H. R. Woodward

THE UNIVERSITY

GEOLOGICAL SURVEY

OF

KANSAS

CONDUCTED UNDER THE AUTHORITY OF THE BOARD OF ADMINISTRATION OF THE UNIVERSITY OF KANSAS, AS AUTHORIZED BY STATE LEGISLATION.

BULLETIN No. 2

ON CRYSTALLINE ROCKS IN KANSAS

BY

ERASMUS HAWORTH, State Geologist

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LETTER OF TRANSMITTAL.

Dr. Frank Strong, Chancellor of the University of Kansas:

SIR—I have the honor to submit to you herewith a special report, "On Crystalline Rocks in Kansas," which I request to have published at once. Conditions in the vicinity of Manhattan and Zeandale are such that certain reports have gained circulation which, in effect, are derogatory to the value of large areas in that part of the state for oil and gas production. Without especially debating the main question as to whether or not such territory is likely to prove valuable, this little report is prepared for the direct purpose of showing that the discoveries made should in no way be used to lessen the prospective value of this part of the state as an oil and gas producer. Should these reports go unchallenged it is feared much damage may be done to this part of the state, reaching even into the millions of dollars. This report is written with a hope of restoring confidence in the area in question, and, therefore, should be given the widest publicity at the earliest possible date. Most respectfully submitted.

ERASMUS HAWORTH, *State Geologist.*

LAWRENCE, KAN., May 15, 1915.

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WHY THIS REPORT.

PREVIOUS to the autumn of 1914 a company was organized for the purpose of obtaining leases on certain lands in Riley, Pottawatomie and Wabaunsee counties, Kansas, in the vicinity of Wamego, Zeandale and Wabaunsee. A large acreage was placed under lease, and arrangements were made whereby drilling should be begun in the autumn of 1914. The first location chosen was about a half mile to the south of the little village of Zeandale, which in turn is situated in the valley of the Kansas river about eight miles east of Manhattan. When the drill had reached a depth of 958 feet it came in contact with a very hard rock, which was pronounced granite by those operating the drill and others who observed the same. Drilling was continued to a total depth of 1093 feet, or 135 feet into the so-called granite.

At that point drilling was stopped, and the drill was moved about a mile almost straight east, and a second hole was begun, which, at a depth of 945 feet struck what seemed to be the same rock. Drilling at this point was continued to something over 1200 feet, making close to 300 feet that it penetrated this so-called granite. As this drilling was very difficult and very expensive, and as people became discouraged on account of the kind of material they were in, the entire enterprise was abandoned.

During the autumn of 1914, also, a well was begun near Elmdale, which at a depth of 1707 feet struck a hard rock, and continued in the same for quite a number of hundred feet, and likewise was abandoned. Various reports have reached me regarding this well, but in general it was reported that the drill struck granite and that the well was abandoned on account of the granite encountered.

In this connection, and in order that the reader may fully understand the situation, it is necessary to describe other events which have transpired in Kansas during the last few years, and other general geological conditions in near-by territory. Beginning on the south of the state, in the vicinity of

Arkansas City and Winfield, we find a strip of territory, approximately 25 miles wide, which reaches entirely across the state, trending a little to the northeast and southwest, passing, we will say, from Arkansas City to Marysville in the Blue River valley. Throughout this area a number of distinct individual anticlines have been found, and a number of different gas pools and oil pools have been located.

This seems to be a northern extension of the Ponca, Oklahoma, territory, and oil wells and gas wells have been found at various places all the way from twenty miles south of Ponca to as far north as Elmdale and Woolsey. Many people have been looking upon this strip of territory as prospectively very encouraging. Its greatest production is in the vicinity of Augusta, where a great many small and medium gas wells have been found, and some that would pass well for larger wells, one being reported at more than twenty million cubic feet capacity. Also, a number of good oil wells have been found. It is well within the truth to say that the developments in the vicinity of Augusta alone are worth anywhere from five to ten million dollars at the present time. Under such circumstances this strip of territory, throughout which so many small anticlines are located, becomes very prominent, and already has attracted the attention of many capitalists and people desiring to engage in the development of oil and gas.

The unfortunate occurrence at Elmdale, added to the still more positive misfortunes at Zeandale, have resulted in a complete condemnation of this territory, practically from Augusta north to the north side of the state, including an area of 25 miles in width and more than 100 miles in length, or more than one and one-half million acres. Of course, it is not believed by any one that the entire area within the limits described would ever develop into good oil and gas lands. Before these unfortunate experiences, however, it was believed that a large proportion of the area was first-class wildcat territory. Other companies, likewise, had obtained leases throughout the area described, who also, unless something can be done to restore confidence, will lose all their investments. The greatest loss, however, will be to the landowners and other property owners in the territory described, which includes many thriving villages and cities, such as Cottonwood Falls, Council Grove, White City, Alma, Wabaunsee, Manhattan, Westmoreland,

Marysville, etc. The wholesale condemnation of this entire territory, therefore, became a serious matter.

Under these circumstances the question came home to me, as state geologist, whether or not a duty rested upon me which would be discharged only by endeavoring to restore confidence in the prospective value of the area described as oil and gas territory. The more this subject was considered the more plainly it appealed to me, as a matter of duty, that I should make public what knowledge I possessed on the subject, and the conclusions which seemed properly to be drawn therefrom. Therefore, this little report has been prepared hastily, and has been hurried through the state printing office in order that it might, in a way, assist in restoring confidence in the area described, and thereby prevent a great damage being done to a large proportion of the citizens of Kansas.

In the pages which follow I have endeavored to present all the facts in my possession which in any way may have a bearing on the question in hand. I have prepared maps and sketches in order that the problem may be better understood. It is true, of course, in one sense of the term, that no one can know to a certainty what there is far beneath the surface without digging down to find out. It is also true, however, that there is a certain regularity in nature's processes which, when properly interpreted, will assist greatly in predicting in advance what may be found. It is my earnest effort, therefore, in the present instance, to bring before the reader all the facts bearing upon this subject and to present them in such a way that he may understand my views on the subject and the reasons therefor. It will then be left with him to draw his own conclusions.

On Plate I are located a number of deep wells, a few of which have been reported to have found granite or other crystalline rocks, while others have found nothing of the kind. It is in order that the geography of the situation may be brought out plainly that the map, with various inscriptions, is herewith presented. The reader is requested to study this map with care, and to note the wells which are reported to have found crystalline rocks, and others near by which have found nothing of the kind. Also, in this same connection, but to be used more especially later, a vertical section—Plate II of this report—has been prepared, showing the surprising regularity of the strata from Kansas City west to the area where granite

is reported to have been found in the Zeandale wells. Similar cross sections might be made at many places to the south in Kansas. In my own individual work I have prepared such a section for the southern part of the state. I mention it here only to assert that a properly prepared section based upon facts produced by the numerous oil wells and gas wells drilled from the southeast corner of the state westward to as far as Arkansas City reveals a surprising regularity of strata in that part of the state. We have many well records in the territory reaching from Arkansas City northward to Zeandale, so that similar sections could be drawn in many different intervening places, and all of them would show the same kind of regularity we have here at the Zeandale section. These two drawings, therefore—the map and the section—should be studied together, and the reader should understand at all times that the Zeandale section in no way differs materially from sections which might be drawn both north of it and south of it, so far as regularity of strata is concerned.

HISTORICAL.

For more than twenty years various reports of finding granite here and there throughout Nebraska and Kansas have come to light. Such reports may possibly have had something to do with the present instance, or possibly there is no connection. As is well known, away to the north in the vicinity of Sioux Falls, South Dakota, eruptive rocks have reached the surface, and a number of wells in that vicinity, some distance removed from the surface exposures, have encountered eruptive rocks at various depths beneath the surface. I am told, on what seems to be first-class authority, that throughout southeastern South Dakota drillers for artesian water frequently strike granite, and also, that in some instances granite has been falsely reported in order to relieve the drill contractor from an unprofitable well.

Little concerns us here, however, until we have passed as far south as Omaha. Here a large number of deep wells have been drilled, fifteen or more, the depth varying from 1000 feet to as great as 1835 feet. In none of these was any granite or other crystalline rock found, and none was reported. To the southwest of Omaha a very interesting well was drilled at Lincoln in 1886, a brief report on which is published by Mr. F. W. Russell in the *American Geologist,* volume I, page 131. After describing various finds from the surface downwards, which conditions need not be considered here, the following description was given for the last part of the well:

> At 1100 feet, or thereabouts, the first magnesian limestone was met, and it was the chief rock onward to nearly 2000 feet Here was found a sandstone very fine in grain and even in texture. Passing onward, one finds magnesian limestone and red sandstone; this last very hard in some places. The work was stopped in this same red sandstone, at the depth of 2463 feet. The boring ceased only on account of a technicality in the law, which made the funds for the purpose unavailable after a certain time. The drill hole was left in excellent condition, however, and there is every reason to believe that the coming legislature will make arrangements for the continuance of the work 500 or 1000 feet further.
>
> F. W. RUSSELL.

Also, a footnote by the editor of the *American Geologist* is interesting, and is as follows:

We are assured that the final report of Mr. B. P. Russell upon this well will soon appear. Mr. Russell was appointed by the Board of Public Lands and Buildings to superintend the boring, and his report will be received with great interest on account of the depth of the well and its remoteness from any similar boring. The fact that no crystalline rocks were encountered in descending 2463 feet makes the discovery of such rocks in Pawnee county at the depth of 550 feet the more remarkable.—ED.

The relations between Mr. F. W. Russell and Mr. B. P. Russell are not known to me. It seems, however, that the latter made a report on the well which is quite at variance with the report first made by Mr. F. W. Russell, as above quoted. Darton* copies the following from the report of Mr. B. P. Russell, which he refers to "Sixth Biennial Report Commissioner of Public Lands and Buildings, to Governor of Nebraska, 1888, pages 57-84," and states that Russell deposited the core of the well in the museum of the State University:

RECORD OF BORING ONE MILE WEST OF THE POST OFFICE, LINCOLN, NEB.

(Copied from N. H. Darton.)

Feet.	
0– 25....	Soil, sand, and gravel.
25– 269....	Sandstones, sands and clays, with brine 21° at 119 feet, and 35° at 195 feet.
269–1,099....	Limestones and shales, with occasional beds of sandstone. Brine, 12° at 600, and 16° at 828 feet.
1,099–1,813....	Magnesian limestones, probably in greater part of Mississippian age; 15 feet of sandstone, 1,218 to 1,233 feet, and 13 feet of red shale, 1,427 to 1,440 feet.
1,813–1,847....	Very fine blue limestone.
1,847–1,867....	Heavy dark magnesian limestone.
1,867–1,947....	Very fine blue limestone.
1,947–2,008....	Sandstone (St. Peter?).
2,008–2,121....	Magnesian limestone.
2,121–2,192....	Red sandstone (Potsdam?).
2,192–2,463....	Quartzite and metamorphosed shale, with quartz veins. Color, dark red to flesh (Sioux quartzite?).

It will be noted that in this report of B. P. Russell the material from 2192 feet to the bottom is spoken of as "quartzite and metamorphosed shale, with quartz veins. Color, dark red to flesh (Sioux quartzite?)." This puts an entirely different meaning to the record of this well from the meaning conveyed

* Darton, N. H. Preliminary Report on the Geology and Underground Water Resources of the Central Great Plains.—U. S. Geol. Surv., Professional Paper 32, page 283. Washington, 1905.

in the report of F. W. Russell in *American Geologist,* volume I, page 131, above quoted. In this connection the following letter from Professor E. H. Barbour, State Geologist of Nebraska, is interesting and timely:

THE UNIVERSITY OF NEBRASKA,
LINCOLN, April 20, 1915.

Dr. Erasmus Haworth, University of Kansas, Lawrence, Kan.:

DEAR DR. HAWORTH: Respecting your inquiry, allow me to enter into a little history. Some years before I came to the state the legislature granted $20,000 for drilling a test well. I regret to say that the work of drilling this test well was political rather than scientific. The man who was put in charge was honest, but without preparation. He had absolutely no knowledge of geology. The well was drilled one mile west of Lincoln, on a line with R street, on the edge of the saline pool known as Capital Beach. A diamond drill was used, and they started with an eight-inch core. This was rapidly pinched down to an inch. They then found it necessary to start over and ream out the hole, beginning with 10 or 12 inches at the top. We have this entire well core from top to bottom. It is a very significant thing that they struck Sioux quartzite on the day the $20,000 was used up. This has been commented upon rather caustically. Beyond a question, as I learn from others, some one, in fun or in earnest, dropped a Sioux quartzite pebble into the hole. As soon as this was struck by the drill and brought up all work stopped. I think there is not the slightest basis for the report that a Sioux quartzite ledge was struck. This was reported as "granite," an unfortunate name very commonly applied to our boulders of Sioux quartzite so common in the drift. This well was drilled to a depth of 2463 feet.

I doubt if much reliance is to be placed on the core itself, it was so badly marked and so badly kept. Still, we have it, and shall keep it. It is often referred to and has been examined by a good many geologists. In a word, this whole undertaking was rendered doubtful by the incapacity of the man in charge. I do not believe that quartzite was struck in fact.

In Nebraska City the Ingersoll Brothers drilled a well for local parties, and kept a rather careful record of the formations through which they passed. The Nebraska City well is probably the deepest well in Nebraska, its depth being about 3010 feet. At about 1700 feet a porous crystalline dolomite was struck, but at no point was any metamorphic or igneous rock struck. Perhaps the reference to a well near Wymore is confounded with the well at Beatrice. The well at Beatrice was sunk to a depth of 1200 feet without piercing the Pennsylvanian.

The Iler well in Omaha is some 1700 feet deep, and no crystalline rocks encountered. There are probably fifteen deep wells in Omaha, varying from 1000 feet to 1835. There is not a hint or an indication in any of these of any metamorphic or igneous rocks. Near Rulo, in southeastern Nebraska, a well was drilled to a depth of about 1400 feet, but nothing outside of the customary sediments was struck.

Very truly yours, EDWIN H. BARBOUR.

It may not be out of order to refer to other instances about which publication already has been made in scientific literature. On page 130, *American Geologist,* volume I, is a short communication from F. W. Russell, of Lincoln, Nebraska, regarding a well in Pawnee County. This is as follows:

A CRYSTALLINE ROCK NEAR THE SURFACE IN PAWNEE COUNTY, NEBRASKA.

During the past summer a rock of no little interest was brought to light in a boring by the Rock Island & Pacific Railroad Company in Pawnee County, Nebraska. The surface formation is Carboniferous. For 532 feet there is an alternation of shales, red and black, and magnesian limestone. At this depth, however, a change begins, and at 552 feet a distinctly crystalline rock is encountered. Much of it is flesh red, but this color is not uniform. It is quite hard, being about six in the scale of hardness. The chief ingredient is feldspar, with, moreover, macroscopic and microscopic particles of hornblende or pyroxene and hematite. The nature of the superincumbent rocks, together with the slight depth at which this rock was found, make it quite an interesting subject for further study.

LINCOLN, NEB. F. W. RUSSELL.

It so happens that this Pawnee County well has become more or less famous. Prof. J. E. Todd, of our University, while living in Iowa sent a short note to the *American Geologist* regarding this and other wells. It was published in the *American Geologist,* volume 15, page 64, January, 1895, and is as follows:

INEQUALITIES IN THE OLD PALEOZOIC SEA BOTTOM.

You will be interested to learn that gray granite, similar to that found at Le Mars, was struck at Sioux City at the depth of 1515 feet, or 355 feet below the sea level. It was penetrated about 500 feet, and showed characters similar to those found in the Le Mars well. At the latter point granite was struck at 1000 feet, about 150 feet above the sea—a difference of 500 feet in a distance of 25 miles. Crystalline schist was brought up by a diamond drill from 560 feet at Pawnee City, Neb., as I believe Prof. L. E. Hicks has published. That I estimate to be not less than 620 feet above the sea. Yet at Brownville, 35 miles northeast, a drill was sent down 1000 feet, probably 100 feet below the sea, without passing through the Carboniferous. At Omaha a boring to the depth of 1782 feet, 785 feet below the sea, failed to clearly reach the Silurian. This gives us a glimpse of the irregularity of the old Paleozoic sea bottom, and shows that the Carboniferous is considerably thicker than estimated by Doctor White in his report on Iowa.

TABOR, IOWA, May 12, 1890. J. E. TODD.

Professor Todd was quoting from memory, and while he named Pawnee City, evidently he was referring to the same well which Mr. Russell referred to in volume I, above quoted. Mr. Darton,* referring to this same well near Bern, Kan., speaks of it as the Dubois well, as follows, copying largely from F. W. Russell, as above:

> In the boring at Dubois, in Pawnee County, it is reported that the formations to 532 feet were an alternation of red and black shales and magnesian limestone. At 552 feet a crystalline rock was found which was penetrated to 652 feet. Much of it is flesh-red color, and it has a hardness of about 6 on the mineral scale. Its chief ingredient is feldspar, with particles of hornblende or pyroxene, and hematite. Probably it is an intrusive rock in the Carboniferous, although possibly part of the Pre-Cambrian "bed rock." There is some doubt whether the sample really came from the boring.

It so happens that the well in question was drilled for the Rock Island Railroad, under the immediate direction of Mr. M. A. Low, of Topeka, Kansas. It is located close to the railroad track in the valley of the Nemaha River, between Dubois, Nebraska, and Bern, Kansas. I have had a personal experience connected with this well, which, under existing circumstances, I think should be given in detail, and which is as follows:

In the early spring of 1904 I was called hurriedly to Wetmore, Kansas, to pass judgment on whether or not a well which was then being drilled at that place had reached the Mississippian limestone. Wetmore is in the extreme southeast corner of Nemaha County, Kansas, on the Central Branch of the Missouri Pacific Railroad. A local company had been organized, and contracted with the driller to put down a well to a depth of 2500 feet unless oil or gas in paying quantities was found earlier, or, as a second proviso, unless the Mississippian limestone was reached before that depth. At about 1750 feet the driller claimed to have struck the Mississippian limestone, and wished his pay and the privilege of abandoning the well. The citizens objected, and sent a hurried message for me to come to Wetmore. I reached there the following day, and found that the bottom of the well was in sandstone. The ultimate history of the well is that it was continued to a depth of 2250 feet and abandoned without finding either oil or gas or the

* Darton, *loc. cit.*, page 284.

Mississippian limestone. The last of the drill cuttings showed plainly that the well was in a sandstone.

While at this meeting with the citizens of Wetmore, a man who was a stranger to me—and whom, I learned afterwards, was a stranger to the parties who sent for me—showed me a little paper box with some fragments of granite in it, and asked me what it was. Of course I told him it was granite, and manifested but little interest in it. However, he persisted in talking on the subject, and told me how that granite had been struck in wells at Seneca—to be mentioned later in this report —and how that a company some years before had drilled a well for the Rock Island Railroad in the valley of the Nemaha River just north of the Kansas state line, near the town of Bern, which is in Kansas.

He went on to say that the well was drilled with a diamond drill, and at a depth of something over 500 feet the driller struck granite, and that a number of feet of the solid granite core were preserved. He further said that the driller was afraid to report this to Mr. Low, the Rock Island official, lest he would not get his money for the well, and therefore made a report stating that the last few feet of the well was in rock salt, or sodium chloride. He added, still further, that if I desired he would send me a piece of this granite core, provided I would guarantee its safe return. This latter precaution was taken because the owner of said core had given away all excepting this one piece and insisted on keeping it. I promised to preserve the core while in my possession and return it safely to the sender. The outcome was that within a few days a piece of core, from a diamond drill apparently, reached me through the mails. It was 5 or 6 inches in length, about $1\frac{3}{4}$ inches in diameter, and was cut through solid granite, red in color, with red feldspar largely predominating. Some of these feldspar crystals, I should judge, as best I could macroscopically, were at least half an inch in diameter, showing a very coarse granite. Along with the red feldspar and quartz was a small amount of black mica, and possibly other ingredients. The point at issue was whether or not it was granite. This being settled in the affirmative, I became very much interested in the matter, assuming, of course, that the story was true as told me.

I immediately took the matter up with Mr. M. A. Low, of the Rock Island Railroad, whose offices were in Topeka. I both wrote to him and saw him personally on the subject. He ridiculed the idea of the well having struck granite, and sent me a copy of the log of the well as reported to him by the well driller at the time the well was abandoned. Mr. Low further said that he allowed the well to be abandoned at the shallow depth of 562 feet because the well was a test well for water, and as salt water had been obtained he had no further interest in it. I include herewith a copy of the record of the well as sent to me by Mr. Low, the heading of which gives the exact location of the well in Pawnee County, Nebraska, within about 2½ miles of the Kansas state line:

Record of hole drilled for the C. R. I. & P. Railroad, on section 25, township 1 north, range 12 east, Pawnee County, Nebraska, near the Nemaha River, known as the Bern well, or the Dubois well. Record furnished by M. A. Low.

Description.	Ft.	In.	Ft.	In.
Soil	8		8	
Limestone	2		10	
Black slate	4		14	
Limestone and shale	13		27	
Soapstone and shale	3		30	
Soapstone and lime	20		50	
Black slate	1		51	
Shale slate and soap	12		63	
Soapstone	54	4	117	4
Black slate	4		121	4
Lime and soap mixed, thin layers	21	9	143	
Limestone	27	9	170	9
Soap and black slate	4		174	9
Limestone	1	6	176	3
Soapstone	11	3	187	6
Limestone	5	6	193	
Red shale	24	4	217	4
Clay shale	5	8	223	
Soapstone	1		224	
Limestone	8		232	
Black slate	32	6	264	6
Shale and soap	12	6	277	
Limestone	4		281	
Soapstone	8	4	289	4
Limestone	20		309	4
Limestone and soapstone	8	4	317	8
Soapstone and shale	7	4	325	
Limestone	35		360	

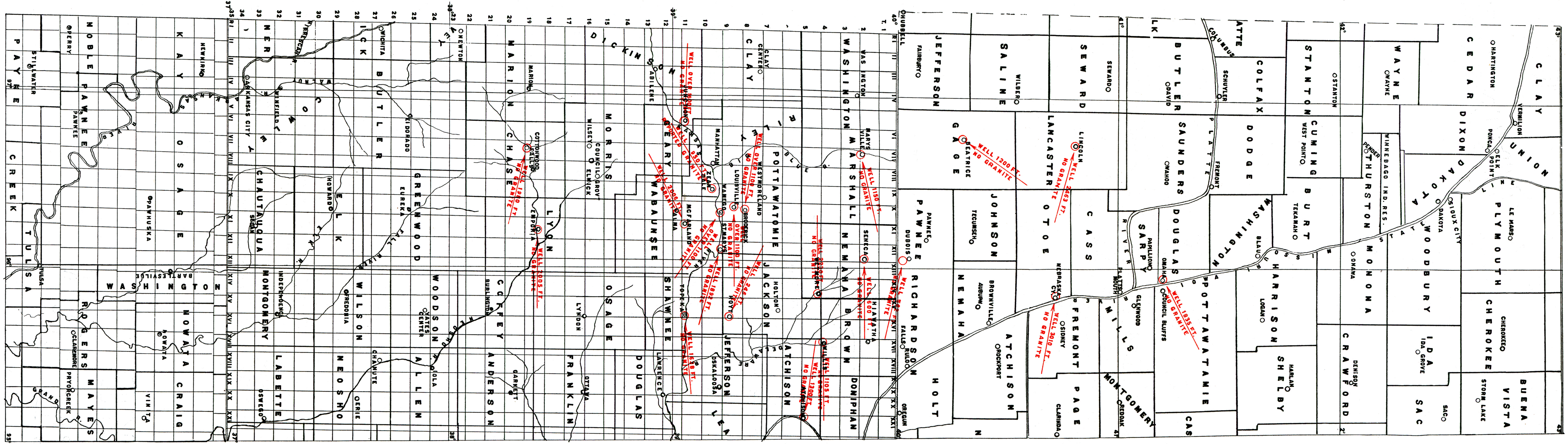
Description.	Ft.	In.	Ft.	In.
Limestone and streaks of soft shale	5	8	365	8
Black slate		6	366	2
Limestone	1	6	367	8
Black slate	26		393	8
Lime soap and shale in thin layers and places	64		457	8
Black slate, changing into soap and back to slate	13	4	471	
Soap, changing to lime and then to soapstone	11	6	482	6
Micacious sand with granular limestone	10	6	493	
Micacious sandstone, still coarse and granular	23		516	
Same, but finer grain	16		532	
A still finer and finer measure	18		550	
The next twelve feet appears to be something of the same but firmer and traces of some chlorid	12		562	

From 482 feet to the bottom rock is full of vertical seams or fissures.

Under all of these circumstances, it is safe to say that this much-quoted well has been very erroneously quoted, and that no granite or other crystalline rock ever was found in the well, unless, possibly, it had been dropped in from the top.

The numerous deep wells in Nebraska which have failed to find crystalline rocks of any description are very interesting. By referring to the map, Plate I, it will be noticed that we have the fifteen or more wells at Omaha with a maximum depth of over 1800 feet; the well at Lincoln with a depth of 2463 feet; the well at Nebraska City with a depth of over 3000 feet; a well at Beatrice 1200 feet deep, and a well in the extreme southeast corner of the state that is 1400 feet deep. Under all of these circumstances, with the single exception of the well in Pawnee County, and the undoubtedly false report of the well at Lincoln, we have no evidence whatever of any crystalline rocks, either intrusive or Archæan ridges, anywhere in the southeastern part of Nebraska.

Crossing now into Kansas, we have equally interesting information. Two different wells have been put down near Marysville, in the Blue River valley, Marshall County, to a depth of more than 1100 feet, neither of which encountered any granite. In Nemaha County, at Seneca, two wells were drilled which reported finding granite, as will be noticed a little later. Then we have the deep well at Wetmore, in southeast Nemaha County, which was carried to a depth of 2250 feet without finding any granite. At Horton, on the south border of Brown County, a diamond-drill well was put down by the Rock Island Railroad to a depth of 1105 feet, in search



TOWNSHIP MAP OF PARTS OF OKLAHOMA, KANSAS, NEBRASKA, AND IOWA.

Red type show wells and kind of rock.

for coal. Mr. Low furnished me a record of this well also. The record has been studied with care, and it shows no approach whatever to any granite or crystalline rock of any description, nor does it show that the regularly stratified rocks are in any way disturbed or out of place. As this was made by a diamond drill, extra importance should be attached to it on account of its probable accuracy.

SENECA WELLS.

During the year 1904 two wells were drilled at Seneca, Kansas. In each of them, at a depth of about 600 feet, it is reported granite was struck. At that time Judge Wells, of Seneca, wrote me on the subject, and asked me to come up and look into the matter. It so happened that my time was occupied with other matters so that I could not go at once. I admit, reluctantly, that the importance of the matter did not present itself to my mind at that time in the same way it does now. In addition, I was so accustomed to reports of wells finding things which they did not find, it occurred to me that this was entirely probable, and that as a result the drillers would go on through whatever hard rock they were in and fulfill their contract.

It seems that the driller claims he drilled into granite at the first well a distance of 220 feet. He then moved the drill to a second location about half a mile away, and struck granite again at about the same depth he did in the first well. Here he went into the granite only a few feet, when he was allowed to abandon his contract and remove his drilling outfit from Seneca.

Later, I visited Seneca expressly to look into the matter. With Judge Wells I went out to the first well, at the north edge of town, and made a very careful examination of the cuttings from the well, which were still plainly visible upon the ground. I found a pile of mud cuttings from the limestone and shale, about as one would expect from a well of that depth. I searched in vain for cuttings of the granite, however, and was told by Judge Wells that, as far as he knew, the driller secured only about half a pailful of such cuttings. This was a great surprise to me, and I immediately asked how he could account for the absence of granite cuttings when a well 6 inches in diameter had penetrated the granite 220 feet. I said to him that the sum total of cuttings from this granite should equal

in volume the amount of granite sand possible to be produced by crushing a cylinder of granite 6 inches in diameter and 220 feet long. It is true, of course, that while drilling in granite a great deal of the material will be pulverized to so fine a condition that it will float away with the water discharged from the sand bucket. It seems inconceivable to me that one should drill 220 feet in granite and obtain only half a pailful of cuttings, or even twenty times a half a pailful.

This presented itself to my mind so strongly that again I dismissed the Seneca matter, thinking that no granite had been struck, which mental condition I maintained until the Zeandale wells were drilled. It then occurred to me that possibly I had made a mistake and had not paid proper attention to the Seneca wells.

OTHER WELLS.

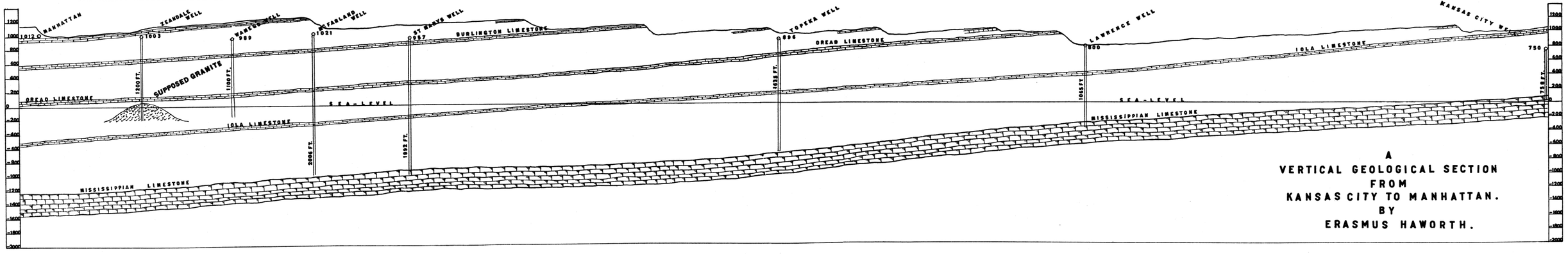
West of Seneca, at Marysville, at least two wells have been drilled to about 1100 feet, but neither struck granite nor other materials of special note.

The well at Wetmore was carried to 2250 feet and stopped in sandstone, as I know from personal examination of the last cuttings. There was a total absence of any indication of metamorphism, or disturbance of any kind, and everything seemed regular and in order.

The well at Horton, already mentioned as being drilled with a core-producing drill, went to a depth of 1105 feet without finding anything at all irregular or unusual. No granite, or metamorphosed rock was found.

The well at Atchison was drilled by the Sullivan Machinery Company, in search for coal, which they found at a depth of over 1100 feet. The well was continued to more than 1300 feet, or into the Mississippian limestone about 10 feet. Later, a shaft was sunk to the coal, and considerable of the coal was mined. Neither the drill nor the shaft revealed the least irregularity, nor the slightest approach to granite, or metamorphosed rock.

To the southeast of Wetmore we find the little town of Hoyt, in the southeast corner of Jackson County, with a well 1246 feet deep without any approach whatever to striking granite or any other form of crystalline rock. We have the Topeka well, 1635 feet deep, and no granite or crystalline rock, and no disturbance of the stratified rock whatever.



A VERTICAL GEOLOGICAL SECTION FROM KANSAS CITY TO MANHATTAN.

BY

ERASMUS HAWORTH.

In 1892 the Rock Island Railroad had a diamond-drill well sunk near McFarland to a depth of 2006 feet. This was done by the Bullock Manufacturing Company, of Chicago, and I remember well that in the mining building, Chicago World's Fair, in 1893, this company had a part of this well core in their exhibit of machinery. The record of the McFarland well has been published several times by this Survey in various volumes of its reports. It also was used to assist in the preparation of the vertical section from Kansas City west, which constitutes Plate II of this report. The record, therefore, has been studied carefully by me on many different occasions, and compared with the record of other wells of this part of the state. It may be said that such repeated study shows that the strata passed through are regularly in place.

A few new wells were put down near St. Marys, in the extreme southeastern corner of Pottawatomie County. Each of these wells went to the Mississippian limestone, and their records were used in the preparation of the vertical section, Plate II of this report. They struck the Mississippian limestone at about 1870 feet. The regularity of the stratified rock here was in no way disturbed, and the Mississippian limestone was found at the depth where it should be, as shown from the records of other wells in this part of the country.

Years ago a well was put down on the river bank at the southwest corner of the town of Wamego, about 16 miles due east of Manhattan. I do not have a record of this well, but understand it was carried to a depth of about 1000 feet, and found nothing whatever in the way of granite. Later, two wells were drilled near the little town of Louisville, five or six miles north and a little west of Wamego. One of these was half a mile south of the village and the other one about two miles north and a little east. I do not have a record of either of these wells, but I paid considerable attention to the two while being drilled. Each of them went to a depth of over 1200 feet, and neither of them found anything of unusual occurrence. We have these three wells, therefore, exactly in a line with the Zeandale wells and close to them, and neither of them found anything in the way of granite.

During the fall of 1914 a well was put down near Junction City to a depth of about 1600 feet, and found nothing unusual or aside from the ordinary. South from this area, wells have

been put down near Council Grove, and many in the vicinity of Cottonwood Falls—shallow wells, however. A well was drilled at Emporia which found the Mississippian limestone at 1950 feet deep. Deep wells are at Eureka, in Greenwood County, and also many wells in the vicinity of Augusta, in southern Butler County. Two or more of these wells have been carried to a depth of more than 2000 feet without finding anything aside from the ordinary. Still further south, at Winfield, three wells have been drilled within the last two years to a depth of more than 2000 feet. One of them reached over 3000 feet without finding anything aside from the ordinary. Also, in the vicinity of Arkansas City a number of gas wells were drilled north and a little east of town, a few of which reached a depth of 1000 feet or more without finding any granite or other crystalline rock. During the year 1914 the Swenson well, which is located a few miles southwest of Arkansas City, just across in the state of Oklahoma, reached a depth of over 3400 feet, and a well very recently found gas at 3270 feet near by. A little south of this we find the oil pool near Newkirk, Okla., which has scores of wells reaching a depth from 1200 to 1400 feet without anything unusual having been found. In the vicinity of Ponca City, and a few miles to the south, much drilling has been done with a number of wells carried to over 2000 feet, and no crystalline rock of any nature whatever has been discovered.

THE ZEANDALE WELLS.

The first well at Zeandale was begun in the autumn of 1914, and the second was begun early in 1915. The first well was located immediately south of town in the flood-plain valley of a little creek which enters the Kansas River from the south. The second well is almost exactly a mile due east from the first well. It, likewise, is on the north bank of this same little stream, and hence in the valley of the Kansas River. The high bluffs on the south side of the river are only a few hundred yards away to the south. The first well struck what was called granite at 958 feet. I copied the log of the well directly from the log book kept by the drillers. In their books it was recorded at 948 feet, but I found they had an error of ten feet in their addition, making it, as a matter of fact, 958 feet. The ground level from here to well No. 2 I have not determined with a high degree of accuracy. As far as one can judge by

looking at it, however, it corresponds exactly to the general fall of the flood plain of the Kansas River. The downstream slope of the flood plain of the Kansas River here is almost $2\frac{1}{2}$ feet per mile. By assuming this to be the same we have the difference of depth at which granite was struck in the two wells of $14\frac{1}{2}$ feet. By careful examination of Plate II it will be found that the westward dip of the different limestone formations there represented varies from $12\frac{1}{2}$ to 15 feet per mile. In other words, the average dip of the stratified rocks from Kansas City west to Zeandale is almost exactly the same as the difference in elevation of the top surface of the hard rock found in the two wells. This is a point of considerable importance.

After the drill penetrated the hard material some distance, well No. 2 was shot, and thereby it was reported a number of coarse pieces of the granite were obtained with the bailer. I do not recall how all of these samples got to me, but I have been presented with more than a dozen different samples of rock from this well No. 2. One of the strange features about it is that these samples, as brought to me, represent three distinct kinds of rock. The first one is, without question, a granite—red granite with red feldspar very prominent in the rock, some of the crystals of which are a fourth of an inch in diameter. A thin section was made from one of these fragments and was examined carefully with a petrographic microscope. It proved to be an ordinary granite, composed principally of quartz, orthoclase, acid plagioclases, and black mica, with some accessory minor constituents, and therefore is an average granite. It is unusually fresh and bears no trace whatever of any kind of metamorphism. The feldspar crystals are so sound they present scarcely a trace of decomposition so common in feldspar of granite.

The other two kinds of rock were dark-colored schists. Word came to me that the granite had crevices in it and that these schists occurred in the crevices. One of the samples was at least three inches in its greatest diameter and the other one about half as large. It is difficult to understand how a well driller could be positive that such pieces as these occurred in crevices in the granite, when we remember that the size of the drill hole was ten inches. How much the shooting broke up the rock no one knows, but, according to report, these three dif-

ferent samples came from the same well after the shooting was done.

Mr. Paul Teetor, of our University, determined the silica in each of the schists, with the following result:

Silica (SiO_2) in No. 1 = 39.41
Silica (SiO_2) in No. 2 = 47.40

It will be seen that one of them had fully 8 per cent more silica than the other, showing it to be quite a different kind of a schist.

Now, we are told, first, that in some way, at some time the granite was formed, was coarsely crystallized at the surface, and yet was not metamorphosed in the least; second, that fissures were made in the granite, and that a second outpouring of lava filled those fissures with a different kind of lava from this granite lava; third, that after the second outflow a third one was produced which supplied a lava that produced a second kind of a schist. Still further, we must believe that the two schists, or rather the two lavas from which the schists were made, were so highly metamorphosed that perfect schists were produced, and this without changing the granite in any respect. It is submitted that no geologist of repute can believe this.

During the latter part of the time while the drill was in this so-called granite, Hon. Robert Stone, of Topeka, president of the lease-holding company, kept a man at the well all of the time. He furnished Mr. Stone with a great many drill cuttings from the well, which cuttings have been sent to me for examination. Also, while at the well I gathered a number of samples of cuttings.

A careful examination with a petrographic microscope shows, first, that the cuttings I gathered in person do not differ materially from those sent me by Mr. Stone; and second, that the cuttings are from a genuine granite. It is true that a few rounded granules of quartz were found. They are so few, however, that I think they were simply grains of quartz which chanced to have a comparatively round surface.

The following minerals were identified: Orthoclase, quartz, black mica; acid plagioclase small traces of other minerals were present, such as inclusions common in granite. If hornblende or augite either was present I failed to find any of it. A considerable amount of dark material was noticeable, which

surely was black mica. I looked in vain for muscovite, but as this mineral possibly would be badly destroyed by the drill, one could not say it was absent, although it might not be recognized in the cuttings.

The feldspars are particularly fresh and free from all appearance of any form of metamorphism or weathering. One might expect this in the cuttings from a hundred feet or more within the granite, but the same is true of the cuttings from near the surface, and also, as stated, in the thin section made from the granite near the surface. Cleavage pieces of the feldspars could be identified in the cuttings, both of orthoclase and the acid plagioclases. In many of the latter the synthetic twinning bands were abundant, and the angles of extinction were determined readily.

In a word, the cuttings seem to have come from a granite practically identical with the larger fragments. The exact characteristic repetition of mineral content, and the properties of each mineral in general appearance, freshness, and other properties, leave little room for doubt as to the identity of the two.

Mr. Paul Teetor made a complete quantitative analysis of cuttings which I gathered from the well, with the following results:

Complete Chemical Analysis of Drill Cuttings from Zeandale Well No. 2.

April, 1915.

PAUL TEETOR, Analyst.

Loss by drying	1.98%
Silica (SiO_2)	69.73
Alumina (Al_2O_3)	13.85
Iron Oxide (Fe_2O_3)	3.59
Lime (CaO)	3.45
Magnesia (MgO)	Trace
Alkalies (K_2O plus Na_2O)	6.57
Total	99.17

A number of other interesting details were found at these wells. While visiting well No. 2 the driller told me that the color of the cuttings was red from time to time, and that always the more red they were the easier the drill penetrated the rock. He said, for example, that at times the color was almost red, and that on such occasions he could drill four or five feet as easily as to drill one foot when the drillings were

light in color. The cuttings themselves which I have examined do not show as much of a change in the character of the rock as this conversation would imply. The record which he furnished me of well No. 1 also showed that at thirty-two feet within the granite was a twelve-inch bed of shale. The presence of shale midway in the granite not only is hard to understand, but is almost unthinkable.

Another interesting feature is that in well No. 1 there was a five-foot bed of shale immediately on top of the granite, and immediately above it the Oread limestone. In well No. 2 this shale had thickened to ten feet. When I first stepped into the derrick building at well No. 2 the driller was using the sand bucket and bringing up shale in comparatively large pieces, some of which were larger than could pass through the valve, and hence were sticking to the inside of the bucket just below the valve. I asked him what this meant, and he said that here, just above the granite, they had ten feet of shale below a heavy limestone, and that this shale had been caving on them. He added, that from the amount of the shale material brought out, the caving must have made a hole four or five feet in diameter, because, he said, they had brought out many bushels of the material.

I examined this shale with great care, and brought home twelve or fifteen pounds of it for more careful examination in the laboratory. It seemed to be ordinary Pennsylvanian shale. I examined it carefully for fragments of crystalline rock, on the assumption that if the hard rock in question should be an old Archæan ridge, then, quite likely, fragments of the Archæan rocks could be found within the shale. No such fragments were found, however, but on the contrary, Professor Twenhofel has succeeded in finding a number of fossils in it, about which he speaks as follows:

> The shale reported to have come from above the supposed igneous rock of the Zeandale well is an ordinary light-blue shale, which is quite soapy when moistened and a little gritty to the teeth. It is just an ordinary slightly compacted mud and fine sand deposit of a type quite common in the Kansas Coal Measures. There is no evidence whatever of any metamorphism, nor does it contain any macroscopic fragments in any way related to any other rock. Numerous poorly preserved fragments of gastropod shells are present. The preservation is not referable to metamorphism, but is of the manner so common in shales which are only slightly calcareous. They show no distortion beyond such as would

be produced by the weight of the overlying rock. Members of the Pleurotomaridæ and Bellerophontidæ are present, and of the former Pleurotomaria brazoensis occurs.

Here is an enigma which I am unable to solve. The drill cuttings which I examined surely came from well-preserved granite. The shale immediately overlying the granite showed absolutely no signs of contract metamorphism, and the granite from the very top seemed to be perfectly fresh and free from weathering in every respect. The pieces of schist were thoroughly metamorphosed into typical schists.

THE ELMDALE WELL.

Gas has been used from Elmdale for many years. Its discovery is due to advice given by Dr. J. W. Beede* while working on our State Survey. A pipe line was built to neighboring towns, even as far away as Emporia. Probably more than fifty wells were drilled previous to 1914. A large majority of them are shallow, some even less than 200 feet deep. A few are deeper, and at least one, quoting from memory, is over 1600 feet deep.

In the autumn of 1914 a contract was let to Mr. A. L. Derby to drill a well to a depth of 2500 feet, if necessary, on the poor farm of Chase County. Later the following correspondence occurred between him and this office, a few days' time being lost on account of his first letter being sent to Topeka instead of Lawrence, and also a letter of inquiry as to details from me to him being necessary. These two points account for the apparent delay in answering his first letter.

ARKANSAS CITY, KAN., Oct. 13, 1914.

State Geologist, Lawrence, Kan.:

DEAR SIR—Enclosed you will find record of the well which I am drilling on the Chase County poor farm. We have this well down to a depth of 1980 feet, and from 1700 feet we have had what we consider granite, practically all the way, or nearly 300 feet of this same formation.

According to our contract, we will have to drill this well to a depth of 2500 feet, unless Mississippian limestone is found at a less depth. As this formation in which we are drilling is very hard and very treacherous to drill, we can not keep the hole going straight. I am enclosing you samples of this formation, under separate cover, and I wish you would examine these samples and the record closely and give me an opinion as soon as possible as to what this formation is, and about how much more of it we should encounter and about where we should find the

* Beede, Dr. J. W. University Geological Survey of Kansas, volume IX, pagt 175, Lawrence, 1908.

Mississippian limestone. This formation looks a great deal more like granite to me than it does like Mississippian limestone.

As our contract would end when we reach the Mississippian limestone, I wish you would also give me an opinion on that, as to whether or not you would consider our contract completed with this formation.

An early reply would be very much appreciated.

Very truly, A. L. DERBY.

Log of Well No. 1, Chase County Poor Farm.

Reported by A. L. Derby, Driller, October 13, 1914.

Formation.	Thickness.	Depth.	Formation.	Thickness.	Depth.
Soil	2	2	Lime	45	885
Clay	33	35	Slate	10	895
Gravel	10	45	Lime	5	900
Lime	3	48	Slate	65	965
Slate	17	65	Sand	10	975
Lime	5	70	Lime	5	980
Slate	60	130	Slate	50	1030
Gas sand	10	140	Lime	5	1035
Slate	50	190	Slate	25	1060
Sand	20	210	Lime	5	1065
Slate	30	240	Slate	80	1145
Lime	10	250	Lime	20	1165
Shale	30	280	Gas sand	5	1170
Lime	20	300	Lime	20	1190
White slate	5	305	Slate	4	1194
Lime	10	315	Lime	30	1224
Black shale	15	330	Slate	4	1228
Lime	10	340	Lime	7	1235
Sand	5	345	Slate	20	1255
Lime	5	350	Lime	70	1325
Shale	5	355	Slate	5	1330
Lime	15	370	Lime	40	1370
Slate	70	440	Slate	10	1380
Lime	10	450	Lime	15	1395
Slate	40	490	Slate	5	1400
Lime	5	495	Lime	5	1405
Slate	15	510	Slate	15	1420
Lime	5	515	Lime	30	1450
Slate	10	525	Slate	5	1455
Gas sand	10	535	Lime	35	1490
Slate	30	565	Slate	5	1495
Lime	5	570	Lime	5	1500
Slate	5	575	Slate	95	1595
Lime	25	600	Black slate	10	1605
Slate	5	605	Lime	15	1620
Gas sand	10	615	Slate	20	1640
Slate	35	650	Lime	20	1660
Lime	10	660	Black slate	5	1665
Slate	15	675	Blue slate	30	1695
Lime	10	685	Dark slate	5	1700
Lime	5	690	Slate	7	1707
Slate	30	720	Pebbly sand	43	1755
Lime	15	735	White sand	25	1780
Slate	10	745	Pebbly sand	25	1805
Lime	20	765	Red sand	142	1947
Slate	10	775	Black sand	7	1954
Lime	10	785	Red sand	16	1970
Black slate	20	805	Black sand	10	1980
Slate	35	840			

LAWRENCE, KAN., Oct. 28, 1914.

Mr. A. L. Derby, Arkansas City, Kan.:

DEAR SIR: I have delayed writing you regarding the drill cuttings you sent me, because the matter was of such importance that I felt disposed to investigate it in all its entirety. I have called to my assistance Professors Todd and Twenhofel of the department of geology.

All three of us are united in pronouncing the drill cuttings as having come from a specially indurated sand rock. It is not granite in any sense of the term; but is a genuine sandstone of a peculiar character.

I estimate that you will hit the Mississippian limestone at about 2600 feet at Elmdale, plus or minus 200 feet. I think any geologist should allow himself 200 feet leeway in this estimate until we have some new wells reaching it closer to Elmdale than any which now exist. A well at Emporia reached it between 1900 and 2000 feet. In making my estimate I assume that the Mississippian continues to dip westward at the same rate it dips to the east of Emporia. To this I add the difference in elevation between Emporia and Elmdale.

Yours very truly, ERASMUS HAWORTH, *State Geologist.*

This ends my direct connection with the Elmdale deep well. Since this correspondence I have heard a number of rumors to the effect that granite was found in the well; that samples of cuttings have been submitted to different geologists, who passed judgment upon them, etc.; but none of the rumors have been verified by me. As the cuttings I examined were certainly from a sandstone with perfectly rounded sand grains, so well cemented that it was very difficult to drill, and as Mr. Derby called them granite in his letter of the 13th of October, although he listed them as sandstone in the log of the well, I supposed, and still think, that most likely the whole of the so-called granite was an unusually hard sandstone.

GENERAL CONCLUSIONS.

In order to draw one or more conclusions from the foregoing, it may be well to take a bird's-eye view in retrospect of all that has gone before.

We have seen, first, that there is an area of country, reaching from the vicinity of Ponca City, Oklahoma, north by a little east throughout Kansas, by way of Arkansas City, Dexter, Winfield, Augusta, El Dorado, etc., including an area in the vicinity of Manhattan and Wamego and extending still farther north, throughout which a large number of little anticlines have been found, and practically every one of them which has been drilled upon to date has been productive of either oil or gas. We have seen how this region is productive in Oklahoma at Ponca and near Newkirk, and also how a number of good wells have been found in the vicinity of Arkansas City and Winfield and further north, in the vicinity of Augusta, where the development has reached a value of from $5,000,000 to $10,000,000. We have seen, also, that farther north gas has been found, even to as far as Wilsey, a little village on the Missouri Pacific Railroad line west of Council Grove.

This entire area, in a measure, had attracted attention of capitalists and developing companies, so that it looked as though we would have a large amount of development work done within the near future. Then came the well at Elmdale and the two wells at Zeandale, with the result that capitalists have withdrawn from the country and developing companies can not be induced to reënter.

The most important effort, therefore, should be to give an exposition of conditions which will have a tendency to restore confidence in the area outlined as a favorable area for oil and gas. This being the main end in view, it follows that it does not necessarily mean every individual encounter must be favorably explained. Neither does it necessarily mean that no well throughout the entire area shall strike anything that can not be accounted for. It is entirely possible that one or more wells may have struck something, or found something unusual, and yet be no cause for condemning the entire area.

We have seen, still further, that the general condition of the stratified rocks throughout the entire area is one of surprising regularity—a regularity, doubtless, which is as great as that to be found anywhere in the world, and that all the way from the south side of the state to the north we have enough wells drilled so that we know the gradual westward dip of the stratified rocks has not been disturbed at any place, excepting in the local anticlinal ridges above referred to.

We have found, also, that in different places, particularly in Nebraska, various reports have been circulated, and have gotten into scientific literature, claiming that wells at certain places have struck granite, or Sioux Falls quartzite, or something of that kind, implying that there is throughout this region either a ridge of ancient Archæan rocks, or a line of intrusive volcanic rocks which have been forced part of the way to the surface, and yet have not disturbed the surface conditions sufficiently to let their existence be determined by surface examinations.

It is the fear of such a ridge that has destroyed confidence in the area mentioned. The burden of this report, therefore, is to show that no such ridge does exist.

Let us now make one more critical inspection of the map, Plate I. Here we find marked with accuracy the location and depth of a large number of wells. In Nebraska only two wells are reported to have struck granite—the one at Lincoln, at a depth of 2463 feet, and the one near Bern, or Dubois, at a depth of 532 feet. As already seen, the report about each of these wells is thoroughly discredited. I am willing, therefore, to be quoted as believing that not a single well in the southeastern fourth of Nebraska ever reached granite, or gneiss, or schist in any form.

Passing southward into Kansas in our investigation of the map, we find the Seneca wells close to the north side of the state. It has been shown already that no credence should be given the stories of finding granite here, so we may dismiss them from our consideration. The many deep wells to the south, southeast and southwest of here almost positively make it impossible for any form of ridge, or continuous formation of crystalline rocks, to exist, even though such does occur at Seneca. The wells are too numerous and too close together to leave it possible.

The Zeandale wells, therefore, stand alone, and can have no connection with any reported granite to the north and northeast.

If we assume an ancient ridge of crystalline rocks, older than the Pennsylvanian stratified rocks which overlie them, we must account in some way for the absence of crystalline fragments in the overlying stratified ones, which should have been found in the ten-foot bed or shale just above the reported crystallines. But no such fragments were found, although diligent search was made, already explained at length by Professor Twenhofel and myself in these pages. A still greater difficulty is to explain the unusual freshness of the rocks, both the drill cuttings and the larger fragments. Stress was placed on the total absence of any approach to weathering or metamorphism in the cuttings, and also in the hand specimens. To one accustomed to a petrographic examination of specimens of granite and schist taken from or near the surface, the extraordinary freshness of these samples becomes an almost insurmountable barrier of belief.

If we assume a mass of intrusive volcanics here at Zeandale we meet with difficulties equally grave. The total absence of contact metmorphism in the soft Pennsylvanian shale above is inexplicable on the assumption of a mass of lava sufficiently large to yield a flat top one or more miles across, or from Zeandale well No. 1 to No. 2. Such an intrusion, also, if made since the Pennsylvanian strata were formed, should not be possible without showing itself in the overlying strata in some manner. The stratified rocks should be disturbed; but nothing of the kind has been observed by any one.

Again, the upper surface of the lava rock should not be so coarsely crystalline. The sudden cooling of the lava when brought in contact with the stratified rock should have produced a glass, or at least a finely crystallized mass, which might grow coarser beneath the surface. But the drill cuttings show no such conditions.

Out in Phillips County, Kansas, is a mass of granite gravel carried eastward from the Rocky Mountains and spread out in stratified form, in which the fragmental particles are so well cemented together that a solid and firm rock is formed, fully as hard as granite, and composed of quartz, feldspar and a siliceous cement. This rock has been quarried and used for

paving blocks under the name of granite. A sample of it was exhibited at the Chicago World's Fair in the collection of Kansas building stone made by Prof. S. W. Williston. A thin section of it showed plainly the mineral content above named, but it did not look like a granite to a trained petrographer, as the thin section made from the large fragment from Zeandale. It did, however, quite resemble the Elmdale materials.

The Phillips County rock is mentioned here to show how a mass of sand may become cemented into a hard rock without the ordinary processes of metamorphism being present, for nothing of the kind is noticeable in Phillips County. It is interesting to note here that in the McFarland well, just below the Oread limestone, is a large mass of sandstone over 200 feet thick. The same is true in many places at the surface, particularly in Chautauqua County, where almost all the space between the Oread above and the Stanton limestone below is occupied by great, heavy masses of sandstone.

It seems to me it is quite possible that the hard rock at Zeandale is a modified form of hard sandstone with unusually large amounts of feldspar present, as in the Phillips County stone, cemented into this hard rock by some of nature's processes. This would admit the one foot of shale within it, as found in the log of well No. 1, and would admit of changes in color and hardness, as the driller explained to me, and would tally with the well-known large mases of sandstone below the Oread limestone in the McFarland well and elsewhere.

But after all and above all is the important fact that we positively know the obstruction, whatever it is, covers but a small area. It should not in any way, therefore, discourage prospecting for oil and gas. Just now, when others are discouraged and have abandoned the field, is a good time for new parties to come in, lease the most promising portions, and begin anew development work.

Respectfully submitted.

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