NOTES ON THE ILLINOIS "LAFAYETTE" GRAVEL*

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Extreme southern Illinois contains many exposures of brown chert gravel and red sand which are loosely referred to as the "Lafayette" formation of Tertiary age. Deposits of Lafayette-type gravel occur in other parts of Illinois but are mostly thin.[1] One of the northernmost sizable deposits in Illinois which closely resembles the southern Illinois gravels is found near Hamilton in Hancock County, about 250 miles northwest of the main body of "Lafayette" sediments in southern Illinois.

The "Lafayette" gravel is commonly regarded as stream deposited. The drainage patterns that must have been involved in most of this deposition have not been established, nor is it possible to say to what extent the gravels may have been reworked. Solution of these problems will involve, among other things, a study of the sedimentology and lithology of many samples carefully taken with regard to their topographic occurrence and elevation. The preliminary work here described was undertaken to obtain better knowledge of some of the physical characteristics of the Lafayette gravel which might be important to broader investigations.

SAMPLES

The six samples used in this investigation were taken from the following exposures (fig. 1):

FIG. 1.—Locations of deposits sampled and of other outcrops of "Lafayette" gravel as reported by Horberg, Leland, Preglacial gravels in Henry Co., Illinois, Trans. Ill. Acad. Sci., vol. 43, p. 172, 1950.

Sample No. 1. SE¼ SW¼ sec. 6, T. 4 N., R. 3 W., near Hamilton, Ill., 10 feet of gravel in gravel pit. Elevation about 620 feet.

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[1] Horberg, Leland, Pre-glacial erosion surfaces in Illinois: Jour. Geol., Vol. LIV, No. 3, 1946, p. 184.

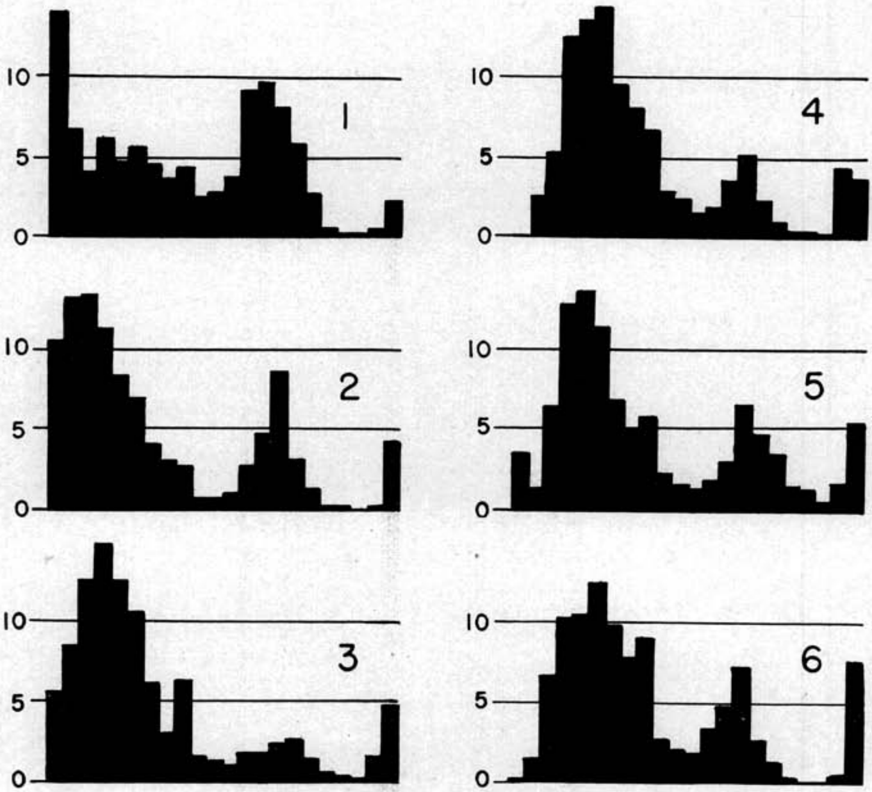

FIG. 2.—Particle-size histograms. The vertical bars, reading from left to right, indicate percent retained on the following sieves: 2″, 1.5″, 1.05″, .742″, .525″, .371″, 3 mesh, 4, 8, 10, 14, 20, 28, 35, 48, 65, 100, 150, 200, and 270 mesh; passing 270 mesh plus 2 microns, and minus 2 microns.

Sample No. 2. NE¼ SE¼ sec. 4, T. 44 N., R. 3 E., near Grover, Mo., 30 feet of gravel. This deposit is not far from Calhoun County, Ill., and was sampled instead of Calhoun County deposits because the exposure was better and the thickness of the gravel greater. Elevation about 820 feet.

Sample No. 3. SW¼ NE¼ sec. 34, T. 15 S., R. 3 W. near Fayville, Ill., 10 feet of gravel in small gravel pit. Elevation about 400 feet.

Sample No. 4. NE¼ SW¼ sec. 15, T. 16 S., R. 1 W. near Mounds, Ill., 3½ feet of gravel in road cut. Elevation about 400 feet.

Sample No. 5. SW¼ SW¼ SE¼ sec. 29, T. 14 S., R. 2 E. near Grand Chain, Ill., 8 feet of gravel in railroad cut. Elevation about 430 feet.

Sample No. 6. SW¼ SW¼ sec. 28, T. 14 S., R. 5 E. near Renshaw, Ill., 20 feet of gravel in road cut. Elevation about 520 feet.

MECHANICAL ANALYSES

Mechanical analyses of the six samples were made by standard procedures. Results are shown in figure

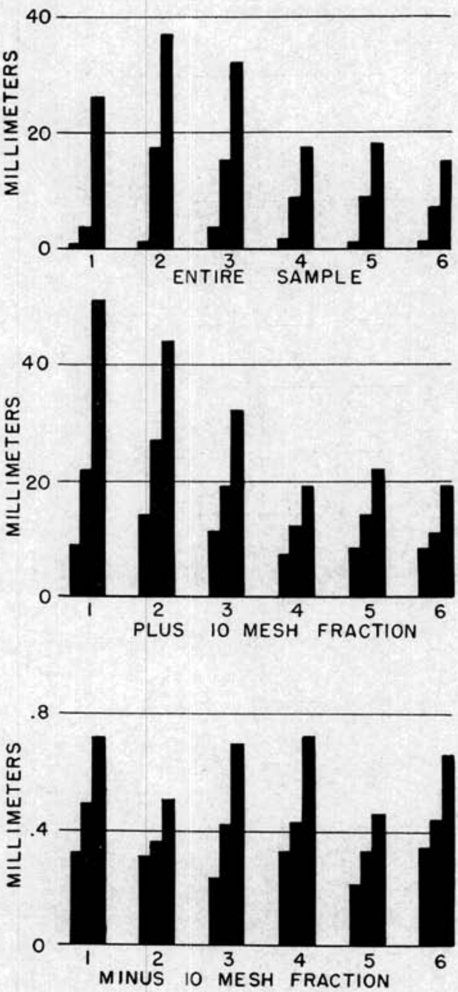

FIG. 3.—Histograms showing first quartile (left-hand bar), median (center bar) and third quartile (right-hand bar) of "Lafayette" gravel samples.

2. All the charts are bimodal. Those for samples 2, 3, 4, 5, and 6 are roughly similar. The curve for sample 1, however, differs in the shape and amplitude of its sand fraction peak and in the particle size distribution of the gravel fraction.

In figure 3 are shown certain statistical values determined from the particle size analyses. The quartile and median data for the samples as a whole indicate that samples 2 and 3 are the coarsest and sample 6 is the finest. In the plus 10 mesh fraction, sample 1 is the coarsest and samples 4 and 6 the finest. In general a kinship is suggested between samples 1, 2, and 3 from Hamilton, Grover, and Fayville, respectively, and between samples 4, 5, and 6.

PEBBLE COUNTS

In order to determine the lithology of the "Lafayette" gravel, pebble counts were made on 100 pebbles selected at random from each of four size fractions of each sample. All chert pebbles were classified according to color: brown, light buff, red, and black. The size fractions counted and the results of the counts are shown in figure 4.

The following characteristics are indicated for each of the size fractions:

1.05 x .742″	Samples 1, 2, and 3 contain black and red chert and sample 2 is relatively high in light brown chert.
.742 x .525″	Sample 1 differs from the other samples in having a high content of red chert and vein quartz. Samples 1, 2, and 4 contained more light brown chert than the other samples.
.525 x .371″	Sample 1 differs from the other samples in having a high content of vein quartz and of buff chert pebbles.
.371 x .19″	Samples 1 and 3 are high in vein quartz pebbles. Sample 2 is high in light brown chert pebbles and Sample 4 is high in red chert.
1.05 x .19″	Sample 1 is unlike all others because of its

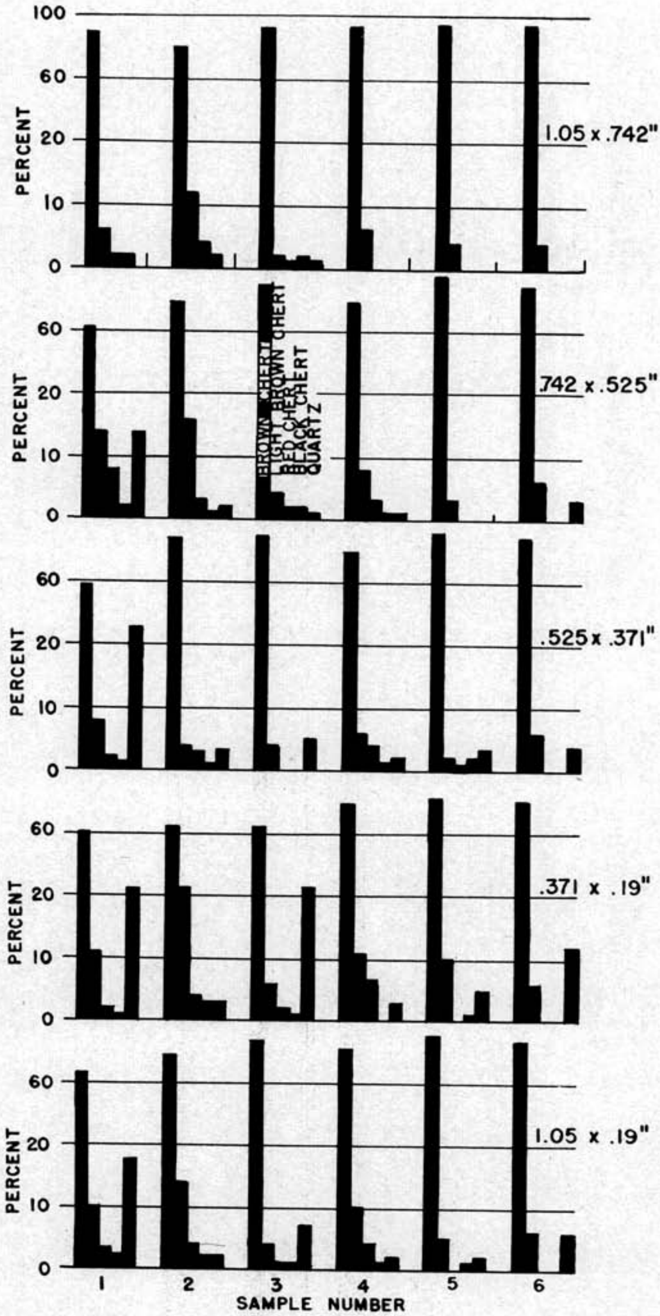

FIG. 4.—Results of pebble counts in percent by number of pebbles. Percent scale changes at 20 percent.

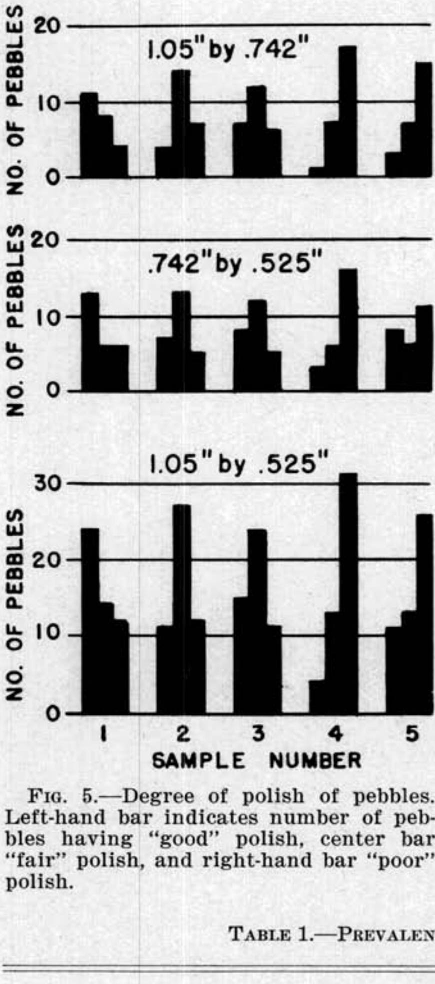

FIG. 5.—Degree of polish of pebbles. Left-hand bar indicates number of pebbles having "good" polish, center bar "fair" polish, and right-hand bar "poor" polish.

low chert content and high compensating vein quartz content. Samples 1, 2, and 4 contain the most light brown chert pebbles and also the most red chert pebbles.

To summarize the foregoing, sample 1 differs from all other samples in its high vein quartz content. Samples 1 and 2 are akin in several respects, as are samples 5 and 6. Samples 3 and 4 are of intermediate character. This is probably to be expected because samples 1 and 2 are from the Mississippi Valley and samples 5 and 6 from the Ohio Valley, whereas samples 3 and 4, near the junction of the two valleys, show affiliations with both valleys. The Mississippi Valley gravel samples commonly differ from the Ohio Valley gravel in the following ways: they contain more vein quartz, light brown chert, red chert, and black chert pebbles. The Ohio Valley samples are characterized by a high content of brown chert pebbles.

Conclusions regarding the lithology of pebbles counted in relation to size are shown in table 1.

TABLE 1.—PREVALENCE OF PEBBLES BY KIND

Kind of pebble	Prevalence	
	Greatest	Least
Brown chert	1.05 x .742 inches	.371 x .19 inches
Light brown chert	.371 x .19	.525 x .371
Red chert	.742 x .525 and .371 x .19	.525 x .371
Black chert	About the same in	all sizes
Vein quartz	.371 x .19	1.05 x .742

TABLE 2.—SHAPE OF PEBBLES
(In percent by numbers of pebbles)

Sample No.	1.05″ x .742″ fraction				.742″ x .525″ fraction				1.05″ x .525″ fraction			
	I*	II	III	IV	I	II	III	IV	I	II	III	IV
1	64	16	4	16	64	24	12	0	64	19	8	9
2	32	40	12	16	28	24	32	16	30	33	21	16
3	32	36	12	20	44	16	20	20	37	27	16	20
4	32	16	16	36	60	20	12	8	47	18	14	21
5	52	28	4	16	56	12	16	16	54	20	10	16
6	36	24	8	32	40	28	8	24	38	26	8	28
2 (quartz)	39	55	0	6	37	47	0	16	38	52	0	10
3 (quartz)	...	...	...	...	38	30	16	16	...	...	...	...

* I—Flattened or disc shaped.
II—Spheres or equidimensional pebbles.
III—Bladed or lath-like.
IV—Rod shaped.

These data carry various implications regarding source deposits. The black chert, and to a lesser extent the red chert, appears to have come from deposits having a uniform particle size distribution. In contrast the vein quartz pebbles came from a source that yielded pebbles mostly smaller than ½ inch.

In addition to the kinds of pebbles mentioned, there were observed in the gravel samples, in amounts probably less than one percent, other kinds of pebbles that may prove valuable in determining the source of the gravel. These were quartzite, agate, and jasper pebbles. No igneous rock pebbles were observed, nor have they been seen in Illinois outcrops.

SHAPE

Shape studies were made on two sizes of chert pebbles, namely, 1.05″ x .742″ and .742″ x .525″. Pebbles of these sizes were selected because they are common and easily handled. In addition, the shapes of 25 quartz pebbles from samples 2 and 3 were measured to provide comparative data.

Standard methods[2] were employed in measuring the pebbles. Shape designations were assigned by the Zingg shape classification[3], which provides for four classes. These are indicated in table 2 together with results of the shape studies.

TABLE 3.—AVERAGE SPHERICITY VALUES

Sample No.	Size of pebbles	
	1.05″ by .742″	.742″ by .525″
1	.70	.69
2	.72	.67
3	.70	.66
4	.65	.67
5	.65	.68
6	.70	.69

[2] Krumbein, W. C., Measurement and geological significance of shape and roundness, Jour. Sed. Petr. vol. 11, no. 2, Aug. 1941, p. 66.
[3] Krumbein, W. C., *op cit.*, p. 67.

The results indicate a similarity of shape between pebbles in samples 2 and 3 in the 1.05 x .742 inch fraction and a less striking similarity between samples 3 and 5 in the .742 x .525 inch fraction. Considering both fractions together there is a likeness between samples 4 and 5. The shape data do not, therefore, show any consistent relationship between the samples.

Flattened or disc-shaped pebbles are most common; they comprise 45 percent of the six samples investigated. Twenty-four percent of the pebbles are spherical or equidimensional, 13 percent bladed or lath-like, and 18 percent rod shaped.

Shape determination on two sizes of quartz pebbles from sample 2 and one size from sample 3 yielded differing results (table 2), but show a dominance of flattened or disc-shaped and spherical or equidimensional pebbles. Sample 2 contains no bladed or lath-like pebbles.

Sphericity

Sphericity was determined directly from a modification of the Zingg diagram.[4] Table 3 gives the sphericity data. No distinctive differences are apparent between samples.

Roundness

The roundness of the pebbles previously measured for shape was determined by comparing them with Krumbein's visual roundness chart.[5] The results are given in table 4; also comparable measurements of 25 vein quartz pebbles from samples 2 and 3. The chert pebbles of sample 1 are the least round. The other samples show no outstanding differences. The quartz pebbles are more round than the chert pebbles.

The roundness values of the chert pebbles commonly result from a rounding of the edges and corners of the pebbles rather than major alteration of the general pebble shape. Well-rounded chert pebbles are infrequent in the sizes studied; such pebbles as are found may have come from a distant source, although some of them may have had a high initial roundness.

Table 4.—Average Roundness Values

Sample No.	Size of pebbles	
	1.05″ by .742″	.742″ by .525″
1—chert pebbles...	.44	.40
2 " "	.50	.48
3 " "	.48	.46
4 " "	.48	.48
5 " "	.50	.51
6 " "	.52	.48
2—quartz pebbles..	...	.73
3 " "	...	.73

Since the quartz pebbles are more rounded than the chert pebbles, and also are probably more resistant to abrasion, it seems likely that they may have attained much of their present degree of rounding in a pre-"Lafayette" cycle of erosion. Conceivably most of them found in the "Lafayette" gravel in southern Illinois may have been derived from the Caseyville (Pennsylvanian) conglomeratic sandstones which form prominent escarpments a few tens

[4] Krumbein, W. C., *op. cit.* p. 68.
[5] Krumbein, W. C., *op. cit.* p. 68.

of miles north of the gravel area. This is suggested by the appearance of the pebbles and by a petrographic and sedimentologic study made of them by Reynolds.[6] The source of the quartz pebbles in the Grover and Hamilton samples is a problem for further study.

Polish

An outstanding characteristic of most "Lafayette" gravel deposits of Illinois is the polish shown by the pebbles. Some pebbles are completely or almost completely polished;

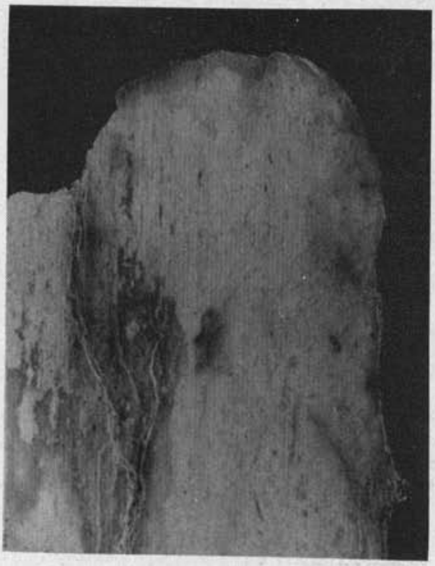

Fig. 6.—Polished section of a brown "Lafayette" chert pebble. The marginal, brown-stained zone which gives the pebble its exterior color is evident except at the broken upper left corner. An area of brown discoloration produced by the infiltration of iron oxide along incipient fractures is shown by the dark-grey area at the left of the picture. Reflected light. X 7.

Fig. 7.—The natural surface of one side of a chert pebble which is silicified oolite. It suggests the surface of a freshly broken oolitic limestone. X 4.

others have rough corners and edges, with polish on only the larger flat or nearly flat surfaces; still others show polish only in re-entrants in the pebbles. The variations in the extent of the polish may be a function of the amount of wear to which a pebble has been subjected since the original development of the polish.

The pebbles of sample 6, which have dull, lusterless surfaces, are an exception. The sampled deposit was partly cemented, and the pebbles were coated with a film of limonite. Attempted removal of the limonitic coating by rubbing resulted in a moderate degree of polish, but this may have been caused by the rubbing. Solution of the limonitic film by hydrochloric acid revealed a dull unpolished surface on most pebbles, but in the re-entrants of a few pebbles some polish was evident. This suggests that the gravel of sample 6 was once normally polished. Its loss of polish could be attributed to processes related to cementation; however, as the deposit from which sample 1 was obtained was also part-

[6] Reynolds, Robert R. A comparative study of the quartz pebbles in the Lafayette gravel and the Caseyville conglomerate of southern Illinois. Masters thesis, Dept. of Geology, Univ. of Illinois, 1942. Unpublished.

ly cemented, though less so than sample 6, and yet contained many highly polished pebbles, cementation cannot be regarded as always adversely affecting polish.

It was evident from an examination of 300 pebbles that in general most of the chert pebbles in the "Lafayette" gravel have a higher degree of polish than the other pebbles. The vein quartz pebbles and the few quartzites as a rule have only a fair degree of polish.

In an attempt to determine variations in degree of polish between samples, the chert pebbles whose shapes were measured were arbitrarily classified according to whether their polish was deemed good, fair, or poor. The results are shown in figure 5. Sample 1 from Hamilton, Ill., has the highest degree of polish. Samples 2 and 3 have a moderate degree of polish, whereas samples 4 and 5 are the least well polished. The data at hand are not sufficient to permit an interpretation of these observations, but it is suggested that they probably relate to the history of the pebbles after polishing and perhaps to the varying susceptibilities of different varieties of chert to polishing.

The means by which the "Lafayette" pebbles received their polish were not investigated. However, the dense surfaces of some of the porous chert pebbles and of some of the infrequent sandstone pebbles observed suggest that they may have been impregnated with silica.

The brown color and polish of the "Lafayette" chert pebbles may be in some way related. Thin sections of chert pebbles show that, although the interiors of the pebbles may be buff, the characteristic brown is commonly restricted to a relatively thin zone at the surface and to bands or streaks along cracks and fractures in the pebble (fig. 6). Twelve pebbles from sample 1 were boiled in hydrochloric acid. Six lost their dark-brown color and changed to an orange brown or yellow brown with cream-colored blotches. Three pebbles became light buff to cream. Three others were little changed. It is noteworthy that though there was a marked color change, the polish of the pebbles was not appreciably altered; the gloss may have been increased, thus suggesting that the polish is not necessarily now linked with the brown color. This inference is further suggested by the fact that the "glazed" pebbles, subsequently described, though white or cream colored, are also polished. It seems possible, therefore, that the polish of some pebbles is unrelated to color.

Oolitic Pebbles

A considerable number of the pebbles in the samples studied are silicified oolite. The abundance of oolitic pebbles in the 50 pebbles studied for shape is shown in table 5. Some of the pebbles are obviously chert; others appear to be more coarsely crystalline quartz, although they may be varieties of chert. Many show pitted surfaces, but oolitic pebbles without pits are also common. Numerous coarser-grained pebbles have on their flat or rounded surfaces an intricate pattern composed of roughly crescentic indentations somewhat akin to chattermarks but not regularly distributed. These markings also occur on pebbles which contain fossil detritus but only

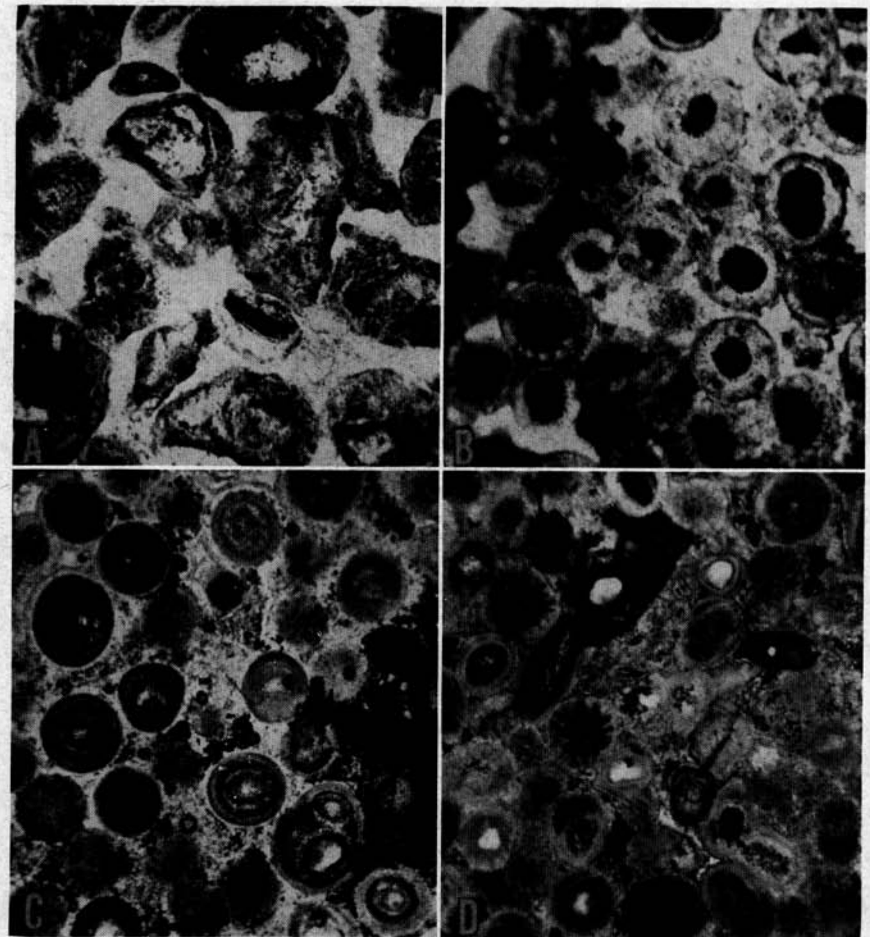

FIG. 8.—Thin sections of silicified "Lafayette" pebbles. A. Originally probably a limestone composed of calcareous detritus and possibly some oolite grains. B. Oolite showing radial structure but little annular banding in grains; grains have dark centers. C. and D. Oolite showing well-developed annular and radial structure; the white centers are macrocrystalline quartz. X 18.

scattered oolite grains. Many of the oolitic pebbles showing the markings are maroon colored. A few oolitic chert pebbles have one natural surface that resembles a freshly broken piece of oolitic limestone. On these surfaces the oolite grains resemble rounded sand grains, and the pebbles might be described as sandstone from casual examination (fig. 7).

The oolitic pebbles are diverse (fig. 8). Some consist largely of roughly spherical oolite grains, generally showing an annular structure; others are composed of numerous annular oolite grains, together with an abundance of granular material, probably detrital, which does not show notable concentric structure or spherical shape. Small fossils

TABLE 5.—NUMBER OF OOLITIC PEBBLES IN PERCENT BY NUMBER OF PEBBLES

Sample No.	.742″ x 1.05″	.525″ x .742″	.525″ x 1.05″
1	4	6	5
2	10	10	10
3	8	4	6
4	12	14	13
5	6	4	5
6	0	0	0

such as brachiopods and fragments of large fossils are common in some pebbles. The grain size of the oolites and other materials is variable, as is the ease with which the textural characteristics of the pebbles can be determined without thin-sectioning.

The source of the oolitic pebbles is not known. The textures and character of many of the pebbles are approximated or essentially duplicated in the oolite of the Ste. Genevieve and Salem formations, as now exposed in Illinois, which may have been the source of many of these pebbles.

It is of interest that no considerable amount of oolitic chert is known in the Salem, Ste. Genevieve, or Chester formations as now exposed in southern or western Illinois. As previously noted, some of the oolite pebbles composed of relatively coarse-grained quartz show natural surfaces like those of a freshly broken piece of limestone oolite, a type of fracture which would probably not be expected from the silicified pebbles as now found (fig. 8). This phenomenon can be accounted for in various ways, but the question is raised whether these pebbles may not be the result of some special set of silicification conditions rather than those which normally produce chert in limestones.

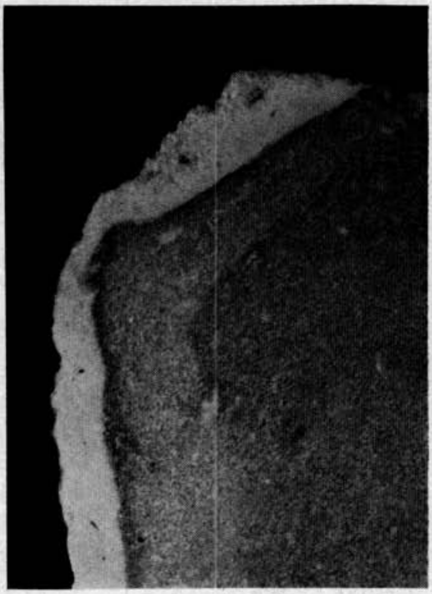

FIG. 9.—Polished section of a "Lafayette" pebble showing white "glaze" over part of exterior, and a light band concentric with the glaze. Reflected light. X 8.

"GLAZED" PEBBLES

The samples studied, especially nos. 1 and 2, contain pebbles whose exterior consists partly or wholly of white, siliceous, often porcelain-like material resembling a "glaze"[7] or coating (fig. 9). On some pebbles the glaze is about 1/8 of an inch thick and covers most of the surface. Other pebbles show only small glazed areas. The glaze occurs alike on brown and black chert pebbles. Both the unglazed and glazed parts of many of the pebbles are polished in normal

[7] The term "glaze" is here used in the same sense as a ceramist would refer to an opaque glaze because the term describes the appearance of the phenomenon. This usage is not meant to connote that the glaze was necessarily an addition to the original pebble.

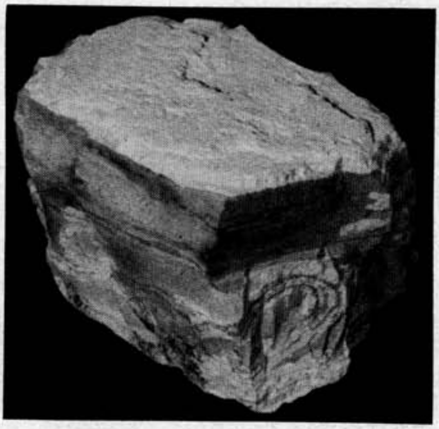

Fig. 10.—Chert from a bedrock outcrop showing the development of a white chalky material on the top of the specimen. Similar material occurs on the bottom but is not visible in the photograph. The white chert in other parts of the specimen is not chalky. About natural size.

fashion. No glaze was observed on sandstone, vein quartz, or quartzite pebbles. In sample 1, 22 of the 50 pebbles examined had more or less glaze; 4 of the 50 pebbles in sample 2 had glaze.

The origin of the glaze cannot be certainly determined from the material at hand. It is suggested, however, that a porous, white, weathered zone, such as commonly develops on chert (fig. 10), was later impregnated with silica to produce the hard, dense exterior material, or glaze. Different degrees of erosion of the weathered zone, possibly before impregnation, would account for the differences in the amount of glaze now evident.

Agate Pebbles

Samples 1, 2 and 3, from the Mississippi Valley, contain pebbles of agate, mostly in shades of gray, white, and brown. These pebbles are not numerous, but they are significant because they are rare or absent in the other samples. They were observed to be also relatively common in the "Lafayette" gravel in Missouri across the Mississippi River from the deposit in Alexander County, Ill., from which sample 2 was obtained. The agate pebbles are rounded to irregular.

In sample 1, two brown chert pebbles were partly coated with banded quartz similar to parts of the agate pebbles.

The agate pebbles are of different types. A common variety is of crystalline quartz, showing comb structure in some specimens, which is interspersed between irregular masses of banded chalcedony and within which round agates as much as ½ inch in diameter are distributed. In one pebble studied in detail, the contact between the comb quartz and the banded chalcedony is transitional and consists of a series of thin alternating bands of crystalline quartz and chalcedony. The crystal size of the macro-crystalline quartz bands decreases away from the comb quartz and ultimately becomes micro-crystalline.

The general structure and character of the pebbles suggest that they were originally cavity linings or fillings. The chert coated with banded silica presumably represents part of a cavity lining and cavity wall.

No deposits from which the agate pebbles could have come are known in Illinois. Their presence along the Mississippi Valley suggests that they may have come from Missouri or other areas adjacent to the valley.

TABLE 6.—FAUNA LIST*

Sample No.	Location	Name	Age
2	Grover, Mo.	Favosites	Silurian to Devonian
		Lithostrotion	Mississippian
3	Fayville, Ill.	Favosites	Silurian to Devonian
		Columnaria alveolata?	Upper Ordovician
		Streptelasma	Ordovician
		Lithostrotion	Mississippian
		Triplophyllum	"
		Cyathophyllum	Devonian and Mississippian
4	Mounds, Ill.	Lithostrotion	Mississippian
		Triplophyllum	"
		Linoproductus	Mississippian to Permian
		Spirifer	Silurian to Pennsylvanian
5	Grand Chain, Ill.	Lithostrotion	Mississippian
6	Renshaw, Ill.	Lithostrotion	Mississippian
		Fenestellid bryozoa	Silurian to Permian
		Zaphrentid corals	" " "

* Identification and age by W. H. Easton, Illinois State Geological Survey, 1942.

FOSSILS

Silicified fossils, commonly as partial specimens of individuals, are relatively abundant in some deposits of "Lafayette" gravel. Corals are most frequent. Some chert fragments contain a great many crinoid stems, and molds or partial molds of brachiopods, bryozoa, and gastropods. Table 6 lists the genera which were obtained as a result of limited collecting.

Undoubtedly a systematic collection from each locality would yield more detailed lists of fauna. The presence of fossil corals, crinoids, and brachiopods of the Lower and Middle Silurian is reported[8] in a deposit of Lafayette-type gravel in Henry County in northwestern Illinois. The data in table 5 suggest that there is no need to assume a distant source for the fossiliferous chert in any of the southern Illinois "Lafayette" deposits studied, as southern Illinois or areas adjacent to it contain outcrops of limestone, some of it cherty, of Ordovician, Silurian, and Mississippian age and also extensive deposits of Devonian chert formations, especially near the localities from which samples 3 and 4 were taken. The Grover deposit is similarly situated with reference to outcrops of Ordovician, Silurian, and Mississippian rocks.

[8] Horberg, Leland, Preglacial gravels in Henry Co., Illinois. Trans. Ill. Acad. Sci. vol. 43, 1950, p. 173.

CONCLUSIONS

It appears from the foregoing that a study, including particle size distribution, particle shape, pebble counts, and paleontology of fossil molds, of a greater number of samples taken with cognizance of the relation of the deposits to topographic levels might yield information which would add materially to the knowledge of the source or sources of the "Lafayette" gravel in Illinois and adjacent states, and which would also broaden the factual basis for interpreting the history of the formation of the gravel. Various special features, such as polish, glazed pebbles, agate pebbles, and silicified oolite pebbles, are in themselves problems that merit further investigation and that may aid in a better understanding of the broader problems of the "Lafayette" gravel.