LITHOLOGIC FACIES OF A PORTION OF THE STILLWATER FORMATION

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The Permian rocks of the world are noted for their unusual conditions of deposition; those of Oklahoma are no exception. The lowest beds of this system in north-central Oklahoma are marked by pronounced lithologic variations. This paper gives a description of those changes occurring in a portion of the Stillwater formation.

The Stillwater, as originally defined,[1] "includes a series of red and gray sandstones and red shales exposed in a zone extending north and south across east-central Oklahoma. Its base is the base of the Cottonwood limestone and the southern equivalent of the same. The top of the formation is the top of the Herington limestone and its southern equivalent. Throughout a considerable portion of the area of the outcrop of the Stillwater in central Oklahoma the exact location of neither the base nor the top of the formation has been accurately mapped at this time.

[1]Aurin, F. L., Officer, H. G., and Gould, Chas. N., "The Subdivision of the Enid Formation," Bull. Amer. Assoc. Pet. Geol., Vol. 10, 1926, p. 791.

"The equivalents of the Stillwater in southern Kansas and in Osage and Kay counties, Oklahoma, consist of a series of limestones and shales which constitute the Flint Hills named, in ascending order as follows: Cottonwood limestone and Garrison shale of the Council Grove group, the Wreford limestone, Matfield shale, Florence flint, Fort Riley limestone, Doyle shale, and Winfield limestone of the Chase group, and the Luta limestone, Enterprise shale, and Herington limestone members of the Marion formation of the Sumner group.

"As one passes south these various beds begin to lose their identity in the region of the Arkansas River in southern Osage, northeastern Noble, and Pawnee counties. By the time the color-change line has been reached the limestones are thinning rapidly and are being replaced by sandstones, while the shales begin to change their color from gray to red. Still farther

south the limestones disappear and the entire formation is found to consist of alternating beds of red shales and red and gray sandstones. This is typical Stillwater, as exposed at the type locality, Stillwater, the county seat of Payne County."

The Stillwater forms the lowest division of the Oklahoma Permian red beds, its base being placed at the base of cottonwood limestone which is accepted as the base of the Kansas Permian.[2] The red beds are regarded to be for the major part of continental origin. The equivalent of the Stillwater beds in Kansas are recognized to be the result of marine deposition. The line separating the marine beds on the north from the continental deposits on the south, if it can ever be accurately drawn, will be of a zig-zag nature because of the interdigitate arrangement of the two types of sediments. The gradation between them occurs chiefly within a zone several miles in width crossing the strike of the strata at an acute angle. The approximate position of this zone is shown on the accompanying geologic map of a portion of northern Oklahoma. The material constituting the red beds of this area was probably derived from the south,[3] and as the sediments spread farther and farther from their source during the deposition of later and higher beds, the zone of graduation shifted to the north. The zig-zag nature of the actual line of color-change is due to the oscillation of the northern border of red bed deposition. The present geographical location of the zone of graduation has been partly determined by the structural attitude of these beds and the way they are intersected by the present erosion surface, although the original distribution of sediments has been the controlling factor.

It is interesting to note that in Texas the contemporaneous Wichita beds, which are similar in lithology to the Stillwater, grade southward into a marine series, the Albany, with relations quite similar to those of the beds in north-central Oklahoma.[4] This duplication of conditions at approximately the same distance north and south of the region known to have been dominantly positive during the late Paleozoic, namely, the Arbuckle-Wichita-Amarillo series of mountains, when considered with other evidence, has led some to believe that the positive region named furnished much of the clastic material incorporated in the lower Permian red beds outcropping in central Oklahoma and north-central Texas.[5]

The Fort Riley limestone of the Stillwater formation and associated beds have been studied by the writer. The accompanying composite cross-section illustrates the described lithologic changes in this portion of the Stillwater.

The outcrop of the Fort Riley limestone is shown on the colored geologic map of Oklahoma[6] as extending in a north-south direction across

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[2]Moore, R. C., and Haynes, W. P., "Oil and Gas Resources of Kansas, Kans. Geol. Surv., Bull. 3, 1917, p. 107.
[3]Tomlinson, C. W., "The Origin of Red Beds," Jour. Geol., Vol. 24, 1916, p. 244.
[4]Willis, Bailey, "Index to the Stratigraphy of North America," U. S. Geol. Surv., Prof. Paper 71, 1912, p. 476.
[5]Gould, Chas. N., and Wilson, R. A., "The Upper Paleozoic Rocks of Oklahoma," Oklahoma Geol. Survey, Bull. 41, 1927. p. 19.
[6]Miser, H. D., Geologic Map of Oklahoma, U. S. Geol. Survey, 1926.

eastern Kay, western Osage, eastern Noble, western Pawnee, and central Payne counties to a point on the Cimarron River two miles east of Perkins. The Fort Riley has a regional dip to the west averaging 30 feet per mile.[7] In regions such as the Mervine anticline in eastern Kay County folding has caused irregularities and even reversals of dip.

At the Cimarron River, in section 3, T. 17 N., R. 3 E., no limestone is present at the Fort Riley horizon, its equivalent being a layer of drab shale five feet thick, overlain by twelve or more feet of red cross-bedded sandstone. The drab shale is underlain by fifteen feet of red clay shale, beneath which occurs a layer or red and yellow sandstone fifteen or more feet thick, cross-bedded, and otherwise similar in appearance to the overlying sandstone. The topographic effect of the two sandstones is to produce a poorly defined scarp, the top of which is formed by the upper sandstone, and the base of which the lower sandstone outcrops.

North of the river, the two sandstone beds become more widely separated by drab shales and calcareous material and tend to form an upper and lower bench on the major east-facing scarp. This condition is seen where Black Bear Creek crosses the outcrop two miles east of Morrison in section 14, T. 21 N., R. 3 E. In the sloping hillside between the two benches thin beds of limestone separated by layers of drab shale may be seen in gullies, but they have no pronounced topographic expression. These limestones represent marine deposition of the Fort Riley.

In the next ten miles, these thin beds combine to form a ten-foot ledge of hard limestone which in the Watchorn oil field and in the bluffs on the south bank of the Arkansas River in section 28, T. 23 N., R. 3 E., is expressed as a persistent low scarp. Here it is sufficiently thick and massive to break off in large blocks, some of which are 8 feet in width by 10 feet in length and nearly as thick as the ledge. These blocks slump and cover the slope below, giving the outcrop a characteristic appearance that identifies it for some distance to the north. The overlying and underlying sandstones are present although their effect on the surface configuration is less than that of the limestone, due to its greater resistance. In this area the upper sandstone caps the hills formed by the limestone ledge.

Farther north, in section 1, T. 24 N., R. 3 E., within the bend of the Arkansas River partially surrounding the Bar-L ranch, the same scarp-forming limestone, slumping in large blocks, is found. The general features are the same in the Watchorn section, although the limestone ledge has thickened to 14 feet. The sandstones above and below retain the same thickness. The sections differ chiefly in the presence of a greater thickness of drab shale here than has previously been seen.

That the increase in thickness is not altogether a regular uninterrupted one is shown by the presence of only six feet of limestone at a point four miles north, in section 19, T. 25 N., R. 4 E., across the Arkansas River from the Bar-L ranch. The associated drab shales are also thinner. The two sandstone beds are present although the upper one has lost most of its Stillwater characteristics in that it contains yellow beds, a layer of drab shale, and one of sandy limestone.

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[7]Wood, R. H., U. S. Geol. Surv. Bull. 531-B, 1915, p. 33.

In the sharp bend of the Arkansas River at Kaw City in section 5, T. 26 N., R. 4 E., the limestone has attained a thickness greater than at any point to the south. Here the sandstone overlying the main ledge of limestone is not present as such, having graded into drab and yellowish shales and brown and yellow sandy limestones that occupy the stratigraphic position it holds farther south. These shales and limestones constitute a division of the Fort Riley easily distinguished from the thick-bedded portion below. The divisions here have a thickness of 55 feet.

In the Mervine anticline in section 2, T. 27 N., R. 3 E., the Fort Riley limestone and the lower formations are brought to the surface. Here, at a point about seven miles northwest of the Kaw City section, the Fort Riley scarp occurs at the crest and on the west flank of the fold, while on the east flank a half-mile distant a prominent hogback is made by the Florence Flint, while the Fort Riley takes a less conspicuous position. This is the first appearance of the Florence which lies below the Fort Riley. Its limestone layers are similar to those of the Fort Riley, but it contains nodules and layers of chert which make it quite resistant to erosion. A sandstone occurring twelve feet below the Florence at this point may represent the one underlying the main ledge of the Fort Riley farther south.

In Cowley County, Kansas, a few miles farther north, the Florence flint in many places forms a more prominent scarp than does the superjacent Fort Riley limestone which then outcrops as a sloping upland extending back from the main scarp. In other places the main ledge of the Fort Riley forms the dominant scarp. Few sandstones exist in the Chase group of Cowley County. Here the Florence has a thickness of from 11 to 35 feet, and the Fort Riley a thickness of 55 feet,[8] of which approximately 30 feet represents the lower massive portion, and 25 feet the overlying division of thin-bedded limestones and interbedded shales.

SUMMARY

A few generalizations made from the interpretation of the foregoing description may be briefly summarized as follows:

1. The marine facies of the Fort Riley limestone is represented in a section of typical Stillwater at the Cimarron River by a thin layer of drab shale which becomes thicker toward the north. A few miles northward thin limestones come in which soon merge into a single thick layer of limestone. This also thickens until, at a point 50 miles north of the Cimarron River, the marine Fort Riley approximates 55 feet in thickness, about the same as its average in Cowley County, Kansas.

2. The sandstones overlying and underlying the drab shale layer at the Cimarron River grade into marine limestones and shales before the Kansas line is reached.

[8]Bass, N. W., Recon. Geol. Map of Cowley Co., Kansas. Geol. Survey., Bull. 12, plate 1, 1929.

3. The overlying sandstone at the Cimarron River changes progressively in character through the following facies as it is traced northward: (a) red cross-bedded sandstone, (b) red and yellow evenly bedded sandstone and calcareous sandstone, (c) sandy limestone and interbedded shale, and (d) thin-bedded limestone and inter-bedded shale. The latter facies constitutes the upper portion of the typical marine Fort Riley of southern Kansas. Therefore, the upper sandstone at the Cimarron River is in part equivalent to the upper division of the Fort Riley farther north.

The underlying sandstone does not show the gradation into marine beds so clearly. It is probably the equivalent either of part of the lower thick-bedded Fort Riley, or of part of the Florence, or both. Further study and analysis of rock samples may throw more light on this question.