 shaft mine, a mile north of the Starr mines, also took coal from the flexure. It is said that the coal in the bottom of the shaft dips 15° toward the east and continues to dip in the same direction for 500 feet eastward down

the main haulageway. Throughout this distance the dip is so steep that slope mining methods had to be used.

Northward, the Henryetta-Schulter anticline disappears beneath the alluvium of Montezuma Creek and of Deep Fork. At the south end of the structure, no east dips are evident on the surface south of the hill in the SE¼ sec. 31, T. 12 N., R. 13 E., near the north side of the city of Henryetta; though the presence of the anticline is reported to have been detectable in now-abandoned mines as far south as the southwest corner of the city.

Faults.—Many small faults cut the poorly exposed surface rocks in the NW¼ sec. 29 and the SW¼ sec. 20, T. 12 N., R. 13 E., near the Starr mines. A small number of faults having a displacement of a few feet were reported to cut the coal in the mines, and others may have gone unrecognized in the area that was drilled but not mined, and in the area where only shale crops out. The faults observed at the surface are evidenced by near-parallel lines of steeply dipping small slabs of sandstone that trend generally northward. The displacement on these faults cannot be measured, but their lack of appreciable offset indicates that they are not much larger than those in the mines. Two observations indirectly suggest that most or all of the small faults are downthrown on the west, their cumulative effect being to decrease the difference in elevation between the two sides of the flexure: (1) on the crest of the flexure, the shale between sandstone unit 5 of the Senora formation and sandstone unit 1a of the Calvin sandstone appears abnormally thin; and (2) on the east flank, where the dip of sandstone unit 5 of the Senora formation is several degrees steeper than the slope of the land, the outcrop of this sandstone is abnormally wide.

A second group of small faults is shown on the geologic map in the vicinity of Schulter. Here the strata in the east limb of the flexure dip eastward at an average rate of 8° for a distance of a quarter of a mile. The difference in elevation between the two sides of the flexure is not the 185 feet one would expect from the dip, however, but appears to be only about 50 feet. The exposures are not good enough to permit reliance on the measurements, though their order of magnitude probably is correct. The contradiction is most readily resolved by postulating that the flexure is cut by another group of small faults, all or most of which are also downthrown on the west. The displacement on a single fault would be so small that the available exposures would not allow its recognition, but the cumulative displacement of the group would be sufficient to drop the top of the flexure to within 50 feet of the bottom. That this group of postulated faults does not extend far to the south is evidenced by two wells drilled for oil which are located 400 feet apart on an east-west line in the NE¼NW¼ sec. 20.

Marker beds were 100 feet lower in the east well than in the west, which would correspond to an average east dip of 15° over the distance between the two wells.

The only other fault observed in the flexure occurs in the SE¼ sec. 31, T. 12 N., R. 13 E., in the trough of a subsidiary fold. It is very likely that small faults are present elsewhere in the flexure, but they could not be recognized in the available exposures.

An alternative explanation of the nature and configuration of the Henryetta-Schulter anticline which is accepted by several geologists is that it includes a fault with displacement on the order of 100 to 150 feet, downthrown on the east. If this were true the lower sandstone of the Calvin, or its basal tongue, or both, would be found in the downthrown block, and would be present under and outcrop south and east of Coalton, where sandstone of the Senora formation unit 6 is shown on the geologic map, plate 21. The nature of the occurrence of the Henryetta coal as revealed in mineworkings, and the stratigraphic evidence of the measured sections shown graphically in the generalized stratigraphic diagram, plate 22, are the main points which have led the writers to reject the interpretation that a large fault is present in the area.

OTHER STRUCTURAL FEATURES

A structural terrace about a mile wide and 5 miles long trends southwestward through the town of Morris and has resulted in a synclinal remnant of the Morris coal bed in the SE¼ sec. 18, T. 13 N., R. 14 E., and an inlier of the same coal bed in sec. 25, T. 13 N., R. 13 E. Further evidence of the terrace is seen in the abrupt deflections of the outcrop trace of the Morris coal bed in the flat country at Morris, and in the great outcrop width of the interval between the Henryetta coal zone and the Morris coal bed in the vicinity of the southeast corner of T. 13 N., R. 13 E.

A probably faulted fold containing beds dipping as steeply as 40° is exposed in the gully in the SE¼ sec. 21, T. 12 N., R. 13 E. The neighboring rocks are neither faulted nor folded, and it is doubtful that the disturbed area exceeds 1,000 feet in diameter.

A second small probably faulted fold occupies a quarter of a square mile on the east side of sec. 36, T. 12 N., R. 12 E. Here too the neighboring rocks are neither faulted nor folded, though the rocks in the disturbed area dip as steeply as 30°. Below ground, this area is encircled by mine workings in which the coal follows the regional dip without interruption.

A faulted anticline 350 feet wide and 20 feet high occurs on the west side of the Henryetta-Schulter anticline in the Starr No. 2 mine. It exhibits five faults, only the largest of which has more than 8 feet of

displacement. That fault drops the coal 20 feet on its west side and dips S. 70° W. at 50°. The faulted anticline is absent in the mines nearby.

Other interruptions of the regional dip may be obscured by the prevailing lack of distinctive beds and the absence in many places of mappable ledges.

COAL

The Henryetta and Morris coal beds in the Senora formation contain all the minable coal near the surface in the investigated area. The average thickness of minable coal in the Henryetta bed is 36 inches in the south and 25 inches in the north, and that in the Morris bed is 16 inches. In spite of their thinness, both coal beds are favorable to mining. Overburden, roof, and floor conditions are generally good, water and gas do not occur in sufficient quantity to hinder underground mining, and, except on the Henryetta-Schulter anticline, neither faults nor folds seriously interfere with the gentle westward dip.

HENRYETTA COAL BED

The Henryetta coal bed lies from 125 to 200 feet above the level of the Morris coal bed and about 200 feet below the base of the lower continuous sandstone of the Calvin. (See pls. 22 and 23.) It crops out the length of the mapped area under a cover of soil, the over-all trend of its outcrop being N. 13° E.

In the middle of the 200-foot coalesced sandstone mass, previously described in the stratigraphy of the Senora formation, a zone of very coaly sandstone occurs at the stratigraphic position of the Henryetta coal bed. This coaly sandstone areally divides the Henryetta coal bed into two parts—one that is strip mined west of Morris, north of the mass, and one that is mined underground around Schulter, Coalton, and Henryetta, south of the mass. The thickness of the bed, distribution of partings, and nature of overburden differ on opposite sides of the mass.

South of the sandstone mass the thickness of clean coal in the Henryetta coal bed ranges from about 28 inches to the maximum of 41½ inches which was measured in the SW¼NE¼ sec. 18, T. 12 N., R. 13 E.; but in most of the area the bed thickness departs remarkably little from an average of 36 inches, and the average thickness of clean coal is just a little less. Measured sections of coal taken from the Henryetta bed are shown in plate 24, Nos. 1–95. Throughout most of the mined area the middle of the bed exhibits a parting which the miners call the "middle band." This parting thickens southward from a trace at Coalton to almost 18 inches at the center of the SE¼ sec. 29, T. 11 N., R. 13 E., and has a thickness of more than 4 inches

in several of the mines in the southwestern part of the district. The decrease in total thickness of clean coal accompanying the thickening of the parting did much to bound the southward growth of the mining district. The parting is absent in the mines working the east side of T. 12 N., R. 12 E., and it is ordinarily absent or too thin to hinder mining in the area between Coalton and Schulter. Where the parting is thick, it consists of gray shale containing thin laminae of coal and of the powdery substance lost in mining called "mother of coal," "mineral charcoal," or fusain; layers of coal locally an inch or so thick are also included. Where thin, the bulk of the parting consists of interbedded fusain and coal. In the immediate vicinity of the sandstone mass, in the center of sec. 10, T. 12 N., R. 13 E., coaly shale contaminates all but 17 inches of the Henryetta bed.

The overburden on the Henryetta coal south of the area of influence of the sandstone mass consists of a uniform-textured gray shale, 60 to 100 feet thick, overlain in turn by sandstone. The upper part of the shale becomes increasingly silty and sandy northward from Coalton, and near the edge of the sandstone mass the overburden is practically all sandstone and silty and sandy shale that grades northward into sandstone. Intervening between the shale and coal in some places is a few inches of coaly shale, which falls when the coal is mined unless it is supported. The floor rock ordinarily consists of a few feet of soft gray underclay, except in the area bordering the sandstone mass, where the floor rock resembles the overburden.

Two reference beds underlie the coal south of the mass. One is a resistant bed of sandstone 1½ to 10 feet below the coal bed and 4 to 12 feet thick, designated 5b (pl. 21). The second is a distinctive bed of shaly limestone 15 to 30 feet below the coal and 2 to 4 feet thick, which contains a great abundance of well-preserved spiny brachiopod shells about a half inch in diameter. After being exposed a short time, the shells weather out of the bed and form a white rubble that is a reliable and prominent guide to the position of the Henryetta coal bed. The most easily reached exposure of the limestone is in the railroad cut in sec. 4, T. 11 N., R. 13 E., 2 blocks south of the center of the town of Dewar. This bed does not extend farther south than Henryetta or farther north than Coalton, though an outlier occurs in the hills near Wildcat.

North of the coalesced sandstone mass, the thickness of the Henryetta coal bed, including partings, ranges from 50 inches near the east quarter-section corner of sec. 11, T. 13 N., R. 13 E., to 23 inches in the SW¼ sec. 1; however, where the bed is 50 inches thick, only 29 inches is clean coal. The several points of minimum thickness were measured by coal operators in prospecting for strippable areas, and their thick-

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ness figures probably include only the minable lower part of the bed, the upper part being mostly coaly shale. The average thickness of minable coal in this area is 25 inches. The lower part of the bed commonly contains 1 to 3 inches of coaly shale and fusain in 1 to 6 partings distributed rather irregularly through the coal. These impurities increase greatly in amount southward toward the sandstone mass, and have limited mining in that direction. Near the sandstone mass, clean coal occupies only 6 inches of the bed.

The lower 60 to 80 feet of overburden on the coal in this northern area is silty and sandy shale, and sandstone that grades northward into silty shale. The nearest distinctive beds are the Morris coal bed 125 to 140 feet below, and the shaly lower sandstone of the Calvin about 200 feet above, neither of which is prominent in the topography or well exposed.

Outside the mapped area the Henryetta coal is known to extend to the north, south, and west. It has been extensively stripped in sec. 31, T. 14 N., R. 14 E., immediately north of the mapped area, where the average thickness was 22 inches, and has been thoroughly prospected for a distance of 7 miles farther northeastward along the outcrop. Its average thickness is very nearly 17 inches of clean coal for 2½ miles of this distance, in secs. 3, 4, 9, 10, and 16, T. 14 N., R. 14 E. The land surface there is nearly level and the dip is low; it would thus seem to be a favorable site for strip-mining operations in the future. Unauthenticated reports of measurements on the outcrop of the Henryetta coal from as much as 6 miles south of the mapped area indicate that the bed decreases in thickness and purity in that direction.

West of the Henryetta mining area, 6 diamond drill holes, located 5 to 8 miles from the outcrop and 1½ to 4 miles ahead of mining, found the coal to be 35 to 39 inches thick. The holes are spaced 1 to 3½ miles from each other, and form a rough line nearly 9 miles long trending about N. 30° E. There is thus no indication of thinning as the coal becomes deeper toward the west; and though the many wells drilled in that area for oil and gas can be expected to interfere to some extent with mining and to reduce over-all recoverability, the almost certain presence of many square miles of coal of a thickness probably equal to that now being profitably mined is established. Two of these test holes are shown as nos. 46 and 47 on the coal map (pl. 23) and in the table of graphic coal sections (pl. 24); data on the others, which are west of the mapped area, are as follows (from Shannon, 1926, pl. 22):

Location	Coal thickness (in)	Depth to coal (ft.	in)
Sec. 17, T. 12 N., R. 12 E	35½	605	6
Sec. 20, T. 12 N., R. 12 E	38½	589	9
Sec. 32, T. 12 N., R. 12 E	35	588	6
Sec. 13, T. 12 N., R. 12 E	35	630	0

MORRIS COAL BED

Near Morris two coal beds have been mined in recent years (pl. 23). One crops out about 2 miles west of town; it lies on the stratigraphic level of the Henryetta coal bed mined at Henryetta, Coalton, and Schulter, and is considered to be an extension of that bed. The second, which at Morris lies about 125 feet below the Henryetta coal bed, crops out in the immediate vicinity of the town and is designated the Morris coal bed in this report.

The mapped outcrop of the Morris coal bed is about 7 miles long, and extends from the northern edge of the mapped area (2 miles north of Morris) to the hills in secs. 12 and 13, T. 12 N., R. 13 E., northwest of the village of Wildcat, where it lies about 180 feet below the Henryetta coal bed. Measured sections of coal from the Morris bed are shown in plate 24, Nos. 96–114.

The Morris coal bed overlies a distinctive sequence of silty and sandy beds more than 100 feet thick and underlies nongritty shale more than 25 feet thick. The beds of sandstone and silty and sandy shale are commonly carbonaceous in the upper part and are locally separated from the coal by a few feet or inches of underclay. The lower part of the nongritty shale above the coal is calcareous, and a few feet of shaly limestone commonly intervenes between the coal and the shale.

In the area around Morris in the N½ T. 13 N., the thickness of the Morris coal bed ranges from 12 to 22 inches and averages 16 inches, all of which is clean coal. Southward its thickness becomes very erratic. This is best illustrated by the excellent exposures in the S½NW¼ sec. 6, T. 12 N., R. 14 E.; there the coal thins southwestward in less than 2,000 feet from 36 inches to 2 inches.

Mining has been restricted to the area of fairly uniform thickness around Morris, where large scale power-stripping has been successful; to small team-stripping pits in the NW¼SE¼NW¼ sec. 6, T. 12 N., R. 14 E., where the coal reaches its maximum thickness of 36 inches in an extremely small area; and to the south quarter-section corner of sec. 12, T. 12 N., R. 13 E., near Wildcat, where the thickness is 15 inches. Minable coal in the Morris coal zone is unknown south of Wildcat.

North of Lake Henryetta, in the southern part of the area, a coal stringer a few inches thick overlies a 4-foot brown shale containing many laminae and thin lenses of coal. The coaly zone occurs between gritty and nongritty beds in the stratigraphic position of the Morris coal bed, here 200 feet below the Henryetta coal bed; it consequently is correlated with the coal at Morris and is labeled the Morris coal on the maps. (See pls. 21 and 23.)

OTHER COAL BEDS

The only other coal bed found at the surface is too thin and local to be mined. It crops out in a gully 1,000 feet southwest of the center of sec. 22, T. 13 N., R. 13 E., where it is but 5 inches thick, and it probably correlates with the 2-inch coal bed exposed in the railroad cut a short distance northwest of the tipple in the SE¼ sec. 11, T. 13 N., R. 13 E. At the latter place this coal is about 50 feet above the Henryetta coal bed.

Wells drilled for oil and gas penetrate about 2,000 feet of Pennsylvanian rocks below the Morris coal bed. The fact that these rocks are known to bear coal in other parts of Oklahoma suggests the possibility that future deep prospect core or churn drilling may uncover presently unknown beds of minable coal.

CHARACTERISTICS

The coal of both the Henryetta and the Morris beds consists of layers of coal having a vitreous appearance, more numerous layers of slightly duller coal, and a few layers of the powdery substance called fusain. Most of the layers are elongate lenses less than half an inch thick and several feet long. A microscopic study of thin sections of the Henryetta coal from the Atlas No. 2 mine (Davis and others, 1944, p. 17) showed its petrographic composition to be 74 percent anthraxylon, 17 percent translucent attritus, 4 percent opaque attritus, and 5 percent fusain. Almost all the thin sections contained fine particles of pyrite, and nodules and veins of pyrite can be seen in fresh exposures of the Henryetta coal beds. Probably most of the sulfur observed in chemical analyses is in the pyrite.

Chemical analyses of the Henryetta coal show that its heat value ranges from 11,700 to 13,450 Btu, on an as-received basis (table 1); an average figure for the Henryetta mining area, south of the Deep Fork, is 12,860 Btu. Its rank ranges from high-volatile A bituminous to high-volatile B bituminous, though by far the greater part is high-volatile B bituminous. Ash content ranges from 3.9 to 12.0 percent and averages 5.8 percent; lines of equal ash content point out that the amount of ash in the coal decreases westward downdip (fig. 30). The sulfur content of the Henryetta coal ranges from 4.3 percent to 0.7 percent, and decreases southwestward (fig. 31). It is noteworthy that toward the west the coal improves, not only in ash and sulfur content, but also in heat value and in thickness.

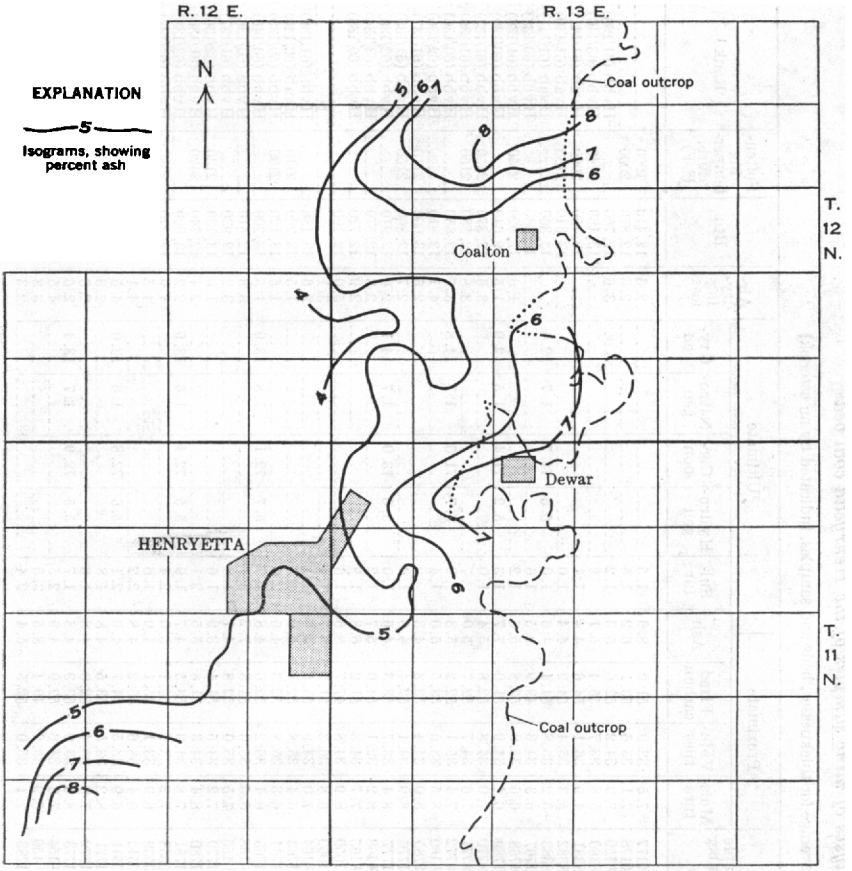

FIGURE 30.—Percentage of ash in Henryetta coal in the Henryetta coal field (based on data from table 1)

Development of the Morris coal bed has been so recent that no analyses of it have been published; however, two analyses, made by a commercial laboratory on an as-received basis, of samples from the strip mines near Morris are:

	Analysis 1 (*percent*)	*Analysis 2* (*percent*)
Moisture	4. 46	6. 49
Volatile matter	35. 15	35. 41
Fixed carbon	54. 75	53. 70
Ash	5. 64	4. 40
Sulfur	1. 41	2. 40
Btu	13. 325	13. 197

TABLE 1.—*Analyses of mine samples of the Henryetta coal bed*

[As received condition. An average for thicknesses, beds and samples, indicated by an asterisk]

Map no. (pl. 23)	Mine	Year sampled	Thickness (inches)		Sample number	Proximate				Ultimate					Air-drying loss	Btu	Softening temperature, (° F)	Rank [1]
			Bed	Sample		Moisture	Volatiles	Fixed carbon	Ash	Sulfur	Hydrogen	Carbon	Nitrogen	Oxygen				
7a	Victoria	1910	?	34	[2]10177	7.5	32.9	51.0	8.6	1.5					2.6	12,410	1960	
4b	Victoria	1910	34½	33½	[2]10178	7.1	33.6	53.1	6.2	1.5					2.6	12,870	2000	
7a–c	Wise-Buchanan No. 1	1928	*34	*31	[2]159	7.9	34.2	52.6	5.3	1.2					3.6	12,760		Hvbb (61/136)
7d	Wise-Buchanan No. 1	1931	32	26	A68380	5.8	33.7	55.4	5.1	.9						13,180	2140	Hvbb (63/140)
7e	Wise-Buchanan No. 1	1931	31½	29½	A68381	4.9	36.1	54.6	4.4	1.1						13,450	2060	Hvab (61/141)
7f	Wise-Buchanan No. 1	1931	37½	31½	A68382	5.3	35.4	54.9	4.4	1.0						13,310	2180	Hvab (61/140)
7d–f	Composite, A68380–A68382				A68383	5.2	35.8	54.4	4.6	1.0	5.6	74.7	1.7	12.4		13,360		Hvab (61/141)
8a	Whitehead No. 2	1926	36	33	A21767	6.3	34.3	49.9	9.5	1.6						12,360		Hvbb (60/138)
8b	Whitehead No. 2	1926	35½	33½	A21768	6.6	35.0	52.8	5.6	1.2					1.6	12,920	2150	Hvbb (61/138)
8a–b	Composite, A21767–A21768				A21769	6.4	34.9	51.0	7.7	1.3	5.2	71.4	1.5	12.9	1.5	12,640		Hvbb (60/139)
8c	Whitehead No. 2	1926	34	32	124770	7.0	34.8	52.8	5.4	1.0					3.6	12,870	2050	Hvbb (61/137)
8d	Whitehead No. 2	1926	34	33	124771	7.6	34.7	52.7	5.0	.7					3.8	12,880	2150	Hvbb (61/136)
8c–d	Composite, A24770–A24771				124772	7.4	35.1	52.2	5.3	.9	5.7	71.6	1.7	14.8	3.7	12,830		Hvbb (60/136)
10a–c	Pittsburg-Midway No. 12	1928	*35	*31	[2]160	8.5	33.0	53.5	5.0	1.4					4.1	12,810		Hvbb (62/136)
10d	Pittsburg-Midway No. 12	1926	32	28	1A2785	8.0	34.4	53.3	4.3	.9					2.6	13,000	2110	Hvbb (61/137)
10e	Pittsburg-Midway No. 12	1926	35	31	A21776	8.9	34.1	52.4	4.6	1.0					2.7	12,860	2150	Hvbb (61/135)
10d–e	Composite, A21775–A21776				A21777	8.4	33.7	53.3	4.6	1.0	5.6	73.0	1.7	14.1	2.6	12,910		Hvbb (62/136)
11a–c	McGinness No. 1	1928	*34	*29	[2]163	8.2	32.1	54.0	5.7	1.2					2.8	12,570		Hvbb (63/134)
21a	Gem	1928	39½	35½	[2]165	7.7	34.3	51.2	6.8	1.9					2.9	12,720		Hvbb (60/138)
22a	Cado	1904	38	38	[2]1059	8.9	34.8	47.7	8.6	1.6					5.0	12,100		
22b	Cado	1904	35½	35½	[2]1060	6.8	36.3	51.2	5.7	1.4					3.1			
24a–c	Warden-Pullen No. 2	1928	*36	*36	[2]164	7.0	34.9	53.5	4.6	1.1					2.6	13,180		Hvbb (61/139)
24d	Warden-Pullen No. 2	1926	35	35	A21763	6.4	35.8	52.8	5.0	1.5					1.5	13,260	2110	Hvab (60/140)
24e	Warden-Pullen No. 2	1926	35	35	A21764	6.3	36.8	52.3	4.6	2.0					1.5	13,120	2100	Hvbb (59/139)
24d–e	Composite, A21763–A21764				A21765	6.4	36.2	52.6	4.8	1.7	5.7	72.1	1.8	13.9	1.5	13,200		Hvbb (60/140)
31a–b	Wadsworth	1928	*33	*28½	[2]158	6.5	35.0	51.3	7.2	3.7					3.3	12,510		Hvbb (60/136)
41a–c	Atlas No. 2	1928	*35	*35	[2]155	7.5	35.0	52.8	4.7	1.8					3.2	12,930		Hvbb (61/137)
41d	Atlas No. 2	1926	37	37	A21779	7.2	34.5	54.4	3.9	1.6					1.9	13,130	2130	Hvbb (62/136)
41e	Atlas No. 2	1926	40½	40½	A21780	8.4	34.3	51.8	5.5	2.1					2.4	12,740	2420	Hvbb (61/136)
41d–e	Composite, A21779–A21780				A21781	7.8	34.0	53.5	4.7	1.9	5.5	72.4	1.6	13.9	2.2	13,000		Hvbb (62/138)
41f	Atlas No. 2	1941	37	37	B60538	7.2	33.7	54.1	5.0	2.4					4.9	12,920	2080	Hvbb (62/137)
41g	Atlas No. 2	1941	35½	35½	B60539	6.9	33.1	55.1	4.9	1.6					4.5	13,020	2100	Hvbb (63/138)
41h	Atlas No. 2	1941	36	36	B60540	6.4	33.6	55.2	4.8	2.2					4.1	13,010	2080	Hvbb (63/138)
41f–h	Composite, B60538–B60540				B60541	6.9	33.5	54.7	4.9	2.1	5.6	72.8	1.6	13.0	4.5	13,000		Hvbb (63/138)
42a	Starr No. 1	1926	37	37	A21771	8.2	33.5	53.5	4.8	1.8					2.3	12,900	2060	Hvbb (62/136)
42b	Starr No. 1	1926	34½	34½	A21772	7.8	35.4	52.0	4.8	1.6					2.6	12,990	1950	Hvbb (61/137)
42a–b	Composite, A21771–A21772				A21773	8.0	33.9	53.3	4.8	1.7	5.5	72.9	1.7	13.4	2.5	12,930		Hvbb (62/137)
43a–c	Starr (old) No. 2	1928	*36	*34½	[2]154	7.6	34.6	52.9	4.9	2.5					4.5	12,950		Hvbb (61/137)
48a–c	B. and A	1928	*38	*38	[2]156	6.9	35.2	49.4	8.5	3.5					3.3	12,475		Hvbb (59/138)
48d	B. and A	1926	41½	41½	A21783	7.1	35.0	52.5	5.4	2.4					2.3	12,920	2110	Hvbb (61/138)

48e	B. and A	1926	40	40	A21784	7.1	34.0	52.5	6.4	2.9					2.2	12,820	2130	Hvbb (62/138)
48f	B. and A	1926	40½	40½	A21785	7.1	34.7	51.5	6.7	2.6					2.1	12,840	2130	Hvbb (60/139)
48d–f	Composite, A21783–A21785				A21786	6.9	34.6	52.4	6.1	2.7	5.5	71.5	1.7	12.5	2.2	12,880		Hvbb (61/138)
51a–c	Sun	1928	*34	*35½	[1] 157	7.5	33.6	50.8	8.1	3.0					3.8	12,350		Hvbb (61/136)
61a–b	Coalton No. 1	1928	*37	*32	[1] 166	7.8	34.0	51.8	6.4	1.6					3.1	12,680		Hvbb (61/137)
62–b	Kincaid No. 2	1928	*46	*34	[1] 162	8.6	31.9	53.7	5.8	2.1					3.5	12,550		Hvbb (63/135)
63a–b	Kincaid No. 1	1928	*35	*32½	[1] 161	6.4	34.9	50.9	7.8	3.1					3.0	12,570		Hvbb (60/138)
84a–b	Gaither No. 1	1928	*27	*23	[1] 167	7.7	29.0	51.3	12.0	4.2					3.3	11,700		Hvbb (64/136)

[1] Hvab, high-volatile A bituminous; Hvbb, high-volatile B bituminous. The numbers in parentheses are a condensed expression of the position of the coal in the scale of rank. The parenthesis signifies that the contained numbers are on the mineral-matter-free basis; the first number represents fixed carbon on the dry basis, reported to the nearest whole percent; and the second number represents Btu on the moist basis, expressed as hundreds of Btu (to the nearest hundred). Calculations were made in accordance with the approximation formulas, except in a few borderline cases, where the Parr formulas were used. (American Society for Testing Materials, Standard Specifications for Classification of Coals by Rank, A. S. T. M. Designation: D 388–38.)

[2] U. S. Bureau of Mines analyses made before 1913 and bearing sample numbers below 16100 were made by methods for determining volatile matter and fixed carbon which were not standard with respect to temperature; consequently, determinations made before this date are not closely comparable with those made after 1913, when a standard temperature was adopted.

[3] These analyses were made by the Oklahoma Geological Survey in cooperation with the School of Chemical Engineering of the University of Oklahoma and the Department of Mines of the State of Oklahoma, and were published in Bulletin 51 of the Oklahoma Geological Survey, entitled "A chemical study of Oklahoma coals", by J. E. Moose and V. C. Searle. All other analyses were made by the U. S. Bureau of Mines, most of them having been published in Technical Paper 411 of the U. S. Bureau of Mines.

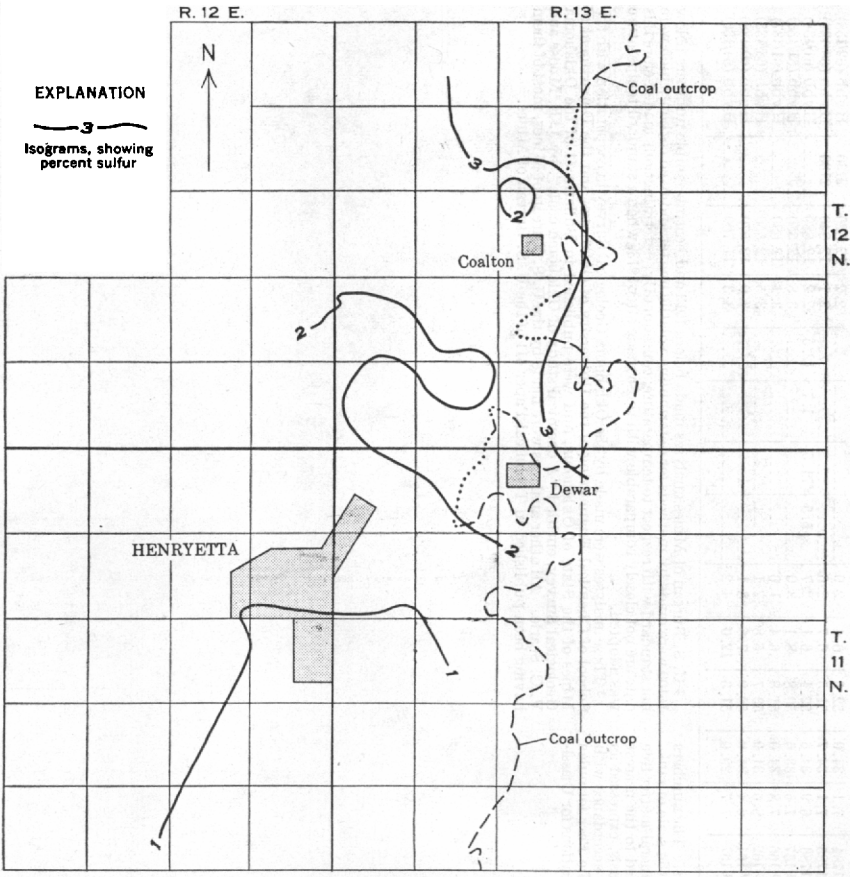

FIGURE 31.—Percentage of sulfur in Henryetta coal in the Henryetta coal field (based on data from table 1).

USES

The coal from the area is used by locomotives, industrial plants, and, in greatest quantity, by home furnaces. A large part of the output is shipped into the St. Louis area, and some reaches points as far north as Milwaukee.

Blast-furnace coke.—The U. S. Bureau of Mines in 1941, in cooperation with the Oklahoma Geological Survey, investigated the coking properties of the Henryetta coal and of various blends of the Henryetta coal with small amounts of Hartshorne coal. (See Davis and Reynolds, 1941, and Davis and others, 1944, p. 1–93.) The Henryetta coal tested came from the Atlas No. 2 mine, and the Hartshorne coal from the Quality mine and the Great Western mine, Sebastian County, Ark. Carbonization tests showed that satisfactory blast-furnace coke can be made from the Henryetta coal, alone or blended. Results of the tests also indicate that the low softening temperature of the ash would probably prohibit use of the coke in water-gas generators, and the resultant clinkering probably would make it unsuitable for domes-

tic heating; but neither of these features is a disadvantage for blast-furnace coke. (Davis and Reynolds, 1941, p. 5.)

The carbonization tests also showed that the high-volatile Henryetta coal by itself yields a weak coke that is lower in crushing strength than that from the high-volatile Appalachian coals ordinarily used, though it is somewhat stronger than the Lower Sunnyside coal of Carbon County, Utah, known to have been used successfully in blast furnaces. The Hartshorne coal, like other low-volatile coals, produces coke of great strength, but can be coked only in the outdated beehive-type ovens for its expansion will destroy the walls of modern byproduct ovens. When Henryetta and Hartshorne coals are mixed in the proper proportions, however, both these disadvantageous properties are lost. Coke made from a 70:30 or 80:20 blend of Henryetta and Hartshorne coals equals in strength the coke made from similar blends of representative eastern coals, and the pressure of its expansion is less than the 2.0 pounds per square inch considered the limit for safe operation of byproduct ovens.

Chemically, the eastern coke is superior. The coke from the Henryetta coal, alone and in blends, contains 1.5 to 1.8 percent sulfur—more than the 1.3 percent that is the preferred maximum in iron smelting, where most blast-furnace coke is used. The sulfur content could perhaps be reduced by substituting Henryetta coal that contains less sulfur than the 2.1 percent in the tested sample, or by substituting low-volatile coal that contains less than the 1.1 percent and the 0.9 percent in the tested samples of Hartshorne coal. In any event, the selection of a coal for coking is determined in part by economic considerations, particularly freight charges, and these may outweigh the disadvantages of the slight excess of sulfur. The suitability of the Henryetta coal is demonstrated by the fact that the Sheffield Steel plant at Houston, Tex., began blending Henryetta coal with low-volatile coal in 1952 and is producing satisfactory blast-furnace coke in byproduct ovens.

PRODUCTION

A recorded total of 22,224,102 tons of coal, or about 13.8 percent of the total recorded production of the State, has been taken from more than 57 underground mines and 5 large-scale strip-mining operations in the Henryetta and Morris coal beds since mining operations began in 1902. Production figures for several years are lacking, but by including conservative estimates for those years, the total production is seen to be very close to 25 million tons. Peak productions of the area were 1.3 million tons in 1918 and 1.2 million tons in 1948. In 1951 the area supplied 0.5 million tons, with all but 6 mines abandoned, and one of these was abandoned before the end of the year. Of the total recorded production, 93.2 percent has been produced by underground mining methods. (See fig. 32 and table 2.)

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TABLE 2.—*Description of mines*

[Information as of January 1, 1952. Data from mine operators and mining engineers; from annual reports and files of the Department of Chief Mine Inspector, State of Oklahoma; and from field work]

Map no. (pl. 23)	Operator and mine	Entry location: Frac. Sec. T(N) R(E)				Thickness of bed (inches)	Shaft depth (feet)	Coal altitude (feet)	Kind of mine	Begun	Abandoned	Total tons produced	Remarks
	Underground mines [All are in the Henryetta coal bed]												
4	Victoria Coal Co	NENW	28	11	12	28–34	335	400	Shaft	1910	1927	763, 277	Also called Crowe Coal Co. No. 6.
5	Creek Coal and Mining Co. No. 2	NWSE	22	11	12	34–36	325	-------	Shaft	1919	1923	169, 789	Also called Crowe Coal Co. No. 7.
6	Creek Coal and Mining Co. No. 1	NWSE	15	11	12	35–37	300	394	Shaft	1906	1929	1, 613, 209	Also called Crowe Coal Co. No. 5.
7	Wise-Buchanan Coal Co. No. 1	NWSE	14	11	12	33–36	235	-------	Shaft	1920	1937	551, 459	Also known as Wise Mine.
8	Whitehead Coal and Mining Co. No. 2	NENW	13	11	12	34–36	158	-------	Shaft	1905	1929	504, 484	Also called Crowe Coal Co. No. 2.
9	Whitehead Coal and Mining Co. No. 1	SENW	7	11	13	36–38	100	-------	Shaft	1903	1929	501, 414	Also called Crowe Coal Co. No. 1.
10	Pittsburg-Midway Coal and Mining Co. No. 12	NWSE	7	11	13	32–36	110	-------	Shaft	1918	1939	226, 858	
11	McGinnis Coal Co. No. 1	NWSW	8	11	13	33½–36	30	659	Shaft	1921	1942	243, 486	
12	Kincaid-Corrigan	SWNE	17	11	13	34	25	-------	Shaft	1921	1923	----------	Tonnage unknown.
15	Oklahoma Coal Co. No. 9	SWNE	8	11	13	36	-------	639	Slope	1902	1922	284, 207	Also known as Hutton Mine.
16	Morgan Coal Co. No. 1	SWSE	4	11	13	----------	-------	703	Drift	1913	1921	65, 558	Also called Monarch Coal Co. No. 2.
17	Harris Coal Co	NWSE	4	11	13	----------	-------	-------	Drift	1915	1922	74, 918	
18	King Coal Co. No. 2	SESW	4	11	13	----------	-------	-------	Drift	1908	1920	235, 501	
19	King Coal Co. No. 1	NWSW	4	11	13	----------	-------	-------	Drift	1908	1917	79, 127	Also called Franklin Mine.
20	Delmel Coal Co	NESE	5	11	13	----------	-------	-------	Drift	1908	1924	103, 969	Also called Hutton Coal Co.
21	Gem Coal Co	SWSW	5	11	13	36	45	584	Shaft	1917	1926	191, 698	
22	Cado Coal Co	NESE	6	11	13	36	133	563	Shaft	1903	1925	776, 117	Also called Henryetta Coal Co. Wise Mine.
23	Warden-Pullen Coal Co. No. 1	SWNE	6	11	13	36	70	-------	Shaft	1903	1931	630, 178	
24	Warden-Pullen Coal Co. No. 2	NENW	6	11	13	35–36	75	629	Shaft	1921	1949	522, 268	
25	Big Four Coal Co. No. 1	SWSW	32	12	13	36	110	-------	Shaft	1936	1940	15, 147	Much fault work and flooding.
26	Dewar Coal Co	SESE	32	12	13	----------	-------	-------	Slope	1905	1932	428, 635	Two entries shown on map.
27	Name unknown	NESE	32	12	13	----------	-------	-------	Slope	(?)	(?)	----------	Very small operation.
28	Consolidated Fuels Co. No. 7	SESW	33	12	13	----------	-------	661	Drift	1911	1922	68, 442	
29	Fred Karrie Coal Co. No. 2	NENW	4	11	13	----------	-------	-------	Drift	1908	(?)	61, 713	Later part of Consolidated Fuels Co. No. 7.
30	Crescent Coal Co. No. 2	NENE	4	11	13	----------	-------	-------	Drift	1917	(?)	44, 404	Also called Oklahoma Coal Co. No. 4.
31	Wadsworth Coal Co	SWSW	34	12	13	36	-------	-------	Drift	1920	1943	116, 929	
32	Coal Creek Coal Co	NESW	34	12	13	34–36	-------	-------	Drift	1930	(1)	228, 070	Now operated by W. E. Trover.
34	Consolidated Fuels Co. No. 6	SENE	32	12	13	36	-------	616	Slope	1907	1925	517, 269	Also called Southern Coal Co.
35	Consolidated Fuels Co. No. 5	SENE	32	12	13	----------	-------	589	Slope	1910	1925	531, 428	Also called Royal Coal Co.
36	Geary and Martin	NESW	32	12	13	36	-------	588	Slope	1936	1948	7, 244	Underground extent not well known.

37	Blackstone Coal and Mining Co. No. 1.	SENE	31	12	13	36	-------	588	Slope	1903	1926	2,988	Later part of Blackstone No. 2.
38	Blackstone Coal and Mining Co. No. 2.	SWNW	32	12	13	----------	-------	-------	Slope	1916	1926	131,252	Flooding difficulties in S. part.
39	Ben Hur Coal Co., Blackstone Mine.	SESE	30	12	13	34–38	-------	637	Drift	1918	(1)	2,369,746	Also known as Blackstone No. 3.
40	Atlas Coal Co. No. 1	SWSW	29	12	13	35–37	50	-------	Shaft	1916	1919	166,507	
41	Atlas Coal Co. No. 2	SESE	30	12	13	37–40½	-------	-------	Drift	1922	(1)	1,655,860	
42	Starr Coal Co. No. 1	NENW	32	12	13	34½–37	40	-------	Shaft	1920	1925	123,145	
43	Starr Coal Co. old No. 2 shaft mine	SENW	29	12	13	34–36	100	-------	Shaft	(?)	(?)	134,679	
44	Starr Coal Co. No. 2	SWNW	29	12	13	33½–37	-------	-------	Drift	(?)	(1)	2,333,570	Formerly Starr Coal Co. No. 3.
48	Acme Coal Co., B. and A. Mine	SWNE	18	12	13	38–41½	102	-------	Shaft	1924	1945	670,200	
50	Interstate Coal and Development Co., Schulter Mine.	NENW	17	12	13	----------	83	-------	Shaft	1905	1906	36,758	Underground extent not well known.
51	Ben Hur Coal Co., Sun Mine	NWSE	17	12	13	38	-------	-------	Slope	1918	1936	395,652	Also called Johnson-Davidson.
52	Whitehead Coal and Mining Co. No. 4.	NENW	20	12	13	----------	110	539	Shaft	1909	1929	197,595	Also called Crowe Coal Co. No. 4.
53	Consolidated Fuels Co. No. 3	SENE	29	12	13	----------	47	547	Shaft	1911	1923	657,813	Had both shaft and slope entries.
54	Consolidated Fuels Co. No. 4	NWNE	28	12	13	----------	-------	-------	Drift	1908	(?)	13,504	Also called Hughes Coal Co.
55	Hughes Coal Co	NENE	28	12	13	----------	-------	-------	Drift	(?)	(?)	----------	Tonnage unknown.
56	Consolidated Fuels Co. No. 2	NESE	21	12	13	----------	-------	630	Drift	1909	1921	101,434	Also called Oklahoma Coal Co. No. 2.
57	Sterling Coal Co. No. 1	NESE	21	12	13	----------	-------	-------	Drift	(?)	(?)	109,042	
58	Name unknown	SWSW	22	12	13	----------	-------	-------	Drift	(?)	(?)	----------	Tonnage unknown.
60	Whitehead Coal and Mining Co. No. 3.	SENE	21	12	13	36–41	-------	635	Drift	1912	1926	978,706	Also called Crowe Coal Co. No. 3.
61	Coalton Coal Co. No. 1	NENE	21	12	13	34½–36	-------	611	Slope	1912	1933	268,751	Also called Herron Coal Co. No. 1.
62	Globe Coal Co., Kincaid No. 2 Mine	SWSE	16	12	13	34	-------	-------	Slope	(?)	1933	74,523	Also called Hillside Coal Co.
63	Globe Coal Co., Kincaid No. 1 Mine	NWSE	16	12	13	33	-------	-------	Slope	1917	1930	209,042	Also called Wilson Coal Co.
64	Fursman Coal Co. No. 3	NENE	16	12	13	----------	-------	-------	Slope	1918	1925	143,077	
65	Fursman Coal Co. No. 2	SWSW	10	12	13	----------	-------	673	Drift	1918	1925	4,045	
67	Fursman Coal Co. No. 1	SENW	10	12	13	17½	-------	-------	Drift	1916	(?)	33,166	
84	Gaither Coal Co. No. 1	SESE	11	13	13	26–30	-------	-------	Slope	1930	1941	19,111	Located near town of Morris.
91	Ashing Coal Co	SENW	1	13	13	----------	-------	-------	Slope	(?)	(?)	----------	Small operation, tonnage unknown.

Strip mines

Operator	Location	Thickness of bed (inches)	Max. cover stripped (feet)	Coal bed	Begun	Abandoned	Total tons produced	Remarks
Alkonak	Secs. 8 and 17, T. 11 N., R. 13 E.	32	32	Henryetta	1916	1924	196,382	Recently reopened by McGinnis and Grafe Coal Co.
McGinnis and Grafe Coal Co., operations near Henryetta.	Secs. 5, 8, 9, and 17, T. 11 N., R. 13 E.	34	20–48	Henryetta	1948	(1)	161,000	Tonnage approximate.
McGinnis and Grafe Coal Co., operations near Morris.	Sec. 1, T. 13 N., R. 13 E., sec. 6, T. 13 N., R. 14 E.	20–30	35	Henryetta	1945	1946	160,000	Tonnage approximate.
Broken Aro Coal Co	Secs. 1, 11, 13, and 14, T. 13 N., R. 13 E.	22–29	30–45	Henryetta	1947	1951	1,347,664	Also stripped in Sec. 31, T. 14 N., R. 14 E., north of map edge.
McGinnis and Grafe Coal Co.,	Secs. 8 and 18, T. 13 N., R. 14 E.	16–19	30	Morris	1946	1948	120,000	Tonnage approximate.

[1] In operation.

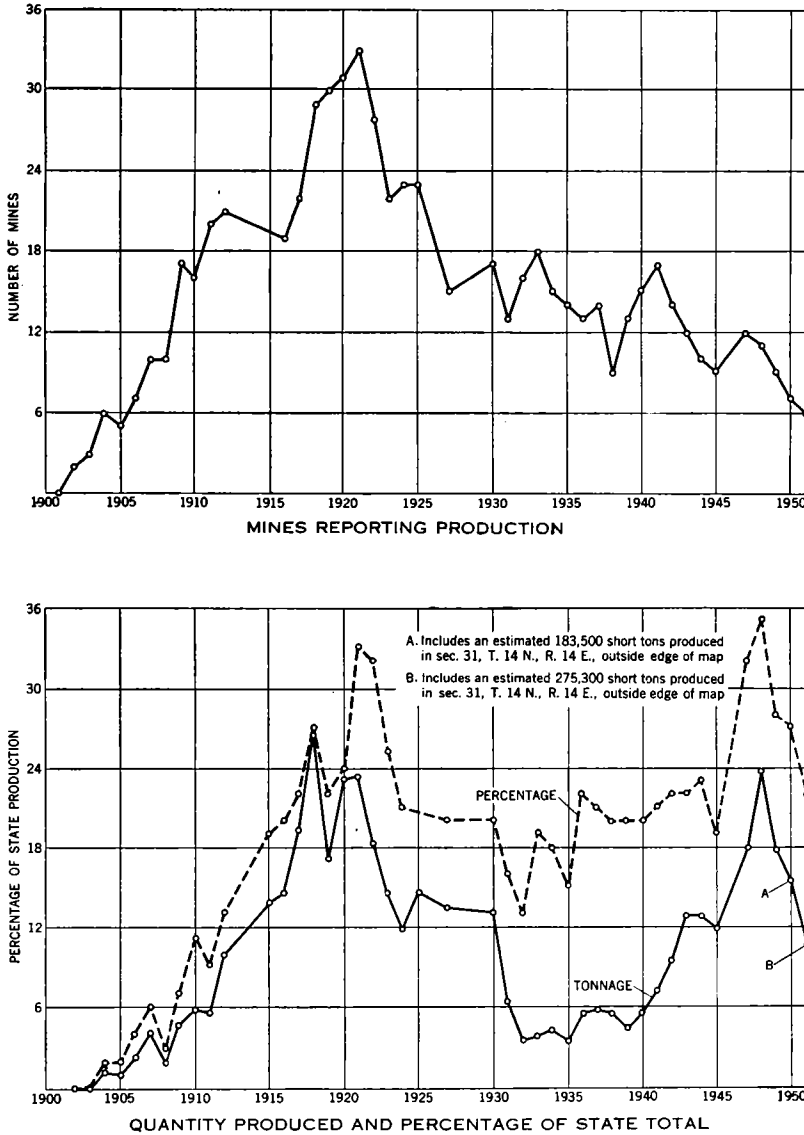

FIGURE 32.—Coal-production data for the Henryetta mining district, 1902–51, including production from both underground and strip operations in the Henryetta and Morris coal beds. Data from operators; from annual reports and files of the Department of Chief Mine Inspector, State of Oklahoma; and from reports of the Mine Inspector for Indian Territory, U. S. Department of the Interior.

Three underground mines have maintained large-scale operations. These are drift mines working in or near the southeastern part of T. 12 N., R. 12 E., on the west side of the Henryetta-Schulter anticline, where the coal is 35 to 41½ inches thick, almost free of partings, and relatively low in sulfur content. In addition to the high quality of

the coal and the good working conditions, the continued operation of these mines has been favored by extensive use of modern equipment. (Coal Age, 1953.) The coal is mined by the room-and-pillar or by a modified panel system, undercut by machines, drilled, shot down, then hand- or machine-loaded and conveyed by belt and trolley-type tram to a preparation plant. Electric power is used throughout. In the one strip mine operating in 1951, located in sec. 8, T. 11 N., R. 13 E., the overburden is stripped from the coal by diesel-electric dragline, then the coal is broken out, loaded onto trucks with a diesel shovel, and taken to a preparation plant. The preparation plants are variously equipped with vibrating, shaking, and bar screens, oil treaters, magnets, and picking tables. Except at a single small truck mine, the improved coal from all mines is loaded directly into cars on the St. Louis–San Francisco Railroad. The tipple at the recently abandoned strip pit at Morris, the Broken Aro mine, was the only installation equipped to wash the coal.

RESERVES

According to a conservative estimate based on information now available, the total reserves remaining in the ground in the Henryetta and Morris coal beds, as of January 1, 1952, were 275 million tons of high-volatile bituminous coal in all categories. (See table 3.) This total is comprised of 243 million tons in the Henryetta bed south of Deep Fork, where underground mining methods predominate; 28 million tons in the Henryetta bed north of Deep Fork, where strip-mining methods have strongly predominated; and 4 million tons in the Morris bed, where mining has also been predominantly by stripping methods. The reserve estimate includes not only coal within the mapped area, but coal in the Henryetta bed which, drilling has indicated, is present downdip to the west of the Henryetta mining area and as far north along the outcrop as the southern part of T. 15 N. The present estimate will probably be revised upward when further prospecting has provided additional information, especially in the Henryetta coal downdip (westward) from the underground mining area near Henryetta.

In order that the estimate may have continuing usefulness, the reserves in each coal bed in each township are classified according to: (1) Thickness of bed (divided into 14- to 28-inch and 28- to 42-inch ranges); (2) whether the amount and reliability of the data justify considering the reserves to be measured, indicated, or inferred; (3) the amount of overburden (divisions of 0–40 feet and 40–1,000 feet), except for the Henryetta coal in the area south of Deep Fork where insufficient data were available. All known reserves of coal are under less than 1,000 feet of overburden.

TABLE 3.—*Estimated remaining reserves in the Henryetta and Morris coal beds on January 1, 1952*

[In millions of short tons]

Township	Overburden (feet)	Measured reserves			Indicated reserves			Inferred reserves			Total in all categories		
		In beds 14 to 28 inches thick	In beds 28 to 42 inches thick	Total	In beds 14 to 28 inches thick	In beds 28 to 42 inches thick	Total	In beds 14 to 28 inches thick	In beds 28 to 42 inches thick	Total	In beds 14 to 28 inches thick	In beds 28 to 42 inches thick	Total
Henryetta coal south of Deep Fork													
T. 10 N., R. 12 E.[1]	0–1000							1.98		1.98	1.98		1.98
T. 11 N., R. 11 E.[1]	0–1000					2.31	2.31	2.90	12.56	15.46	2.90	14.87	17.77
T. 11 N., R. 12 E	0–1000	0.34	12.20	12.54	9.24	35.31	44.55	4.00	17.28	21.28	13.58	64.79	78.37
T. 11 N., R. 13 E	0–1000	1.42	6.53	7.95	7.14	.33	7.47	.97		.97	9.53	6.86	16.39
T. 12 N., R. 11 E.[1]	0–1000							.65	2.92	3.57	.65	2.92	3.57
T. 12 N., R. 12 E	0–1000		8.08	8.08		35.45	35.45	6.10	47.22	53.32	6.10	90.75	96.85
T. 12 N., R. 13 E	0–1000	.51	17.16	17.67	[2].90	4.36	[2] 5.26	.50	3.69	4.19	[2] 1.91	25.21	[2] 27.12
T. 13 N., R. 12 E	0–1000							.40	.66	1.06	.40	.66	1.06
Total		2.27	43.97	46.24	[2] 17.28	77.76	[2] 95.04	17.50	84.33	101.83	[2] 37.05	206.06	[2] 243.11
Henryetta coal north of Deep Fork													
T. 13 N., R. 13 E	0–40	3.01	0.35	3.36							3.01	0.35	3.36
	40–1000	3.36		3.36	5.55		5.55	5.82		5.82	14.73		14.73
		6.37	.35	6.72	5.55		5.55	5.82		5.82	17.74	.35	18.09
T. 14 N., R. 13 E	0–40	.09		.09							.09		.09
	40–1000	.76		.76	1.44		1.44	1.84		1.84	4.04		4.04
		.85		.85	1.44		1.44	1.84		1.84	4.13		4.13
T. 14 N., R. 14 E	0–40	1.36		1.36							1.36		1.36
	40–1000	1.48		1.48	1.66		1.66	.73		.73	3.87		3.87
		2.84		2.84	1.66		1.66	.73		.73	5.23		5.23
T. 15 N., R. 14 E	0–40	.20		.20							.20		.20
	40–1000												
		.20		.20							.20		.20

Total	0–40	4.66	.35	5.01							4.66	.35	5.01
	40–1000	5.60		5.60	8.65		8.65	8.39		8.39	22.64		22.64
Grand Total		10.26	.35	10.61	8.65		8.65	8.39		8.39	27.30	.35	27.65
Henryetta coal													
Total	0-1000	12.53	44.32	56.85	[2] 25.93	77.76	[2] 103.69	25.89	84.33	110.22	[2] 64.35	206.41	[2] 270.76
Morris coal													
T. 13 N., R. 13 E.	0–40	0.25		0.25	0.07		0.07				0.32		0.32
	40–1000	.08		.08	.53		.53	1.13		1.13	1.74		1.74
		.33		.33	.60		.60	1.13		1.13	2.06		2.06
T. 13 N., R. 14 E.	0–40	1.11		1.11	.14		.14				1.25		1.25
	40–1000	.10		.10	.27		.27	.48		.48	.85		.85
		1.21		1.21	.41		.41	.48		.48	2.10		2.10
Total	0–40	1.36		1.36	.21		.21				1.57		1.57
	40–1000	.18		.18	.80		.80	1.61		1.61	2.59		2.59
Grand Total		1.54		1.54	1.01		1.01	1.61		1.61	4.16		4.16
Henryetta and Morris coals													
Total	0-1000	14.07	44.32	58.39	26.94	77.76	104.70	27.50	84.33	111.83	68.51	206.41	274.92

[1] Okfuskee County.
[2] Includes an estimated 0.10 million short tons of Morris coal, in secs. 12 and 13, T. 12 N., R. 13 E.

In general, "measured coal" is coal for which mine workings, drill holes, and surface exposures afford observation and measurement at points less than half a mile apart. The outer edge of a block of measured coal is drawn a quarter of a mile from the last point of definite information or half a mile from a continuous outcrop. The computed tonnage is judged to be within 20 percent of the true tonnage. Computations of "indicated coal" are based partly on specific data and partly on projection of that data on geologic evidence. Blocks of indicated coal lie less than half a mile from isolated points of observation and less than 2 miles from a continuous outcrop. "Inferred coal" is coal for which quantitative estimates are based on broad knowledge of the bed and geologic evidence for its continuity. Inferred coal generally falls within a semicircular area lying against the outcrop and having a radius of half the length of the outcrop, but may extend beyond such a semicircle to embrace drill holes and mine workings nearby.

The thickness assumed for each coal bed in each township is a weighted average based on all measurements. Beds containing less than 14 inches of clean coal after the subtraction of partings thicker than three-eighths of an inch were excluded, as were thin benches separated from the main part of a bed by a parting of more than half the thickness of the bench. The coal was assumed to weigh 1,800 tons per acre-foot, a figure obtained by using 1.32 as the average specific gravity of bituminous coal in the ground.

An abundance of detailed information in the form of mine maps and surveys of nearly all the underground mines and stripped areas made it possible to estimate reserves directly on the basis of coal remaining in the ground, as of January 1, 1952, rather than estimating original reserves in place before mining began and then subtracting from that the recorded production and an allowance for losses in mining to obtain remaining reserves. This abundance of data on mined-out areas also made it possible, by measurement, to get a fairly accurate estimate of the total amount of coal mined and lost in mining, including that left in pillars, in barriers between mines, at small depths under streams, and the like. By comparing this figure with data on production, it is possible to arrive at meaningful figures for over-all recoverability, both for underground and strip mining methods. For underground mining in the Henryetta mining district, over-all recoverability in the past has been 50.5 percent of the coal originally present, which figure accords closely with the figures obtained in many other areas in the United States. Assuming that future losses in underground mining will continue to be approximately equal

to production, the recoverable coal reserves in the Henryetta bed in the map area south of Deep Fork, as of January 1, 1952, total about 121 million tons.

STRIPPABLE COAL

The relatively thick Henryetta coal in the area south of Deep Fork has already been stripped from the more favorable areas of its occurrence where the overburden is less than 40 feet thick. Available data did not permit making an estimate of the remaining strippable reserves in this area, but there remain small amounts between underground mines and the outcrop, and under the alluvium of Coal Creek, in the area from Coalton southward through Dewar to near Kusa. (See pl. 23.) The most favorable area is in secs. 8 and 9, T. 11 N., R. 13 E., where the McGinnis and Grafe Coal Company is now working. South of this area, through section 16 and along the west side of Lake Henryetta, small tonnages probably could be produced by contour stripping near the outcrop, but the apparent increase in the impurities in the coal in this direction might make this a poor prospect.

The Henryetta coal north of Deep Fork has been almost completely stripped to an overburden depth of 40 feet for more than 4 miles along the outcrop, mainly in sec. 31, T. 14 N., R. 14 E., and secs. 1, 11, and 14, T. 13 N., R. 13 E. (See pl. 23.) It is noteworthy that the coal in sec. 23, T. 13 N., R. 13 E. was considered too impure for economic recovery, even though the tipple in use was equipped to wash the coal. The seemingly most feasible area for large-scale stripping operations in the Henryetta coal bed is north of the mapped area, in secs. 3, 4, 9, 10, and 16, T. 14 N., R. 14 E., where drilling has indicated that the coal averages nearly 17 inches in thickness and is not less than 14 inches thick for 2½ miles along the outcrop. An estimated 1,330,000 tons of coal is present in that area under less than 40 feet of overburden. Test drilling in the Henryetta bed has been carried on as far north as sec. 23, T. 15 N., R. 14 E., but no coal thickness greater than 15 inches was found in this township.

Much of the strippable coal between 16 and 20 inches in thickness in the Morris bed is still in the ground, though the more favorable areas have already been stripped. The tonnages given for this bed in the table of estimated remaining reserves do not include coal in place under the townsite of Morris. No information is available about the extent or thickness of this bed beyond the north boundary of the map.

A comparison between the amount of coal produced by strip mining and the estimated amount of coal originally in place in the stripped areas indicates a recoverability of 76 percent in the Henryetta-Morris

district. This figure compares favorably with the 80 percent recoverability which experience has indicated is obtained by one of the large strip-mining companies operating in the State.

OIL AND GAS

The Henryetta-Okmulgee-Morris area has been an important producer of oil and gas for many years, and many hundreds of wells have been drilled there. Production began in 1904 when a small quantity of oil was produced from a well near Okmulgee, and in the same year gas was produced at Henryetta. Active search was spurred by oil and gas production in 1906 and 1907 in and near Morris, and by a successful oil well drilled near the site of Coalton. By 1910 so much gas had been discovered in the area that smelters were brought to Henryetta (Clark, 1926, p. 62–65).

Subsurface units which have been productive in the area discussed in this report include, in descending order, the Salt, Booch, and Dutcher sands of Pennsylvanian age and the Wilcox sand of Ordovician age, and more than a dozen named oil and gas pools occur in or very near the area (Richardson, 1939; Skelton and Skelton, 1942, app. C). Petroleum occurrence and possibilities of the area are discussed by Clark (1926), by Clark and Bauer (1921), and by Reed (1923). Considerable drilling still continues. In 1952 in Okmulgee County as a whole, 94 productive oil and 3 productive gas development wells, and 5 productive wildcat oil wells were completed (Oil and Gas Journal, 1953, p. 361–362). An oil refinery has been operating in Okmulgee for many years, and in 1951–52 expanded its capacity by the construction of an 8,000 gallon-per-day catalytic cracker.

OTHER MINERAL RESOURCES

In former years the shale between sandstone units 4 and 5a of the Senora formation was used as raw material in the manufacture of clay products by the Kusa Brick & Tile Co., which operated a large plant and open-pit quarry in sec. 3, T. 11 N., R. 13 E., near Kusa. Samples of shale from this locality and the following other localities in the mapped area have been thoroughly tested and found satisfactory for use in the manufacture of various clay products: Sec. 11, T. 11. N., R. 12 E.; the immediate roof of the Henryetta coal bed in the abandoned Gaither Coal Company mine in sec. 11, T. 13 N., R. 13 E.; the shales above and below the Henryetta coal bed just north of the abandoned Coalton Coal Company mine, northeast of Coalton. (Sheerar and Redfield, 1932, p. 189–192.)

Building stone is quarried at several places in the mapped area, most notably at the large quarry in the SE¼SW¼ sec. 25, T. 12 N., R. 12 E., northwest of Henryetta.

SELECTED MEASURED SECTIONS[1]

1. *Section in secs. 25, 26, and 36, T. 11 N., R. 13 E.*

[Measured northwestward from edge of alluvium, 500 feet south of the south quarter-section corner of sec. 25, and extending about 1,000 feet to top of hill; measurement resumed at top of sandstone 2 in creek one-eighth of a mile east of the center of sec. 26, about 400 feet south of stock pond, and continued westward up hill to the center of sec. 26]

Senora formation:

	Feet
Sandstone (3), not measured.	
Shale, light-brown, very poorly exposed	60
Sandstone (2), light gray-brown, very fine grained, badly weathered and poorly exposed; about	15
Covered, probably shale	50
Sandstone (1b), light-gray, medium bedded, very fine grained	15
Covered, probably silty shale	20
Sandstone (1a), light brown-gray, weathers gray brown, very massive, very fine grained, very resistant; base not exposed	40+
	200

Talus.

Alluvium.

2. *Section in secs. 15 and 16, T. 11 N., R. 13 E.*

[Measured southwestward from base of sandstone, about a quarter of a mile north of the south quarter-section corner of sec. 15, and extending about a quarter of a mile to top of dam spillway at north end of Lake Henryetta, thence measured about 1,000 feet northwestward to sandstone 5a on hilltop; measurement resumed in road a quarter of a mile west of the southeast corner of sec. 16, and continued westward about five-eighths of a mile along ditch on north side of road to a point about a quarter of a mile northeast of the southwest corner of sec. 16]

Senora formation:

	Ft	in
Sandstone (6b), light brown-gray, flaggy to medium-bedded, very fine grained, contains plant impressions; interbedded with light brown-gray shale; upper half very poorly exposed, top eroded	18+	0
Shale, greenish yellow-brown, blocky, lacks siderite	16	0
Sandstone (6), light yellow-gray, thin-bedded, very fine grained, bedding irregular	5	0
Sandstone (6), light-gray, thin-bedded; interbedded with green-gray to gray-brown shale; in part poorly exposed	34	0
Shale, dark-gray, weathers light blue-gray, contains many siderític concretions; basal 37 feet computed using west-dip component of 5 feet per 100 feet	97	0
Coal (Henryetta), badly weathered		11
Underclay, light-gray	1	10
Shale, silty and sandy, greenish-gray, some ripple cross-lamination, fragmental plant fossils	5	0
Sandstone (5b), light brown-gray, medium-bedded, very fine grained	12	0
Shale, gray-brown; poorly exposed; computed using west-dip component of 4 feet per 100 feet	35	0
Shale, very silty and sandy, thin-bedded, weak; in part covered	15	0
Sandstone (5a), gray-brown to light-brown, weathers dark brown, well-bedded. Caps the hill in the W½SW¼ sec. 15	9	0

[1] Numbering in accordance with plate 22.

2. *Section in secs. 15 and 16, T. 11 N., R. 13 E.*—Continued

	Ft	in
Senora formation—Continued		
Shale, light green-gray, weathers light blue-gray to very light gray, contains sideritic concretions	14	0
Sandstone, light-gray, very fine grained, slightly limy		2
Shale, light green-gray, weathers light blue-gray to very light gray, contains sideritic concretions	25	0
Limestone, silty, reddish-brown, roughly nodular, fossiliferous; shale for 1 inch above and 2 inches below is limy		2
Shale, very poorly exposed	61	0
Sandstone (4), light-brown to light-gray, medium-bedded, very fine grained, bedding planes irregular	2	0
Shale (mapped with 4), greenish-brown, weathers light brown; blocky until weathered; includes 4-inch bed of light-gray sandstone 3 feet from base	4	6
Sandstone (4), light-gray, weathers light brown, massive, calcareous	1	9
Shale, gray, calcareous; contains resistant stringers of siltstone and sandstone; contains sideritic nodules	12	7
Limestone, silty, and limy shale; strongly fossiliferous (brachiopods)		8½
Shale (Morris coal zone), carbonaceous, dark gray, weathers gray with red-brown mottling, fissile; contains three thin coal lenses ½ to 2 inches thick	2	8½
Shale, very silty and sandy; dark-gray silty shale intimately interlaminated with light-gray siltstone and very fine grained sandstone, highly micaceous, contains dark minerals, becomes more sandy toward base, ripple marking common in basal 10 feet	16	8
Sandstone (3), gray-brown, massive, base not exposed	15+	0
	405	0

4. *Section in secs. 17 and 18, T. 11 N., R. 13 E.*

[Measured westward from stream, about an eighth of a mile south of the north quarter-section corner of sec. 17, and extending a half a mile to water tank on hilltop about an eighth of a mile south of the northwest corner of sec. 17]

	Feet
Calvin sandstone:	
Sandstone (1), light gray-brown, massive, has contorted and rolled bedding, top eroded	10+
Senora formation:	
Covered, probably gray shale	95
Sandstone (6b), shaly, light-gray, very fine grained; poorly exposed, about	3
Covered, probably shale or silty shale	45
Sandstone (6), shaly, light-gray, flat-bedded, very fine grained, calcareous, sporadically exposed	50
Shale, gray, contains sideritic nodules; about	80
Coal (Henryetta), not exposed, position inferred from abandoned strip pit east of stream	0
	283

5. *Section in secs. 2 and 11, T. 11 N., R. 12 E.*

[Measured westward from south side of U. S. Highway 75, at foot of hill on east side of the NW¼SE¼ sec. 11, and extending a quarter of a mile uphill to cemetery; then from road cut about 300 feet northeast of the center of sec. 11 to top of escarpment in the center of the NW¼SW¼SE¼ sec. 2]

	Ft	in
Calvin sandstone:		
Sandstone (2), light-brown, fine-grained, top eroded	10+	0
Shale, dark-green; measured barometrically, about	100	0
Shale, silty, strongly silty in upper third; about	15	0
Siltstone, light-brown, massive	2	0
Shale, dark-green, weathers light gray-green, lacks siderite	12	0
Shale (mapped with 1), silty, light gray-brown, contains one 8-inch siltstone bed	5	0
Siltstone (1), and silty shale, light-brown, weathers light brown; siltstone beds in lower half thin- to medium-bedded, lenses and channel fillings of siltstone in upper half range in thickness from 6 inches to 2½ feet in a horizontal distance of a few feet; all but basal 3 feet displays crossbedding and very irregular bedding	10	6
Shale (mapped with 1), silty, light-brown, contains 6 inches of light-gray shale which has ½-inch bed of sideritic ironstone in upper part	2	6
Sandstone (1), light-brown, massive except uppermost 8 inches, very fine grained	2	0
Shale (mapped with 1), dark-green, weathers to light gray-green flakes, lacks siderite	3	6
Sandstone (1), basal 10 inches massive, remainder thin-bedded, very fine grained	2	0
Shale (mapped with 1), dark-green, weathers to light gray-green flakes, lacks siderite	5	0
Sandstone (1), light-brown, weathers light gray-brown, massive, very fine grained, basal 6 inches contains fragmental plant fossils	2	0
Senora formation:		
Shale, dark-green, weathers to light gray-green flakes, lacks siderite, base not exposed	9+	0
	180	6

11. *Section in sec. 34, T. 12 N., R. 12 E.*

[Measured in road cut in the southwest part of the SW¼NW¼SW¼ sec. 34]

	Feet
Calvin sandstone:	
Sandstone (2), poorly exposed, probably as in next lower unit	10
Sandstone (2), light-brown, massive, fine-grained	22
Sandstone (2), thin-bedded, very fine grained, interbedded with light-gray shale	16
Shale, light brown-gray, base not exposed	10+
	58

18. *Section in sec. 34, T. 12 N., R. 13 E.*

[Measured northwestward from sandstone outcrop about 1,000 feet east of the southwest corner of sec. 34 to outcrops about 800 feet distant in road up hillside in the center of the W½SW¼SW¼ sec. 34, thence measured northward on this road to coal exposure in ditch on west side of road; measurement resumed at a point about 2,400 feet to the northeast at coal in mine of Coal Creek Coal Co., and continued northward up power line cut to top of hill at the center of the N½SW¼ sec. 34]

Senora formation:	Ft	in
Sandstone (6), light gray-brown, massive, fine-grained, top eroded	13+	0
Covered, probably shale or silty shale	55	0
Coal (Henryetta), in Coal Creek Coal Co. mine, also in road to west	3	0
Shale	1	6
Sandstone (5b), light-gray, very thin bedded, very fine grained, ripple-marked	7	0
Shale, gray, weathers light-gray	9	0
Limestone, very shaly, strongly fossiliferous (predominantly brachiopods); about	3	0
Covered; shale poorly exposed near top	38	0
Sandstone (5a), weathers brown, massive, very fine grained, base not exposed	3+	0
	132	6

19. *Section in secs. 29, 30, 31, and 32, T. 12 N., R. 13 E.*

[Description of bottom two units based on reported data on abandoned shaft of Atlas No. 1 mine in the SW¼SW¼ sec. 29; middle unit measured in the extreme northwest corner of sec. 32 and the extreme northeast corner of sec. 31, from railroad intersection westward 500 feet along road to Blackstone mine; top two units measured northwestward uphill in the SE¼SE¼ sec. 30]

	Feet
Beds transitional between Calvin sandstone and Senora formation:	
Sandstone (1a, basal tongue of lower sandstone of Calvin intercalated into Sonora formation), light gray-brown, fine-grained, bedding in upper part contorted and rolled, top eroded	10+
Senora formation:	
Shale, light gray-brown, in part somewhat silty, about	120
Sandstone (6), light brown-gray, thin- to medium-bedded, very fine grained, with intercalated beds of silty shale	20
Covered; in mine shaft reported to be about 50 feet deep and to be sunk through shale or silty shale, now inaccessible. Base of next higher unit coincides with top of shaft	50
Coal (Henryetta), reported to be	3
	203

24. Section in sec. 21, T. 12 N., R. 13 E.

[Measured southward on west side of north-south road, from a point about an eighth of a mile north of the east quarter-section corner of sec. 21, and extending about 300 feet to coal exposure, thence northwestward about 500 feet to sandstone (5) at top of hill; measurement resumed at same horizon in road to the west and continued northward on road about 500 feet to top of sandstone (5) exposure; measurement resumed at same horizon in east-west road at a point about an eighth of a mile east of the center of sec. 21 and measured to top of small hill in exact center of the N½ sec. 21]

	Ft	in
Beds transitional between Calvin sandstone and Senora formation:		
Sandstone (1a, basal tongue of lower sandstone of Calvin intercalated into Senora formation), light-brown, weathers brown, thick-bedded, fine-grained, bedding contorted and rolled, top eroded	15+	0
Senora formation:		
Covered	6	0
Shale, light-brown, contains platelets and stringers of sideritic ironstone ¼- to ½-inch thick	40	0
Covered, includes thin, weak sandstone (6b); about	50	0
Sandstone (6), massive, very fine grained, poorly exposed	10	0
Shale (mapped with 6), light-green, contains platelets of sideritic ironstone, poorly exposed	5	0
Sandstone (6), light brown-green, very fine grained, contains light green-gray weak bed bearing plates of sideritic ironstone	8	0
Shale, silty, light-gray, ragged in appearance, contains abundant plates of siltstone	9	0
Shale, very silty, light gray-brown to gray, micaceous, contains 3-inch resistant layers	20	0
Covered, probably shale or silty shale	13	0
Shale, light yellow-gray, contains 1-inch thick platelets of sideritic ironstone about every 18 inches	9	0
Coal (Henryetta), excellent exposure in road cut	3	3½
Underclay, carbonaceous, gray	1	6
Sandstone (5b), shaly, light-gray, very fine grained, micaceous, carbonaceous	9	0
Sandstone (5b), light-gray, weathers brown, massive, ripple-marked, cross-laminated	5	0
Shale, dark blue-gray, contains lenses of sideritic siltstone	9	0
Limestone, very shaly, light-gray, abundantly fossiliferous (predominantly brachiopods)	2	3½
Shale, gray, contains sideritic platelets, base not exposed	10+	0
	225	1

28. *Section in secs. 13, 14, and 23, T. 12 N., R. 13 E.*

[Measured westward in east-west road, from a point about 500 feet west of the south quarter-section corner of sec. 13, and extending about 650 feet to top of hill; measurement resumed at same horizon in the center of the N½NE¼NE¼ sec. 23, and continued northward about 900 feet across road to top of hill]

Senora formation:	Ft	in
Sandstone (6), light-brown, weathers brown speckled with dark brown, thick-bedded, very fine grained, top eroded	5+	0
Covered, probably shale or silty shale, includes horizon of Henryetta coal in lower part	55	0
Sandstone (5b), light-brown, weathers brown speckled with dark brown, massive to thin-bedded, very fine grained; about	8	0
Covered, probably shale or silty shale	20	0
Limestone, very shaly, gray, highly fossiliferous (predominately brachiopods)	2	0
Shale, gray, contains lenses of sideritic ironstone, intermittently exposed. Calcareous concretions containing small gastropods found in 1-foot zone near middle of unit	35	0
Sandstone (5a), light-brown, weathers dark brown, massive, very fine grained	1	6
Shale (mapped with 5a), silty, bedding irregular, ripple-marked, contains siltstone stringers 2 to 6 inches thick	6	0
Sandstone (5a), light brown-gray, weathers light brown-gray, thin- to medium-bedded, very fine grained, micaceous, bedding irregular, ripple-marked	6	6
Shale, light brown-gray, weathers to small light-gray flakes, contains sideritic ironstone as stringers and tabular concretions about 1 inch thick	22	0
Siltstone, brown, sideritic	1	0
Shale, light brown-gray, weathers light brown; contains sideritic concretions throughout, which increase in number toward top of unit; base not exposed	18+	0
	179	0

30. *Section in sec. 12, T. 12 N., R. 12 E., and secs. 7 and 18, T. 12 N., R. 13 E.*

[Measured westward from sandstone exposure in creek, an eighth of a mile south of the northeast corner of sec. 18, and extending to the low hill at the south quarter-section corner of sec. 7, thence westward to roadside ditches on west side of hill at the south quarter-corner of sec. 12. West-dip component used to correct measurements, 100 feet per mile]

	Ft	in
Calvin sandstone:		
Sandstone (2), light yellow-gray, flaggy to massive, very fine grained to fine-grained, top eroded	20+	0
Sandstone (2), shaly, light yellow-gray, very fine grained	6	0
Shale, gray, contains thin siltstone or very fine grained sandstone stringers, which increase in frequency toward top of unit	20	0
Limestone, sandy, blue-gray, weathers reddish brown, ferruginous, very fossiliferous (small brachiopods predominating)		3½
Shale, light yellow-gray, contains stringers of limy siltstone	3	6
Limestone, sandy, blue-gray, weathers reddish brown, ferruginous, very fossiliferous (fossil assemblage includes pelecypods, gastropods, and brachiopods)		9½
Shale, yellow-gray	20	0
Limestone, sandy, blue-gray, weathers reddish brown, ferruginous, very fossiliferous (fossil assemblage includes pelecypods, gastropods, and brachiopods		3½
Shale, yellow-gray	2	3
Sandstone, shaly, light yellow-gray, very fine grained, weak, poorly bedded, base not exposed	2	0
Covered, probably shale or silty shale; about	85	0
Sandstone (1), shaly, light yellow-gray	15	0
Beds transitional between Calvin sandstone and Senora formation:		
Shale, gray	10	0
Covered, probably shale or silty shale; about	90	0
Sandstone (1a, basal tongue of lower sandstone of Calvin intercalated into Senora formation), light-gray, flaggy, very fine grained, base not exposed	10+	0
	284	1½

38. *Section in sec. 2, T. 12 N., R. 13 E.*

[Measured in gully in the S½SE¼NE¼ sec. 2]

	Ft	in
Senora formation:		
Covered, traced into shaly carbonaceous sandstone (Henryetta coal zone) at bottom of measured section no. 40	6	0
Sandstone (5), light-brown, weathers brown, very fine grained, consists of two massive and two weak zones	8	0
Shale (mapped with 5), silty, gray-brown, finely laminated	5	6
Sandstone (5), shaly, light-brown, weathers brown, very fine grained, weak, weathers into thin plates; about	17	0
Sandstone (5), light-brown, massive, very fine grained	7	0
Shale (mapped with 5), slightly silty, gray-brown	2	0
Sandstone (5), light-gray, very fine grained, in part shaly but predominantly massive	4	6
	49	6

Alluvium

39. *Section in secs. 5 and 6, T. 12 N., R. 13 E., and sec. 32, T. 13 N., R. 14 E.*

[Measured in creek from the center of the S½ sec. 32 southwestard across the northwest corner of sec. 5, and westward across the N½ sec. 6 to coal exposure at the center of the S½NW¼ sec. 6, measurement resumed at coal exposure about 50 feet south of creek, just north of the west quarter corner of sec. 6, and continued southward in road about 600 feet to hilltop. Estimated west-dip component, 2 feet per 100 feet]

Senora formation:

	Ft	in
Sandstone (5), brown, weathers dark red-brown and dark yellow-brown, massive, very fine grained, soft, ferruginous; contains claystone pellets as much as 2 inches in diameter. Limonitic sandstone boulders abundant in float. Top eroded	8+	0
Shale, light-gray, lacks siderite	11	0
Shale, gray, weathers light yellow and somewhat blocky, contains abundant lenses of sideritic ironstone	30	0
Shale, gray, weathers dark gray and fissile, contains a few zones of sideritic concretions and, in lower part, calcareous cone-in-cone concretions	29	0
Limestone, very shaly, gray, abundantly fossiliferous (small pelecypods and gastropods)	1	6
Coal (Morris), also exposed at the center of the S½NW¼ sec. 6, where it is 2 feet 10 inches thick		2
Shale, silty, medium hard; very light-gray silt laminae in light-gray shale matrix. Poorly exposed, about	30	0
Sandstone (3), light-brown, massive, very fine grained, resistant	1	0
Shale, silty, medium hard; very light-gray silt laminae in light-gray shale matrix. Poorly exposed; measured in creek in the NE¼NE¼ sec. 5; about	10	0
Covered, probably silty shale; about	35	0
Shale, silty, medium hard; very light-gray silt laminae in light-gray shale matrix. Seen in creek bank just south of road at a point about ⅜ mile east of the southwest corner of sec. 32	3	0
Covered, probably silty shale	8	0
Sandstone (1), light-brown, thin bedded in upper 5 feet, massive below; very fine grained, base not exposed	6+	0
	172	8

40. *Section in sec. 34, T. 13 N., R. 13 E.*

[Bottom three units measured in creeks in the NE¼NE¼ sec. 34, higher units measured northeastward, then northward, from railroad bridge abutment in the center of the S½NW¼ sec. 34 up creek to the center of the NE¼NW¼ sec. 34, thence to the north quarter-section corner of sec. 34 and to sandstone outcrop a quarter of a mile to the west in road]

Senora formation:	Feet
Sandstone (6), shaly, light brown-gray, top eroded	10+
Covered (mapped with 6), probably as in unit above	20
Sandstone (6), light brown-gray, very massive, very fine grained	35
Sandstone (6), light-brown, very fine grained; grades in a horizontal distance of 200 feet from a weak sandstone, that is very finely laminated and cross-laminated and has dark shale particles coating bedding planes, to one that is resistant and moderately cross-bedded on a large scale	4
Covered (mapped with 6)	6
Sandstone (6), light-brown, very fine grained, displays slight to very marked large-scale crossbedding; contains abundant limonitic ironstone concretions 1 to 2 inches in diameter and, in lower part, contains scattered flakes of carbon	9
Shale (mapped with 6), silty and sandy, light brown-gray, micaceous, carbonaceous, nonresistant; grades laterally from silty shale to shaly sandstone; has 1- to 3-inch stringers of shale that contain coalified plant fragments	8
Sandstone (6), light-brown, very fine grained, slightly crossbedded, contains casts of large pieces of trees; thickness ranges from 1 to 5 feet, averages	3
Sandstone (Henryetta coal zone), shaly, very carbonaceous, micaceous, crossbedded; carbon occurs as flakes strongly concentrated on bedding planes and as numerous large fragments of coalified wood in a sandstone matrix. This coaly sandstone lies in the approximate stratigraphic position of the Henryetta coal bed. It and the two overlying, less carbonaceous units, form a low bench that can be traced southward from the southernmost occurrence of clean Henryetta coal north of Deep Fork, into and through the outcrop of the sandstone mass resulting from the near coalescence of resistant sandstones 5 and 6	4
	99

44. *Section in secs. 10, 11, 13, 14, 15, and 16, T. 13 N., R. 13 E., and sec. 18, T. 13 N., R. 14 E.*

[Measured westward from bottom of abandoned strip pit, an eighth of a mile east of the west quarter-section corner of sec. 18, and extending to top of sandstone 5; measurement resumed at same horizon an eighth of a mile east of the northwest corner of sec. 13, and continued westward along section-line road to hilltop three-eighths of a mile east of the northwest corner of sec. 16]

Calvin sandstone:	Ft	in
Sandstone (2), light-yellow, weathers light gray and light brown, massive, fine grained, top eroded	25+	0
Sandstone (2), shaly, light-yellow, weathers light gray and light brown	11	0
Shale, light-gray	24	0
Sandstone (1), in part silty and shaly, light-yellow to light-gray, weathers gray to brown, flaggy and shaly-bedded, very fine grained. Exposed in the gully at the north quarter-section corner of sec. 16 and on the hill in the N½NW¼ sec. 15	35	0

44. *Section in secs. 10, 11, 13, 14, 15, and 16, T. 13 N., R. 13 E., and sec. 18, T. 13 N., R. 14 E.*—Continued

	Ft	in
Senora formation:		
Shale, locally silty, gray, contains lenses of sideritic ironstone. Exposed on the hill in the N½NW¼ sec. 15	30	0
Covered, probably shale as above	25	0
Limestone, sandy, gray, weathers light brown. Exposed in the SW¼SE¼ sec. 10, in gully on north side of road	1	0
Covered, probably shale or silty shale	8	0
Shale, dark blue-gray, calcareous, lower one foot contains 1- to 2-inch nodules of medium-crystalline limestone	5	0
Limestone, dark-gray, weathers light yellow, flaggy, finely crystalline		3½
Shale, calcareous, dark blue-gray, contains ¼-inch bed of fossiliferous clastic limestone at base	0	6
Shale, slightly silty, dark-gray, poorly bedded, calcareous; contains stringers of shaly and silty limestone	2	0
Shale, dark-gray, fissile, contains lenses and concretions of sideritic ironstone. Exposed in bank of creek in the center of the SE¼ sec. 10	19	0
Shale, slightly silty, dark-gray, fissile, contains sideritic concretions; about	30	0
Covered, probably shale or silty shale; about	10	0
Shale, gray	10	0
Covered	5	0
Shale, silty and sandy, light-brown and light-gray, weathers brown, very weak	3	0
Covered, probably silty and sandy shale; about	10	0
Shale, silty and sandy, light-gray and light-brown, ripple cross-laminated; upper part contains 1-inch bed of coal, 5 feet above which is a zone of black limestone concretions 1 foot in diameter containing gastropods. Well exposed in railroad cut in the SE¼ sec. 11, northwest of abandoned tipple; also well exposed in abandoned strip pit at the southeast corner of sec. 11; about	50	0
Coal, Henryetta	3	0
Covered, probably shale or silty shale; about	5	0
Sandstone (5), light-gray, weathers brown, shaly to massive, very fine grained; about	50	0
Shale, gray; lower 20 feet calcareous, upper 30 feet noncalcareous	50	0
Covered, probably shale	15	0
Coal (Morris), under water in strip pit; reported to be	1	6
	428	3½

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UNITED STATES DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY

EXPLANATION

QUATERNARY

Qal — Alluvium
Sand, silt, and clay in flood plains

Qt — Terrace deposits
Sand, silt, and clay above flood plains

PENNSYLVANIAN

Pc1a, Pc, Pc2 — Calvin sandstone
Sandstone, shale, and a few beds of limestone. Lighter bands designate sandstone beds; darker bands designate shale. Symbols Pc1a-Pc2 are those used in stratigraphic diagram; tops of sandstone beds marked by dashed contact lines

Ps, Ps6b, Ps6, Ps6a — Senora formation
Sandstone, shale, coal, and a few beds of limestone. Lighter bands designate sandstone beds; darker bands designate shale. Symbols Ps1a-Ps7 are those used in stratigraphic diagram; tops of sandstone beds marked by dashed contact lines

Area from which coal has been stripped

Outcrop of coal bed containing more than 14 inches of clean coal
Dashed where approximately located, dotted where concealed

Outcrop of thin or dirty coal bed or of coaly zone
Dashed where approximately located, dotted where concealed

Contact
Upper contacts of sandstone beds are dashed, as are all other contacts where approximately located

Fault
Dashed where approximately located; U, upthrown side; D, downthrown side; queried where doubtful

Anticline
Showing trace of axial plane; dashed where approximately located; dotted where concealed; queried where doubtful

Syncline
Showing trace of axial plane; dashed where approximately located; dotted where concealed; queried where doubtful

Strike and dip of beds
Shown only where measurements indicate beds depart from gentle westward dip

Shaft mine entry

Slope mine entry

Drift mine entry

Quarry

R. 13 E. R. 14 E. R. 12 E.

T. 13 N. T. 12 N. T. 11 N.

OKMULGEE MORRIS SCHULTER COALTON HENRYETTA DEWAR KUSA WILDCAT HOFFMAN Junction

Lake Morris

MORRIS COAL BED
HENRYETTA COAL BED

Okmulgee Creek Coal Creek Montezuma Creek Wolf Creek

DEEP FORK

SAN FRANCISCO ST LOUIS GULF KANSAS OKLAHOMA AND NORTHERN

HENRYETTA-SCHULTER ANTICLINE

OKMULGEE CO
McINTOSH CO

A A′ B B′

TRUE NORTH
MAGNETIC NORTH
9°

Base compiled from aerial photographs and township plats

Geology by R. J. Dunham and J. V. A. Trumbull, 1951

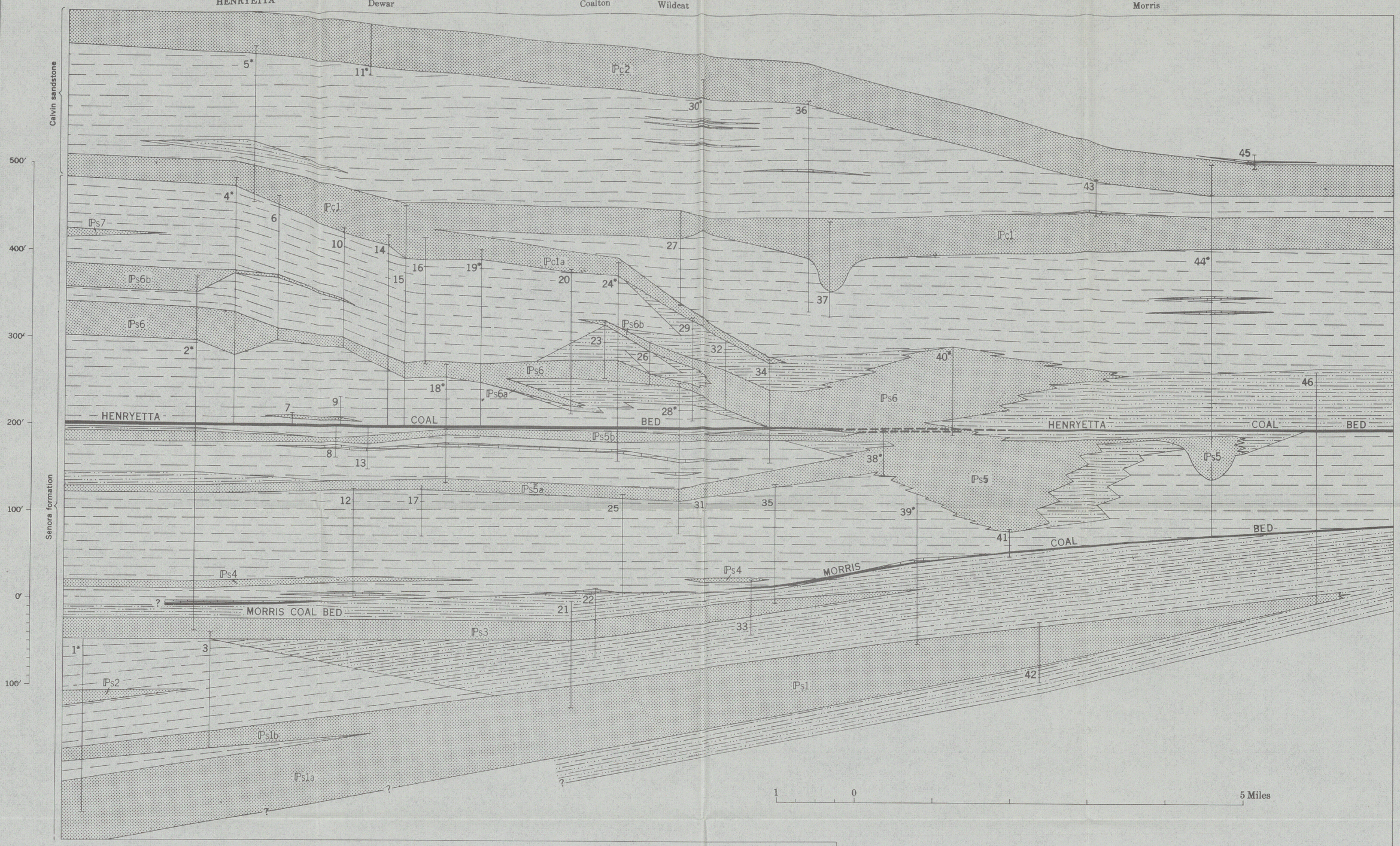
INTERIOR-GEOLOGICAL SURVEY, WASHINGTON, D. C.
M R-5847

GEOLOGIC MAP AND CROSS SECTIONS OF THE HENRYETTA MINING DISTRICT, OKMULGEE COUNTY, OKLAHOMA

Scale 1:48,000
1 0 2 Miles

S. T. 11 N. T. 12 N. T. 13 N. N.

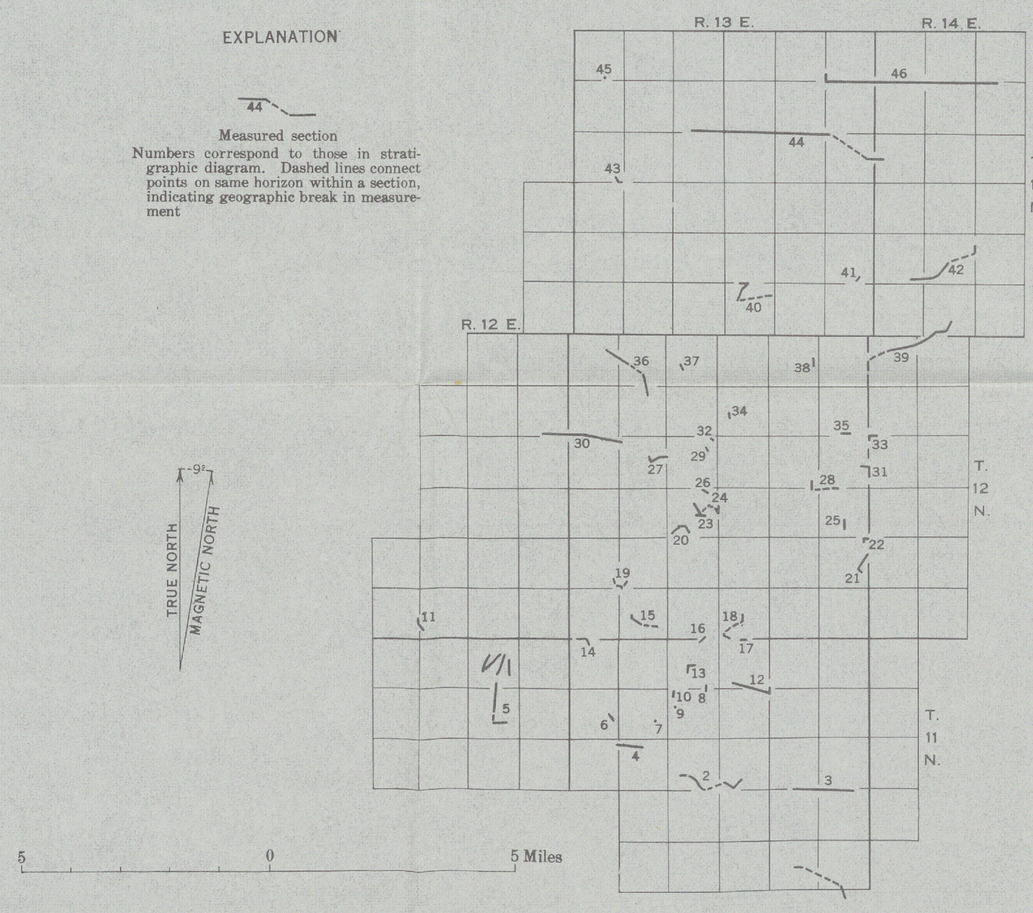
HENRYETTA Dewar Hoffman Coalton Schulte Wildcat OKMULGEE Morris



EXPLANATION

Measured section

Numbers correspond to those in stratigraphic diagram. Dashed lines connect points on same horizon within a section, indicating geographic break in measurement



INDEX MAP, SHOWING LOCATION OF MEASURED SECTIONS

EXPLANATION

Sandstone

Limestone

Silty and sandy shale

Coal

Shale

Diagram constructed by projecting measured sections into a vertical plane which is parallel to the regional strike of about N. 15° E. Numbered vertical lines show relative position of measured sections; * indicates selected sections given at end of report. Orientation of lithologic symbols does not indicate angular relations between beds

GENERALIZED SOUTH-NORTH STRATIGRAPHIC DIAGRAM, HENRYETTA MINING DISTRICT, OKMULGEE COUNTY, OKLAHOMA

315409 O - 55 (In pocket) No. 1

UNITED STATES DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY

EXPLANATION

Outcrop of coal bed containing more than 14 inches of clean coal
Dashed where approximately located, dotted where concealed

Outcrop of thin or dirty coal bed or of coaly zone
Dashed where approximately located, dotted where concealed

U / D — Fault
Dashed where approximately located; U, upthrown side; D, downthrown side; queried where doubtful

Anticline
Showing trace of axial plane; dashed where approximately located; dotted where concealed; queried where doubtful

Syncline
Showing trace of axial plane; dashed where approximately located; dotted where concealed; queried where doubtful

14 — Lines of equal thickness of clean coal; interval 7 inches

x41b 41 — Active underground mine
Showing type and location of entry and approximate limit of workings; numbers refer to table of mines, table of analyses, and to graphic coal sections; cross indicates location of measurement or sample

x51c 51 — Abandoned underground mine
Showing type and location of entry and approximate limit of workings; numbers refer to table of mines, table of analyses, and to graphic coal sections; cross indicates location of measurement or sample

Area from which coal has been stripped

Shaft mine entry

Slope mine entry

Drift mine entry

59 — Location of outcrop measurement of coal bed
Numbers refer to graphic coal sections

72 — Diamond-drill hole for coal
Numbers refer to graphic coal sections

109 — Drill hole for coal
Numbers refer to graphic coal section

R. 13 E. R. 14 E. R. 12 E.

T. 13 N. T. 12 N. T. 11 N.

OKMULGEE MORRIS SCHULTER COALTON DEWAR HENRYETTA KUSA WILDCAT HOFFMAN Junction Alkonak

Broken Arc Coal Co Mc Ginnis and Grafe Lake Morris

MORRIS COAL BED HENRYETTA COAL BED

ST LOUIS SAN FRANCISCO OKMULGEE NORTHERN OKLAHOMA GULF KANSAS OKLAHOMA AND GULF

Okmulgee Creek Cosselta Creek Montezuma Creek Wolf Creek

DEEP FORK

HENRYETTA-SCHULTER ANTICLINE

OKMULGEE CO McINTOSH CO

TRUE NORTH 9° MAGNETIC NORTH

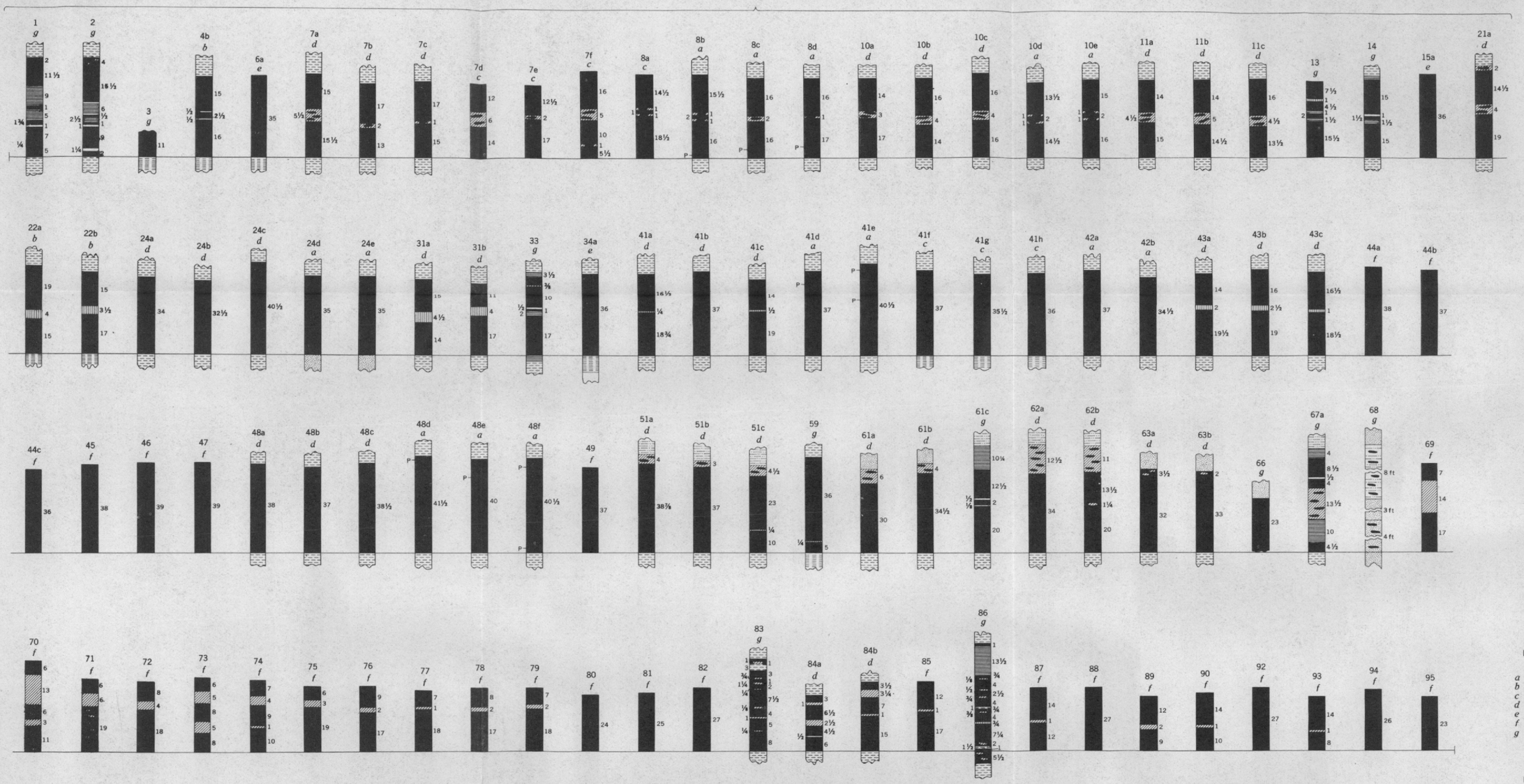
MAP OF HENRYETTA AND MORRIS COAL BEDS, SHOWING THICKNESS AND EXTENT OF MINING IN THE HENRYETTA MINING DISTRICT, OKMULGEE COUNTY, OKLAHOMA

Scale 1:48,000
1 0 2 Miles

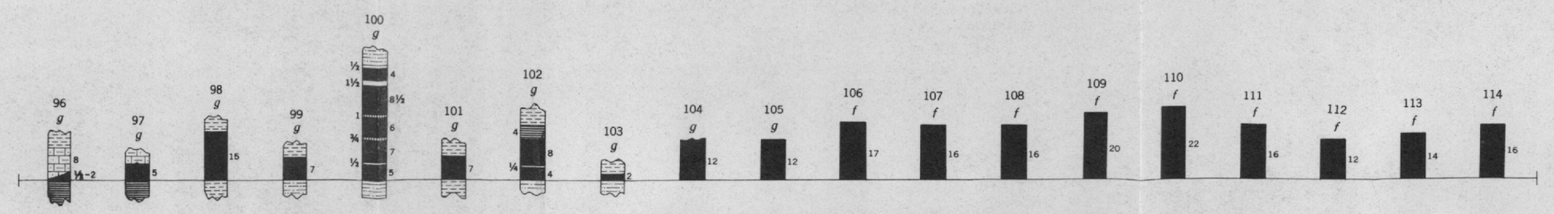
INTERIOR-GEOLOGICAL SURVEY, WASHINGTON, D. C.
M R-5847

UNITED STATES DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY

HENRYETTA COAL



MORRIS COAL



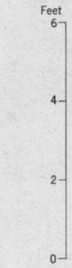
EXPLANATION

- Coal
- Fusain or "mother coal"
- Bony coal
- Bone
- Thin, impure partings in coal
- "Dirty band"
- P— Pyrite streak in coal
- Carbonaceous shale
- Carbonaceous, silty, and sandy shale
- Carbonaceous sandstone
- Clay
- Shale
- Silty or sandy shale
- Sandstone
- Silty and shaly limestone

Letters in italic indicate source of information, as follows:

a U.S. Bur. Mines Tech. Paper 411, 1928
b U.S. Bur. Mines Bull. 22, pt. 2, 1913
c U.S. Bur. Mines unpublished analyses
d Okla. Geol. Survey Bull. 51, 1929
e Okla. Geol. Survey Bull. 4, 1926
f Exploratory and development drilling
g Authors' field measurements

Numbers at top of sections refer to locations shown on plate 23. Thickness is in inches unless otherwise noted



GRAPHIC SECTIONS OF THE HENRYETTA AND MORRIS COAL BEDS, HENRYETTA MINING DISTRICT, OKMULGEE COUNTY, OKLAHOMA

315409 O - 55 (In pocket) No. 2

GRAPHIC SECTIONS OF THE HENRYETTA AND MORRIS COAL BEDS, HENRYETTA MINING DISTRICT, OKMULGEE COUNTY, OKLAHOMA

MORRIS COAL

HENRYETTA COAL

UNITED STATES DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY

BULLETIN 1078-G, PLATE 34

EXPLANATION