T. 20 N., R. 10 E.

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INTRODUCTION.

The area described in this report is that part of T. 20 N., R. 10 E., which lies in Osage County. (See fig. 1.) The area was mapped in July and August, 1918, in two portions, as shown on the key map on Plate L. One portion was covered by Kirtley F. Mather, assisted by Harold C. Wire, instrument man. Edmund M. Spieker, W. G. Argabrite, and the writer cooperated on the geology of the other portion, in which most of the instrument work was done by Milton G. Gulley, with some help from E. Russell Bickel and Mary Ware Goldman. The description of surface features in the area covered by Mr. Mather was prepared by him.

In general, the area is one of thick series of sandstones with strong relief and a heavy cover of timber. Large parts of it, however, are so deeply buried under wind-blown sand that rock outcrops are more or less completely concealed and the topography assumes a much more rounded character; but even these parts are, to a large extent, covered with timber. On the structure map (Pl. L) the areas in which the mantle of sand was so heavy that the structure could not be determined are indicated by shading.

Over much of the area the structure was difficult to work out, on account of the lack of persistence of the beds followed. They were parts of thick series of sandstones and were brought out as benches only locally by the weathering back of softer overlying sandstone or thin lenticular beds of shale, so that they could be followed over only short distances and even there with some uncertainty. It is believed, however, that the general character of the structure is correctly represented, even if the portrayal is not exact in all details.

STRATIGRAPHY.

EXPOSED ROCKS.

The beds exposed in this area and the average distances between them are represented in the diagrammatic section (fig. 49). The most readily identifiable beds, which occur in the lower part of the section, are the Dewey limestone, Avant limestone, and *Fusulina*-bearing sandstone.

Dewey limestone.—The Dewey limestone, to which the position of all the other beds is referred, crops out in only a small area along the southeast edge of the township. It was identified by K. F. Mather, who was familiar with its occurrence in adjacent areas. As the exposure is poor and meager within this area it will be best to consult, for a more detailed description, the text describing T. 20 N., R. 11 E.,[1] directly adjacent. The lower half appears as a blue-gray fine-grained fossiliferous limestone; the upper half as a limestone that is more or less sandy or has a conglomeratic or brecciated structure. The total thickness is probably about 10 feet.

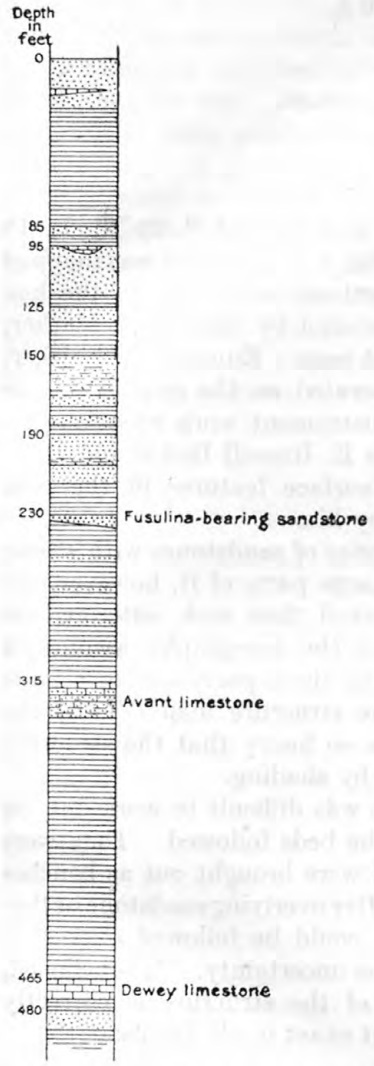

FIGURE 49.—Stratigraphic section showing rocks exposed in T. 20 N., R. 10 E.

Avant limestone.—The slope separating the Dewey limestone from the Avant limestone, which was also identified by K. F. Mather, is generally covered by soil and vegetation, a fact which in itself indicates the predominance of shale. No sandstone or limestone was noted in this interval. The Avant, though distinguished as a limestone, is really a variable and irregular mass of limestone and sandstone about 13 to 18 feet thick. Its most evident characteristic is the dark-brown, rusty color to which it weathers. This color penetrates more or less the interior of all the sandy portions and some of the more sandy limestone, but the pure limestone is light blue-gray on a freshly broken surface. Fossil shells are few and scattered. At the base is a massive bed, generally 10 to 15 feet thick. The upper 3 feet of this bed is a fairly pure ocherous limestone that grades into the sandy limestone or sandstone below. Above this basal bed are frequently found poorly exposed fragments of a compact, pure limestone which weathers to a creamy color and occupies a zone apparently about 3 feet thick. The top of this bed is taken at the

[1] Lloyd, E. R., and Mather, K. F., U. S. Geol. Survey Bull. 686-J, 1919.

top of the Avant limestone in this township. Above that there is in places 10 feet or so of a sandy bed similar to that at the bottom. The principal occurrence of the Avant limestone is in a strip 1¼ to 1½ miles wide along the southeast edge of the township, running south about 3½ miles from the northern part of secs. 13 and 14. It reappears, however, in small exposures in the southwestern part of the area, in the bottoms of the branch valleys at the edge of the flood plain of Arkansas River. In T. 20 N., R. 11 E., where opportunities for measuring intervals from the Avant to beds above and below it were more favorable, E. R. Lloyd and K. F. Mather reached the conclusion that the position of the Avant in the section is rather variable. In T. 20 N., R. 10 E., the interval to a *Fusulina*-bearing sandstone above it was found to range from about 86 feet in the southeastern part of the township to 60 feet or so in the southwest. The interval between this *Fusulina*-bearing sandstone and the Dewey limestone was found by Mather to be very constant. In T. 20 N., R. 10 E., therefore, the *Fusulina*-bearing sandstone was taken as the reference bed, to which, as far as possible, all elevations were reduced. The interval between the Avant limestone and the *Fusulina*-bearing sandstone is occupied mainly by shale but also contains beds of sandstone, some of them locally rather thick, but as none of these sandstones were used in working out the structure of the area they are not considered here.

Fusulina-bearing sandstone.—The *Fusulina*-bearing sandstone is a hard, platy bed, 3 to 5 feet thick, lying in the midst of shale. It is usually characterized by more or less abundant external molds of *Fusulina;* here and there these give way to shells of mollusks or brachiopods, and in some places no fossils are found, but this last condition is only local and where it occurs the bed can generally be recognized by its isolated position in the shale series and its relation to the heavy sandstone above it, or it can be traced to a point where *Fusulina* will be found in it. Five feet above the *Fusulina*-bearing sandstone there is in many places a sandstone of the same general character though without the *Fusulina* casts, and, where the lower bed does not carry them either, the two may be hard to distinguish.

Beds above Fusulina-bearing sandstone.—The series of beds above the *Fusulina*-bearing sandstone is highly variable and could be represented in the diagrammatic section (fig. 49) only in a general and somewhat arbitrary way. As a whole it may be said to consist of a thick succession of massive, generally soft sandstones. In the northeastern part of the area there are interbedded layers of shale, some of which are definite and persistent, but in the western and southwestern parts these shales become fewer and less persistent, the thinner sandstone lenses uniting to form heavy, massive sandstones, 30 feet or more thick, which along Arkansas River appear in precipitous

walls about 250 feet high. There are some definite beds of shale in the series in the southwestern part of the area, but in many places the benches in the series are probably due rather to overlying, softer sandstones or sandy shales, which have weathered out. The same is true of many of the benches in the northeastern part of the area. As a consequence, no attempt has been made to correlate beds across areas through which they could not actually be traced more or less continuously. The highest bed observed in the northeastern part of the area was a sandstone about 380 feet above the Dewey limestone. The remainder of the section occurs in the western part of the area. In the northwestern part of the area, according to K. F. Mather, there are almost no shales in the section. A well-defined bench of sandstone about 315 feet above the Dewey limestone appeared to be the most constant and best-defined bed in the northeastern part of the area. Red shales are fairly common in the 60 feet above this sandstone, and some were also observed in various parts of the series in the area to the southwest. In the southwestern part of the area most of the elevations used in mapping (except those on a heavy bed of sandstone which forms a well-defined rim on the highest ridges, about 465 feet above the Dewey limestone) are referred directly to the *Fusulina*-bearing sandstone, which can be traced along the lower parts of most of the valleys. The rim-forming sandstone about 465 feet above the Dewey limestone can be identified over most of its outcrop by a dark blackish-brown limestone, resembling the Avant, in some places full of shells, especially of *Productus*, which occurs about 15 feet below the top of the sandstone. In the northwestern part of the area K. F. Mather recorded at 15 feet above what appears to be, from its position, the equivalent of the top of this high sandstone, "a thin sandstone * * * which contains abundant fossils, the majority of which are pelecypods and brachiopods."

UNEXPOSED ROCKS.

The records of only two wells in this area are available, and only one of these is at all complete. The important beds encountered are given in the following table:

Principal beds penetrated in well in sec. 13, T. 20 N., R. 10 E.

	Feet.
Lime [undoubtedly the Dewey limestone]	140– 153
Big lime	1,280–1,297
"Oswego lime"	1,370–1,415
Bartlesville sand	1,844–2,002
Tucker sand; little gas at 2,031 feet	2,028–2,045
Burgess sand	2,094–2,101
"Mississippi lime"	2,101–2,105

STRUCTURE.

In that part of T. 20 N., R. 10 E., which is covered by this report there are no closed anticlinal folds such as have been found to be favorable for the accumulation of oil and gas elsewhere in the Osage Reservation, and even the most pronounced of the folds which are present are not of a type to encourage a hope that they will prove to be underlain by great accumulations of either oil or gas. However, some parts of the folds are unquestionably better adapted to bring about such accumulations than others, and these moderately favorable areas should be the first to receive the attention of the "wildcatter." The possible presence of lenses of open-pored sandstone that can not be recognized in advance of boring may determine the presence of important oil pools, even where the surface structure is unfavorable.

The most prominent structural feature in the area is an anticlinal nose whose axis runs approximately east through the eastern part of sec. 26, a little south of the center of sec. 25, and into T. 20 N., R. 11 E., where the fold is much better developed and more prominent than it is in T. 20 N., R. 10 E. At least three wells have been drilled on that part of the fold which lies in T. 20 N., R. 10 E., without encountering oil in commercial quantity, but as no records are available it is not possible to state whether or not they were drilled to adequate depths and constitute fair tests of the possibilities of the fold, or whether they encountered showings of oil that would be sufficient to justify further drilling. One of these wells, a little northwest of the center of sec. 36, low on the flank of the fold, was producing gas at the time of the field examination. A second well, a little more than 1,000 feet east of the first, is a dry hole. Neither of these tests is well located with respect to the anticlinal folding, and the fact that one is a producing gas well is more surprising than the failure to encounter commercial quantities of oil. A third test, in the SE. ¼ SE. ¼ NE. ¼ sec. 25, is much better located with regard to the structure, as it is but 500 feet north of the axis of the fold, and if it was drilled into the "Mississippi lime" without finding good "shows" of oil or gas it indicates that the probabilities of obtaining good yields from the part of the fold which lies in T. 20 N., R. 10 E., are very poor. However, in the absence of definite information, this test can not be said to condemn the fold, and further testing in sec. 25, southeast, northwest, or west of this dry hole, appears justifiable.

In sec. 28 there is a terrace-like flat on which occurs a small dome-shaped bulge. This departure from the regional westerly dip should be tested. A good location for the test is a little northeast of the center of sec. 28.

In sec. 13 there is a rather pronounced anticlinal nose whose axis trends north-northwest across the section. This fold has already

been tested by a hole that went to the "Mississippi lime" very near the crest without favorable results. However, another test a little farther north and to the west of the axis of this fold is probably justified, especially if good oil wells are developed in near-by territory.

In secs. 11 and 12 a gentle anticlinal fold pitching westward holds some promise of yielding oil or gas. In a region of more pronounced deformation it might well be overlooked, but in this district of low relief it stands out as more promising than the surrounding territory and is well worth a test. A good location for this test would be a little northwest of the center of sec. 11. Another location, perhaps less favorable, is a little west of the center of the SE. ¼ sec. 11.

A broad, flat terrace in sec. 2 presents structural conditions similar to those which at numerous localities in the Osage Reservation have been found to be associated with small accumulations of oil and gas. Where oil pools are developed near such terraces they are, as a rule, on the steep structural slopes either above or just below the broad flat. Accordingly, good places for testing this terrace would be just west of the east line of sec. 2, about midway between the east quarter corner and the northeast corner of the section. A second test might be made a little south of the center of the NE. ¼ sec. 3.

Terrace structure of some promise appears in the southwest corner of sec. 33 and the southeast corner of sec. 32, where a flattening of the westerly dip is succeeded by a marked steepening of the beds. A good location for a test would be just west of the east line of sec. 32, about midway between the east quarter corner and the southeast corner of the section.

A very considerable part of the township is concealed beneath wind-blown sand, and the structural conditions beneath this cover can only be guessed at. It seems probable that in sec. 34 there are either anticlines or synclines which depart radically from the general westerly dip of the regional structure. However, any anticline that may be concealed beneath the sand mantle is small in magnitude and consequently in probable importance.