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Investigations to determine a possible source of the Carboniferous sandstone of the Ozark region

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INVESTIGATIONS TO DETERMINE A POSSIBLE SOURCE OF THE CARBONIFEROUS SANDSTONE OF THE OZARK REGION

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INTRODUCTION

In preparing this thesis the object has been to determine, by comparisons, a possible source of the Carboniferous sandstones. It is perfectly obvious that the material came from some older formation. Considering all the possible sources from which the Carboniferous sandstone could have originated, we, have the Pre-Cambrian igneous rocks of the St.Francois Mountains, the basal Cambrian sandstone or the La Motte formation, the Roubidoux formation (chiefly sandstone), and the St. Peter formation (essentially sandstone).

The fact that the crystalline rocks of the St. Francois Mountains were covered by Pre-Carboniferous sediments to a great extent, and that by Carboniferous times erosion had greatly reduced the mass of igneous rocks outcropping, and also the relative geographic positions of the outcrops of Carboniferous sandstone and the Pre-Cambrian rocks have led us to eliminate the igneous rocks as being the least possible of the sources above mentioned.

The La Motte sandstone is, next to the Pre-Cambrian, the least possible source. It is believed that sufficient amounts of this formation had not been eroded at the time of deposition of the Carboniferous sands to account for much of the material. This is evidenced by the fact that the areal distribution is not great as compared to the bulk of the Carboniferous sands. Then, too, much of the area of La Motte now exposed has been denuded since Carboniferous times. These facts when considered with the geographic relations of outcrops, led us to eliminate the La Motte formation from our considerations as a possible source.

There remains the Roubidoux and the St. Peter formations as possible sources. The Carboniferous areal distribution is so related to that of both of these formations that it might have been derived from either. The Carboniferous rests unconformably on the Roubidoux over considerable area. This indicates to us that during Carboniferous times the Roubidoux was exposed to erosion, and that,no doubt some of the material must have been derived from the Roubidoux. On the other hand the long erosion escarpment of the St. Peter which faces in a general direction towards the outcrops of Carboniferous may be the result of erosion during Carboniferous times.

In making our comparisons we have determined the relative sizes of grains of the Carboniferous, St. Peter, and Roubidoux sandstones. This was done by collecting representative samples from various points of the exposed areas of these formations, and making screen tests of these samples. Curves have been plotted showing the relation between sizes and percentages. Photomicographs have been taken of a few samples with the idea of showing any difference or similarity between the angularity of grains of sand of the three formations.

It is believed that these comparisons will show to which formations (the Roubidoux or the St. Peter) the Carboniferous is most similar. The one which it most nearly resembles will be taken as the most likely source of the material for the Carboniferous. We realize that many assumptions have been made and there are a great many chances for error. It may be that the Carboniferous sands were derived from all of the sources mentioned in the first part of the introduction, and also from other sources not mentioned and not apparent to the authors. However, we offer the conclusions of this thesis as a result of laboratory experiments which we were enabled to conduct, and not as absolute or as even definite information as to the absolute source of the Carboniferous sandstones of the Ozarks.

DESCRIPTION OF FORMATIONS

Roubidoux:

The Roubidoux formation consists of several alternating limestone or dolomite and sandstone members. Its thickness varies from 70 to 150 feet, averaging, perhaps, about 100 feet.

In most places the sandstone is more abundant than the dolomite. In Phelps and Dent Counties are especially good outcrops of the sandstone members of the formation. Within the Rolla Quadrangle the formation consists of seven members, four sandstone and three dolomite. Here the aggregate thickness of the sandstone amounts to about 70 feet and the dolomite to about 30 feet. A study of the accompanying map (Page 30) will show the areal distribution of the Roubidoux.

As to the lithological characteristics, the Roubidoux sandstone is composed of a rather angular or sub-angular sand, which, in most places is friable and usually stained red by Oxide of iron. In some places it is quartzitic due to a silicification by weathering.

St. Peter:

The St. Peter sandstone outcrops in a belt along the Mississippi and Missouri River from Cape Girardeau County northward into Jefferson County.

The sand of this formation is very pure, often analyzing as high as 98% SiO_2. Because of its purity it is very white in color. The grains when examined under a microscope are much more rounded than the Roubidoux sand grains.

Carboniferous:

The Carboniferous sandstone outcrops in Phelps, Maries, Franklin, Gasconade, and Osage Counties, lying between the outcrops of the Roubidoux and St. Peter formations.

The Carboniferous occurs as massive irregular deposits of sandstone grading into clays and shales. Stratification planes are almost entirely absent. The noticeable characteristic of the whole is its typical purple color.

The sand grains are moderately well rounded. When examined under a microscope the degree of angularity is very nearly the same as it is for St. Peter.

The color of the Carboniferous sandstone varies in different localities. In some places it is very white and pure resembling the outcrops of St. Peter, and in other places it is stained red to brown by oxide of iron.

Age of Formations.

Carboniferous	(Pennsylvanian)
Ordovician	St. Peter
Cambrian	Roubidoux

EXPLANATION OF CURVES AND TABLES

Curve 1 is obtained by plotting the average percentage retained on each screen against the screen size in millimeters. The average analysis of eight representative samples of Roubidoux was used. For the St. Peter, thirteen analyses were averaged and for the Carboniferous, nine.

Curve 2 is obtained by plotting the cumulative average percentage against the screen size in millimeters. The Tyler Standard Screen Scale was used in plotting the curve.

Curve 3 was plotted to show the maximum difference between the percentage retained on the screen for the Roubidoux and Carboniferous. That sample of the Roubidoux which showed the largest percentage of large grains in the screen analysis was plotted against the sample of Carboniferous, the screen analysis of which showed the largest percentage of small grains. The sample of the St. Peter which showed the largest percentage of large grains was also plotted.

This shows graphically the maximum difference in the quantity of any grain size of the original and the derived sandstone.

Curve 4 was plotted to show the minimum difference in size between the grains of the three sandstones. Screen analyses which were most nearly alike were chosen.

Curve 5 was plotted to show the relation of some other sandstones to the ones under consideration. The La Motte (Miscellaneous No.1) is the lowest sandstone member in Missouri. The Potsdam sandstone (Miscellaneous No. 2.) is from Wisconsin It has been correlated with the La Motte of Missouri. The curves for the other sandstones are the same as those used in Curve 1.

Table 5. The terms used in this table may need some explanation. The term"uniformity coefficient" is defined as "the ratio of the size of grain which has 60 percent of the sample finer than itself to the size which has 10 percent finer than itself.

That is, in a sand, if just 10 percent were finer than 1 mm. and just 60 percent finer than 2 mm., the uniformity coefficient would be 2. In other words fifty percent of the sample lies between 1mm and 2mm. in diameter. It merely expresses a ratio of variation of size of grain.

The term "effective size" is defined as a size "such that 10 percent of the sample is of smaller grains and 90 percent is of larger grains than the size given". That is, if 10 percent of the sand passed a 1mm. screen and 90 percent was retained on the screen, 1mm would be the effective size. As effective size is one of the factors used in determining the uniformity coefficient this together with the uniformity coefficient defines rather closely the size and uniformity of a sand, and where effective size is also shown, the coefficient of uniformity means much more than it otherwise would.

ROUBIDOUX

Sample	28	35	48	65	100	150	200	Fines
No.1	4.8	16.5	31.7	27.5	15.1	3.1	0.5	0.9
No.2	4.2	14.2	50.9	25.1	4.1	0.6	0.1	0.3
No.3	10.0	28.0	32.3	18.6	8.0	0.9	0.1	0.5
No.4	4.0	12.2	27.9	22.4	9.9	1.0	0.1	0.6
No.5	4.2	27.3	43.8	19.9	2.6	0.1	0.1	0.4
No.6	5.0	18.1	33.4	29.1	12.5	1.0	0.1	0.4
No.7	6.7	18.7	39.4	25.7	5.7	1.2	0.3	0.6
No.8	-	-	-	-	-	-	-	-
No.9	1.1	4.6	16.3	21.7	30.5	12.2	2.5	1.1
Misc.No,4	1.2	6.1	17.1	39.7	31.8	2.5	0.1	0.3
Misc.No.5	5.9	23.6	34.1	22.6	9.2	2.7	0.2	0.7
Misc.No.6	3.6	9.8	22.6	39.8	20.5	3.2	0.3	0.2
Misc.No.8	2.2	11.8	25.2	23.3	27.2	7.9	0.8	1.0
Misc.No.9	13.9	40.7	32.1	10.4	2.2	0.2	0.0	0.1

Table 1

ST. PETER

Sample	28	35	48	65	100	150	200	Fines
No.1	0.3	5.1	24.6	16.5	20.3	2.3	0.3	0.1
No.2	1.9	18.1	42.3	23.6	9.1	1.3	0.2	0.1
No.3	0.4	1.9	27.6	49.3	18.8	1.2	0.2	0.3
No.4	1.9	9.9	34.2	28.2	14.6	5.7	1.9	3.4
No.5	0.6	19.4	52.4	23.5	1.9	0.4	0.2	1.0
No.6	0.3	4.9	26.7	39.9	21.2	4.0	0.7	1.9
No.7	0.4	9.2	34.8	29.8	20.5	4.4	0.8	0.3
No.8	1.3	5.1	13.1	25.3	43.0	9.8	0.6	0.5
No.9	0.6	4.9	16.7	40.0	33.8	3.3	0.2	0.2
No.10	0.2	3.3	34.5	38.1	17.0	6.1	0.5	0.2
No.11	0.6	7.1	35.5	42.7	12.2	0.9	0.1	0.2
No.12	0.4	3.0	16.4	41.5	26.9	9.6	1.5	0.5
No.13	0.9	6.4	11.8	18.7	36.8	21.4	2.8	1.1

Table 2

CARBONIFEROUS

Sample	28	35	48	65	100	150	200	Fines
No.1	3.5	10.2	24.0	34.4	21.8	3.0	0.8	1.6
No.2	0.2	3.2	11.9	24.9	42.1	15.0	1.6	0.3
No.3	7.8	45.4	27.2	11.3	3.4	1.9	0.9	1.0
No.4	0.3	5.7	19.1	30.2	35.1	8.3	0.8	0.3
No.5	1.0	7.0	21.6	32.9	28.3	6.9	1.9	0.9
No.6	6.5	21.4	29.1	23.3	15.7	2.9	0.2	0.5
No.7	2.3	11.2	25.2	29.6	21.9	5.3	1.1	2.8
No.8	0.1	3.2	10.2	22.2	47.1	15.2	1.0	0.2
No.9	0.5	2.8	8.2	16.0	24.7	24.7	1.2	1.2

Table 3

MISCELLANEOUS

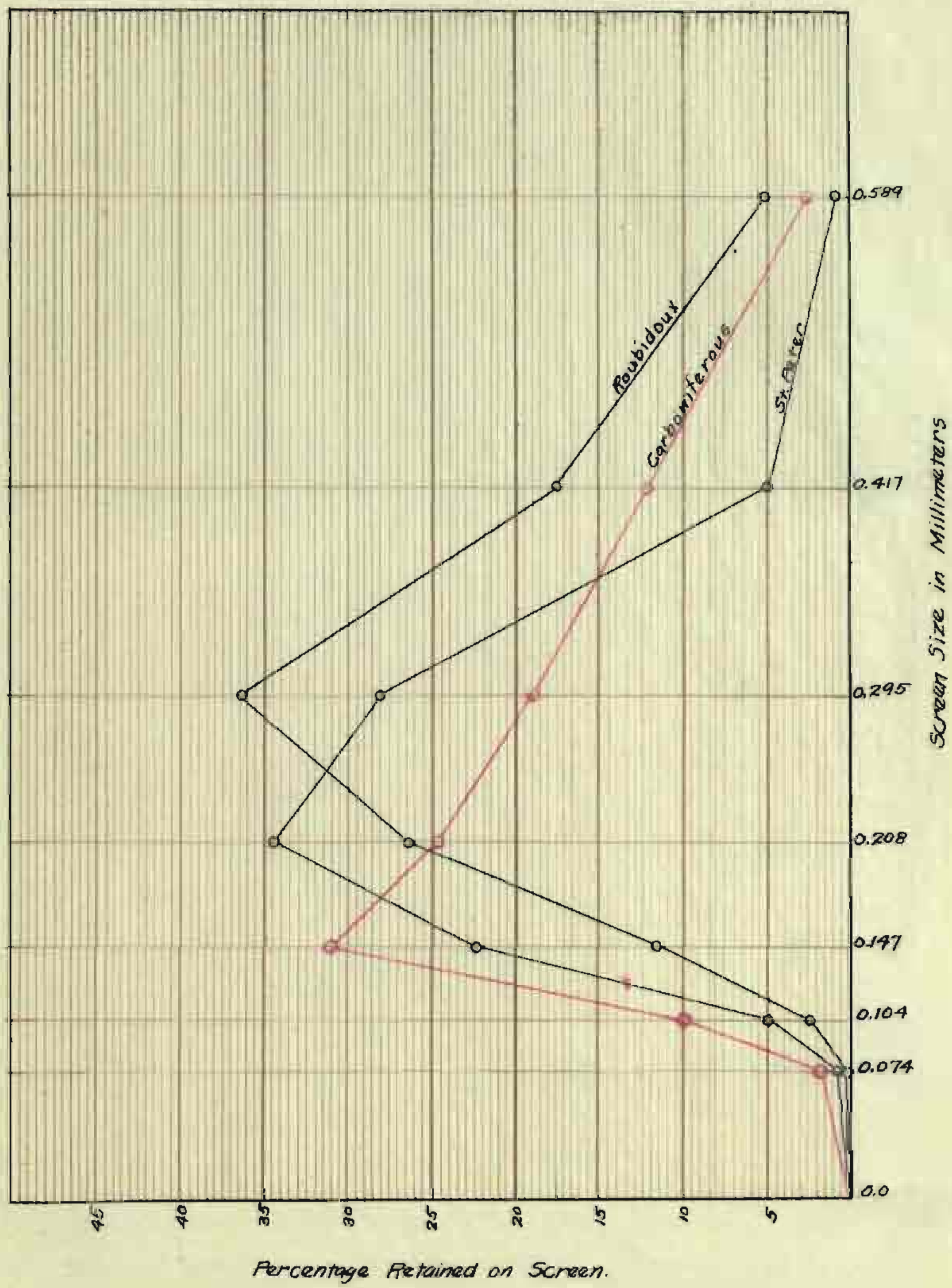
Sample	28	35	48	65	100	150	200	Fines
No.1	0.2	3.7	22.5	49.9	20.6	2.6	0.3	0.1
No.2	0.2	2.7	16.1	31.9	39.8	8.0	0.3	0.2

Table 4

No.	Roubidoux		St.Peter		Carboniferous	
	Effect. Size	Unif. Coef-ficient	Effect. Size	Unif. Coef-ficient	Effect. Size	Unif. Coef-ficient
1	.169	2.04	.168	1.65	.158	1.82
2	.222	1.68	.208	1.73	.104	1.70
3	.208	1.96	.172	1.61	.221	2.11
4	.136	1.82	.137	2.27	.147	1.70
5	.230	1.70	.230	1.55	.148	1.81
6	.186	1.90	.155	1.77	.170	2.14
7	.208	1.83	.160	1.95	.147	1.97
8	-	-	.139	1.61	.127	1.74
9	.126	1.94	.156	1.62	.111	1.67
10	-	-	.158	1.82	-	-
11	-	-	.187	1.58	-	-
12	-	-	.138	1.82	-	-
13	-	-	.116	1.75	-	-
Av.	.192	1.83	.163	1.75	.148	1.83

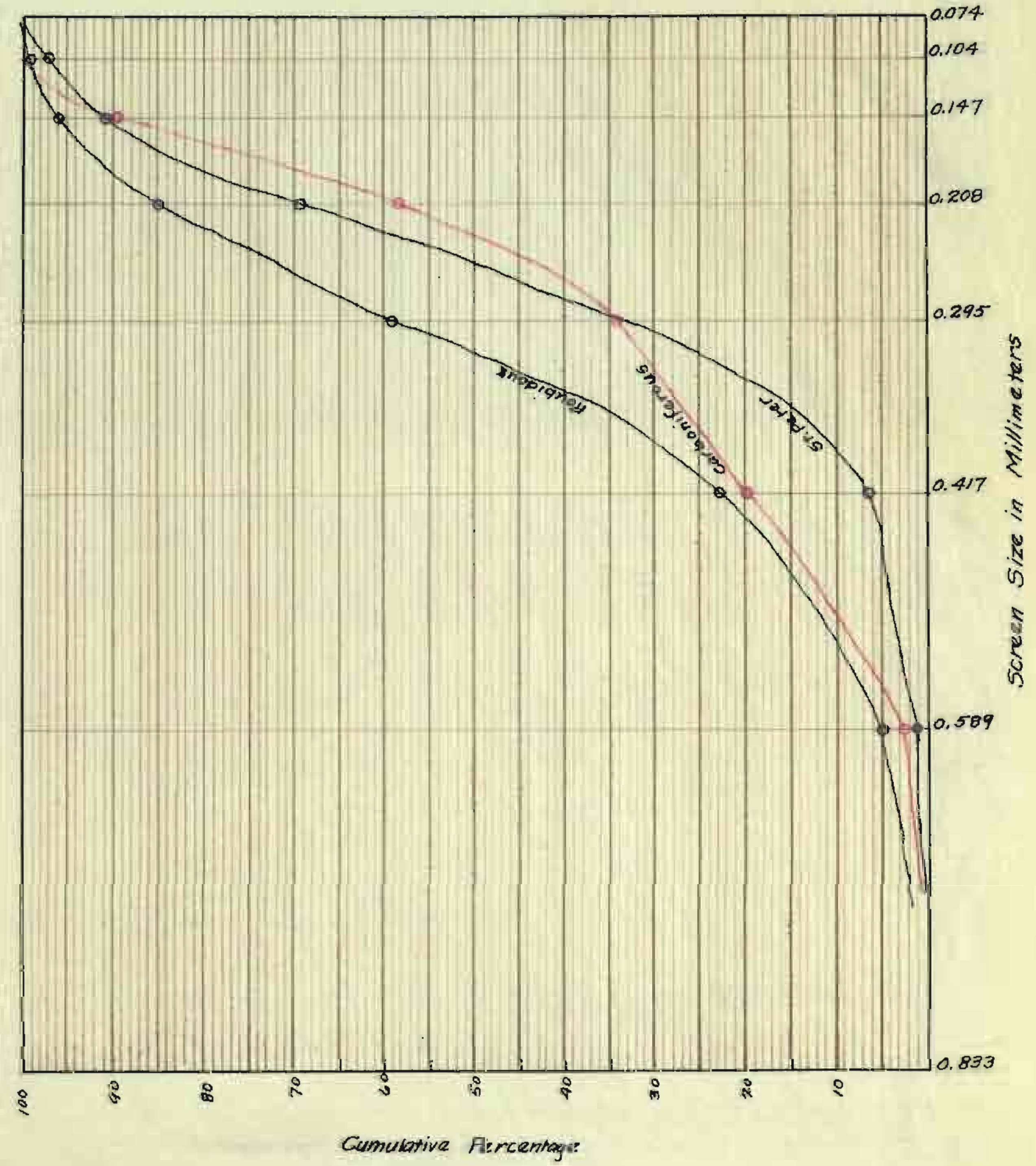
Table 5

AVERAGE SCREEN ANALYSIS



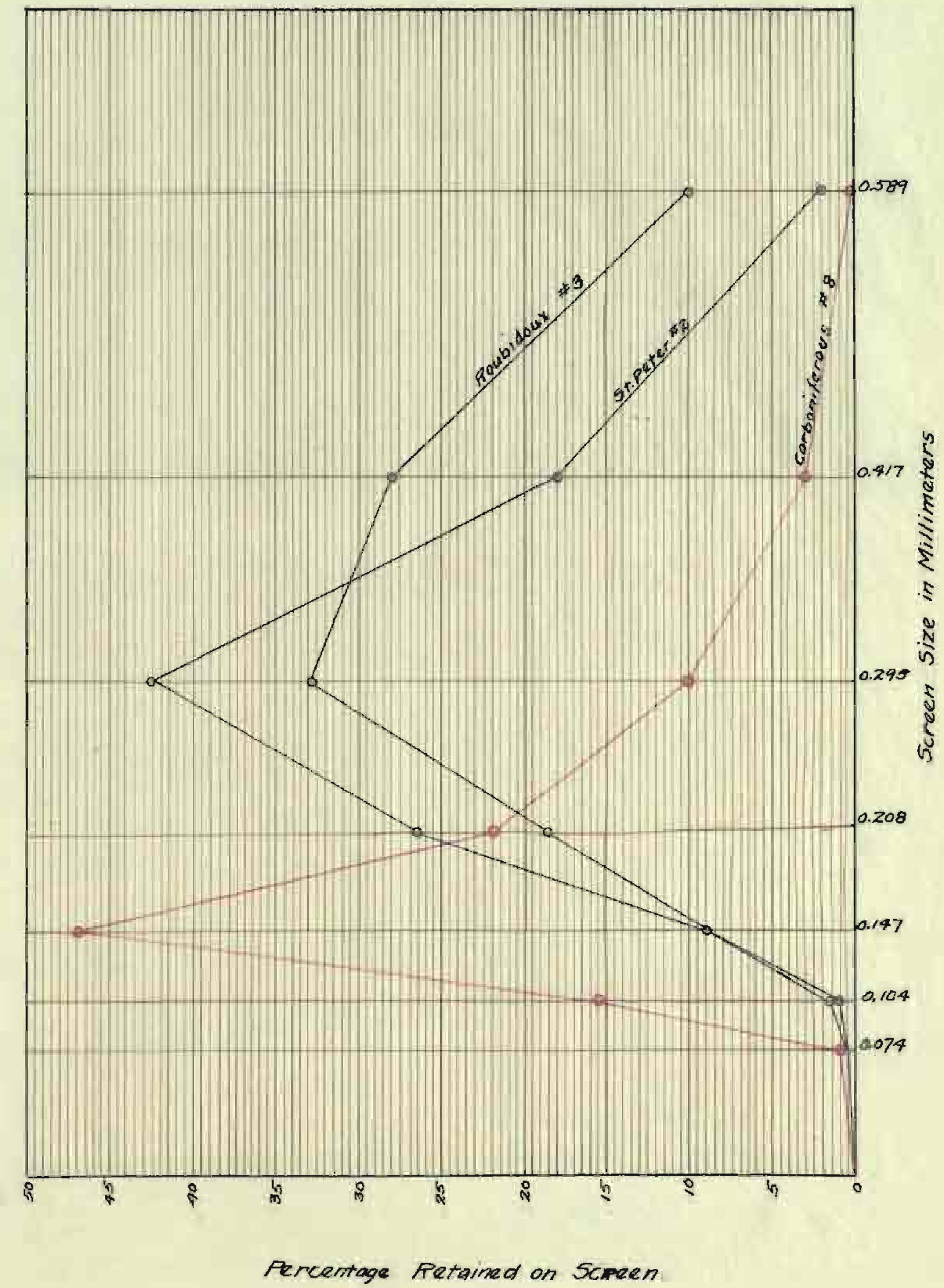
CURVE 1

CUMULATIVE DIRECT DIAGRAM OF AVERAGE SCREEN ANALYSIS



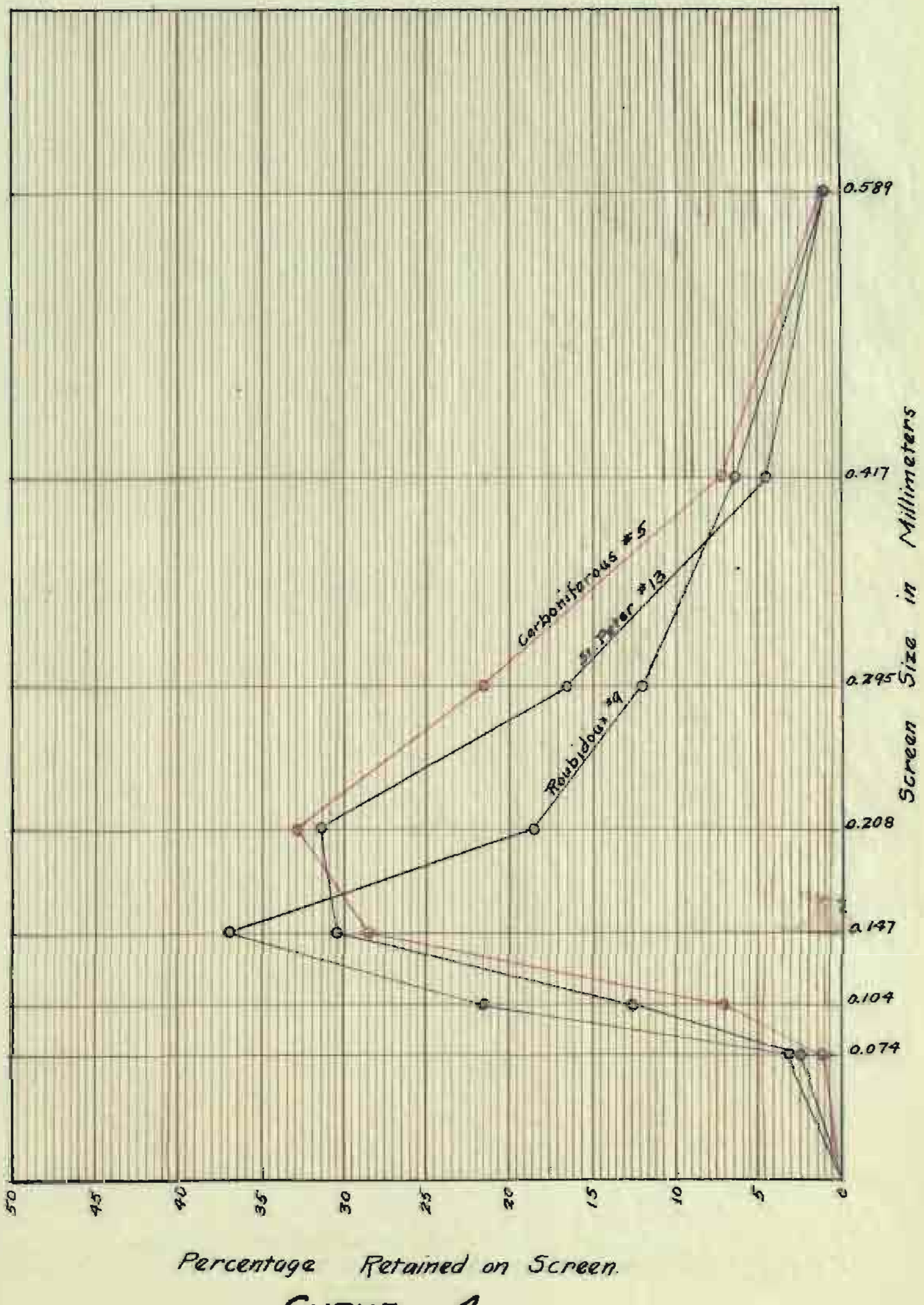
CURVE 2

CURVE SHOWING MAXIMUM DIFFERENCE IN SIZE BETWEEN THE ROUBIDOUX AND ST. PETER AND THE CARBONIFEROUS.



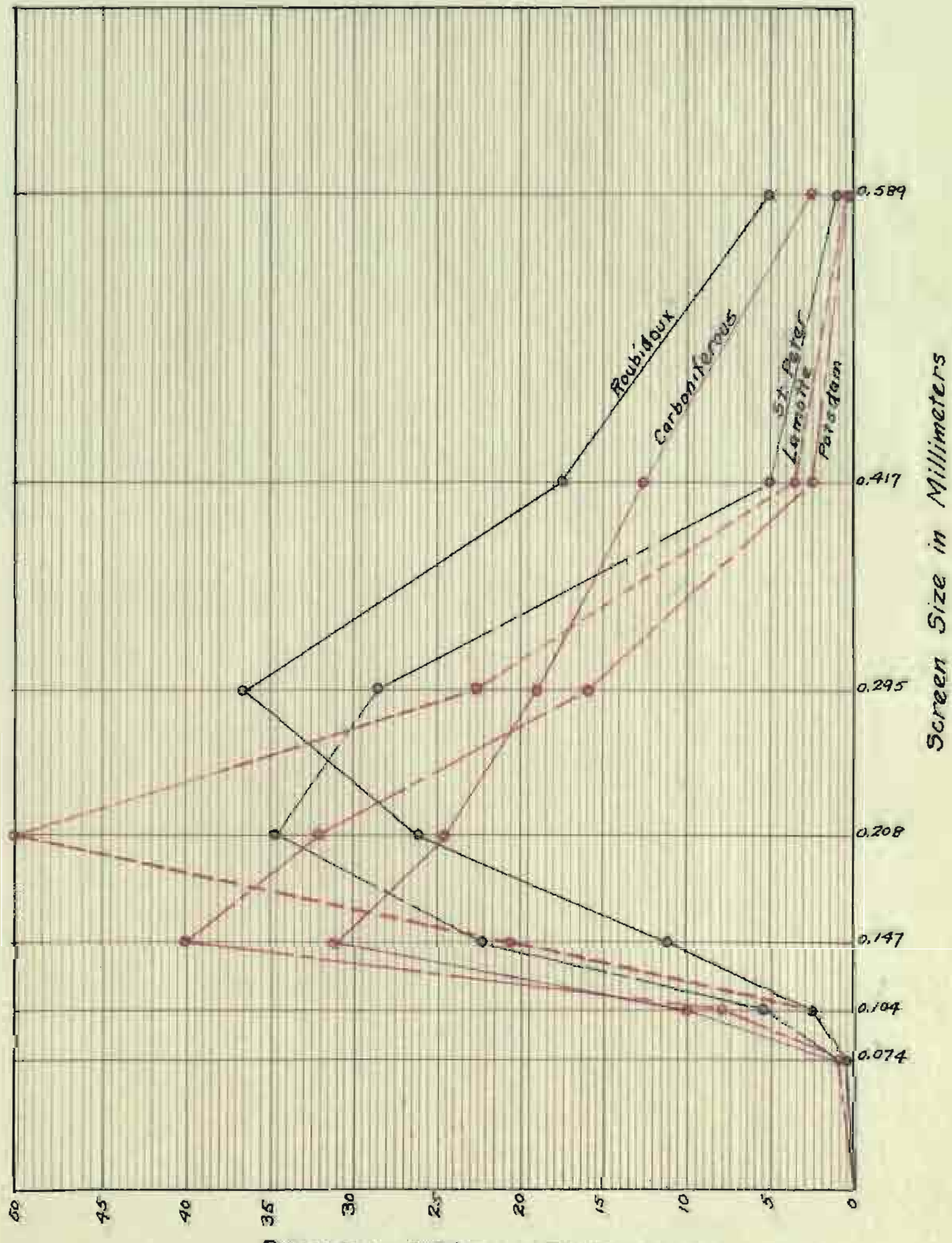
CURVE 3

CURVE SHOWING THE MINIMUM DIFFERENCE IN SIZE BETWEEN THE ROUBIDOUX AND ST. PETER AND THE CARBONIFEROUS

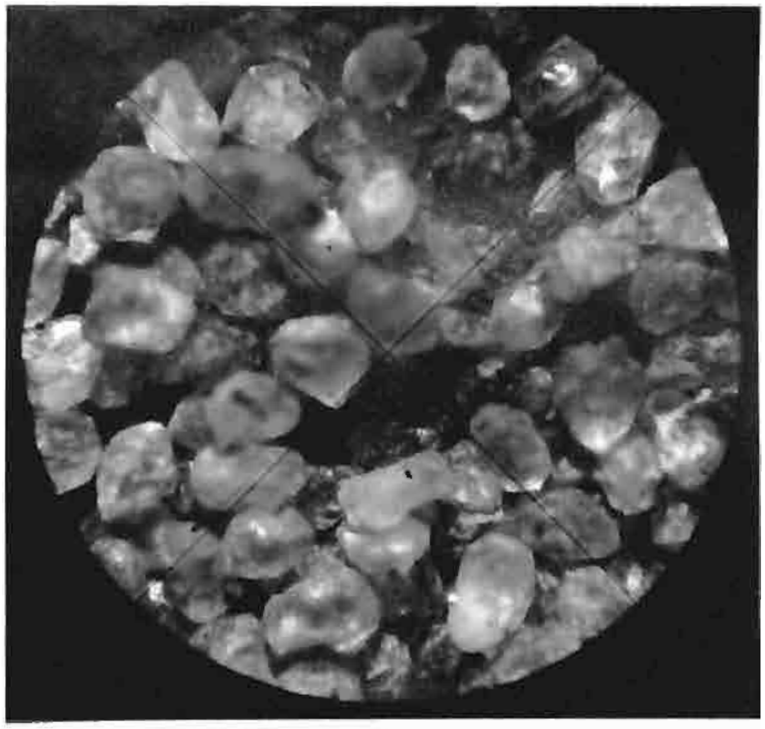


CURVE 4.

CURVE SHOWING RELATION BETWEEN ANALYSES OF LAMOTTE, POTSDAM, ROUBIDOUX, ST. PETER AND CARBONIFEROUS.



CURVE 5



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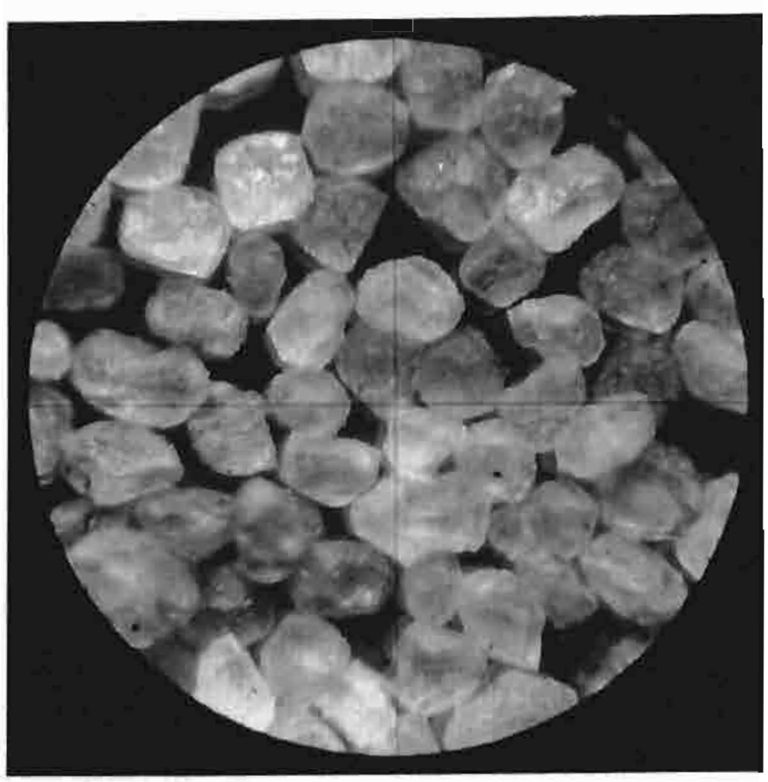

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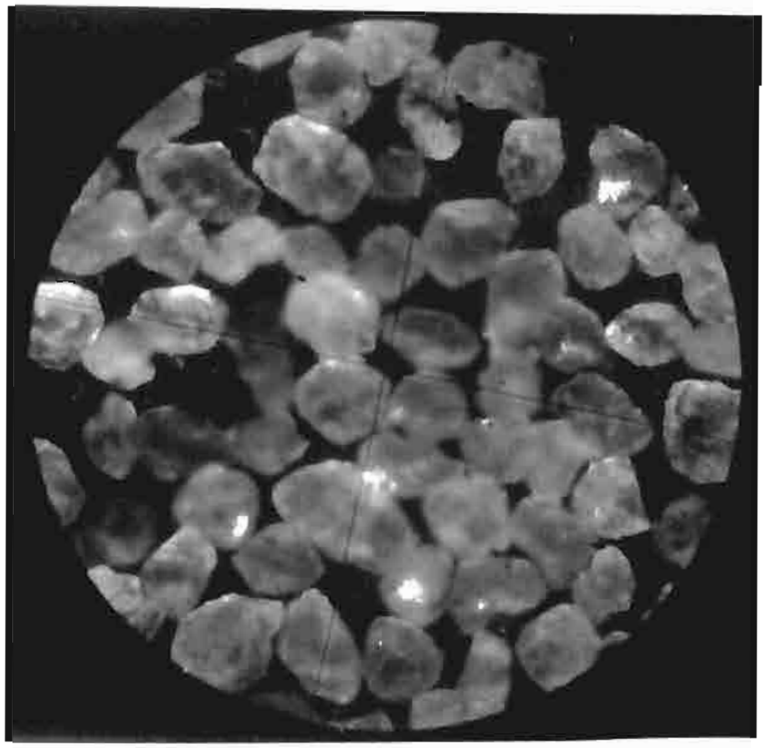

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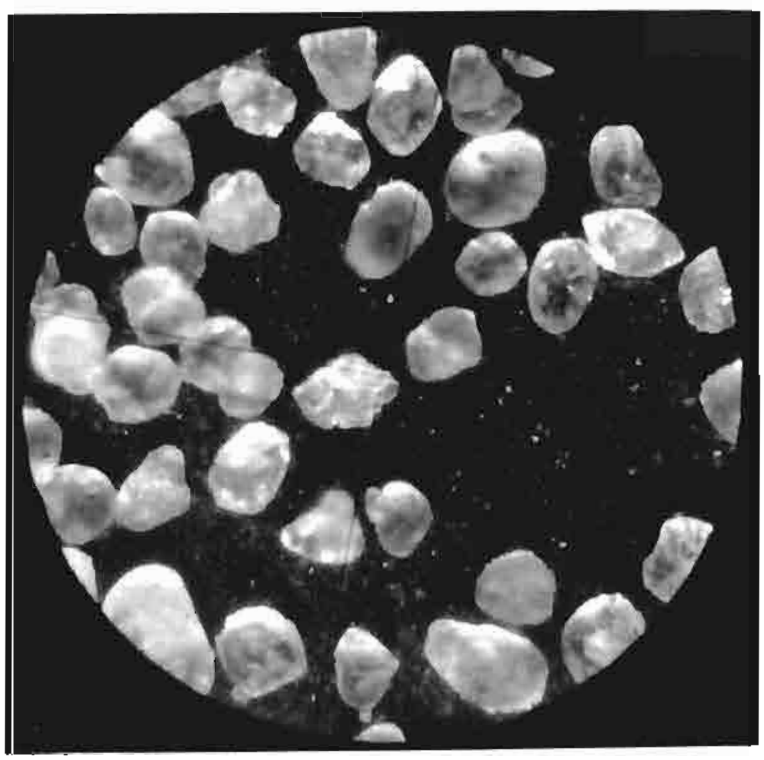

4

CONCLUSION

From a careful study of several sandstones, collected from various points in Missouri, especially those of the Roubidoux, St. Peter, and Carboniferous, it seems that the Carboniferous sandstone resembles very closely, both in appearance under the microscope, and by screen analysis, the St. Peter sandstone.

The grains of these two sandstones seem to have about the same degree of rounding. This lack of angularity is in marked contrast to that of Roubidoux. Photomicrographs (1) and (2) are the samples of Roubidoux, (3) is of St. Peter, and (4) is of Carboniferous. It can readily be seen that in photomicrographs (1) and (2) the grains are much more angular than either (3) or (4), but that in (4) the grains are even less angular than those in (3). Although this difference of angularity is fairly well illustrated by the accompanying photomicrographs it was even more apparent in microscopic examinations where successive portions of various samples could be examined.

In color the St. Peter and Carboniferous sandstones resemble each other very closely. In the majority of samples examined the color is almost white in marked contrast with samples of Roubidoux which in most cases is heavily iron stained. Some of the samples of Carboniferous contained considerable iron oxide. This might be accounted for by the fact that some of the Carboniferous sandstones were possibly derived from the disintegrated Roubidoux formation. It might also be caused by a secondary infiltration of iron oxide as a cementing material. The latter was apparent in the microscopic examinations of some samples which showed a film of iron oxide adhering to practically white grains.

As stated in a preceding paragraph the Carboniferous sandstone lies uncomformably on the Roubidoux formation. This indicates that a portion if not all the Roubidoux formation was submerged at the time of the deposition of the Carboniferous sands. That the St. Peter sandstone, being at a higher stratigraphic horizon, would be at a higher elevation, and therefore subject to erosion at the time of the deposition of the Carboniferous sands, is not illogical.

The marked uniformity in size of grains of St. Peter and Carboniferous sandstones is shown by comparative curves contained in this treatise. This would lead us to believe that the distance from the point of weathering to the point of deposition of the Carboniferous sands was not great. The accompanying map shows that the distance between the erosion scarp of the St. Peter sandstone and the exposure of Carboniferous sandstone is relatively small.

The curve of average screen analysis shows that the Carboniferous sandstone shows a slight excess of large grains over that of the St. Peter sandstone. This might easily be accounted for by the fact that a portion at least of the Carboniferous Sands have been derived from the Roubidoux formation. In some of the samples examined under the microscope there appeared to be a concretionary growth or rather a tight cementing of small particles which would of course account for some larger particles.

A gradual reduction of size in re-worked material is to be expected. A study of accompanying curves shows that this reduction in size though slight is very persistent. The maximum difference in size seems to be at about 65 mesh. It seems probable that sands slightly larger than this would be subject to greatest abrasion. Although the maximum surface exposure per unit volume is less than in smaller particles, the cushioning effect of water film below this size will more than offset the extra surface expesure.

The foregoing comparisons and examinations, although in no way conclusive proof of the facts, have led us to believe that the Carboniferous sandstone of the Ozark Region has been in a large measure derived from the weathering and redeposition of the St. Peter sandstone.