# MINERAL COMPOSITION OF SANDS FROM MONONGAHELA, ALLEGHENY, AND OHIO RIVERS

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The region drained by the Monongahela, Allegheny and Ohio Rivers is underlain almost entirely by sedimentary rocks, and the alluvial sands in the rivers are therefore derived mainly from the weathering and erosion of these rocks. However, the fact that some of the area drained by the Allegheny and other northern tributaries of the Ohio has been glaciated while none of that drained by the Monongahela has been, might be expected to lead to some differences in the composition of these sands. It was to investigate these differences that the study described here was undertaken. The laboratory work was done at West Virginia University, Morgantown, West Virginia.

Sands were collected from old stream terraces, recent bar and beach deposits, the river channels, and in some few cases it was necessary to rely upon samples taken from the stock piles of sand companies dredging these rivers. It was possible to get a sample from the channel of the Cheat River from a barge which had been just previously loaded. In every case a representative portion of the sand was taken and analyses were made of only those sands of which the source and location were definitely known.

## LIST OF SAMPLES

CHEAT RIVER—(Tributary of Monongahela River).
No. 3001—Stock Sand, McClain Sand & Gravel Co., Point Marion, Pa.
3002—Dredged Sand from Barge below Cheat Haven Dam, Pt. Marion, Pa.
3008—Flood Plain, near Kingwood, West Virginia.

MONONGAHELA RIVER
No. 3003—River bar, sample dug, East Millsboro, Pa.
3004—River bar, scooped sample, East Millsboro, Pa.
3009—Dunkard Creek, a tributary of Monongahela River.
3012—River bar near West Masontown, Pa.
3011—River terrace, Brown's Ferry, Pa.
3013—River terrace, Fairmont, West Virginia.
3017—Old river terrace, Star City, West Virginia.

ALLEGHENY RIVER
No. 3006—Stock sand, Allegheny Wharf Company, Pittsburgh, Pa.
3007—Channel sand, Freeport, Pennsylvania.

OHIO RIVER
No. 3005—Stock sand, McClain Sand Company of New Martinsville, W. Va.
3010—Fish Creek, tributary of Ohio River.

3014–15–16—Neville Island, Pittsburgh, Pennsylvania.
3018—Beach deposit at Dayton, Kentucky.
3019—Dredged sand, Florence, Indiana.

BEAVER RIVER

No. 3020—Terrace sand, East Moravia, Pennsylvania.
3021–22—River bar, East Moravia, Pennsylvania.

A representative portion of about 15 grams (Table 1) of the original sample was used in the following laboratory procedure. The

TABLE I. MECHANICAL ANALYSIS OF SAMPLES USED

| Sample Number | % of Minus ½ mm | % of Heavy | Deposit | Results of Acid Treatments |
|---|---|---|---|---|
| 3001 | 61.0 | 0.57 | Dredged | Limonite stain removed |
| 3002 | 78.7 | 1.86 | Dredged | " " " |
| 3008 | 100.0 | 1.20 | River bar | " " " |
| 3003 | 92.7 | 2.80 | River bar | " " " |
| 3004 | 100.0 | 2.20 | River bar | " " " |
| 3009 | 46.7 | 0.50 | Creek bar | " " " |
| 3011 | 100.0 | 0.70 | Terrace | " " " |
| 3012 | 80.0 | 0.30 | River bar | Carbonate min. removed |
| 3013 | 60.0 | 0.05 | Terrace | Limonite stain removed |
| 3017 | 99.5 | 0.13 | Terrace | " " " |
| 3006 | 80.0 | 3.80 | Dredged | Carbonate min. removed |
| 3007 | 78.0 | 3.40 | Dredged | " " " |
| 3005 | 68.6 | 2.40 | Dredged | Limonite stain removed |
| 3010 | 90.0 | 0.70 | Creek bar | Slight effervescence |
| 3014 | 94.5 | 5.60 | Island | Carbonate min. removed |
| 3015 | | | Island | Sample of glac. pebbles |
| 3016 | 96.7 | 5.50 | Island | Slight effervescence |
| 3019 | 73.2 | 6.25 | River bar | Carbonate min. removed |
| 3020 | 98.5 | 4.3 | Terrace | " " " |
| 3021 | 77.5 | 17.2 | River bar | Contaminated* |
| 3022* | 71.5 | 36.2 | River bar | Contaminated* |

* Of 36.2% heavy concentrate 74.5% is metallic-iron.

sands were thoroughly washed several times with water, then a bath consisting of dilute hydrochloric and sulphuric acids was applied to clean the grains of any limonite coating or stains. After drying, the material was sieved through a half-millimeter sieve. The portion under ½ mm. in size was separated by means of bromoform having a specific gravity of 2.83. After each process the sands were weighed. Permanent slides of the light and heavy portions of these sands were made for later microscopic determination. Canada balsam was the imbedding medium.

TABLE II

| Number of Sample | Leucoxene | Brown Opaque | Ilmenite | Pyrite | Magnetite | Zircon | Sillimanite | Cyanite | Barite | Muscovite | Biotite | Tourmaline | Hypersthene | Garnet | Hornblende | Augite | Epidote | Calcite | Rutile | Titanite | Chlorite | Anatase | Brookite | Tremolite | Enstatite | Xenotime | Light Portions | Quartz | Orthoclase | Plagioclase | Microcline | Micro-perthite |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 3001 | a | F | s | R | P | A | | | | c | | c | | | | | | | | | | | | | | | | F | s | | | |
| 3002 | a | F | s | | P | A | | | | c | | c | | | | | | | | | | | | | | | | F | s | | | |
| 3003 | a | F | s | | P | A | | | | c | R | c | | | | | | | R | | R | R | R | | | | | F | s | | R | |
| 3004 | a | A | s | s | P | A | | | | c | | c | | R | | | | | r | | | | | | | P | | F | | | r | |
| 3005 | s | S | c | | P | C | c | s | | c | | c | c | A | c | s | s | P | s | S | | | | | | | | F | R | | | c |
| 3006 | C | r | c | | X | C | c | s | | s | | s | c | A | c | s | s | P | S | | | | | | | | | F | c | | r | c |
| 3007 | C | r | c | | X | c | c | s | P | c | | s | c | A | c | s | | | | R | R | | | P | | | | F | c | r | r | |
| 3008 | a | A | | | X | C | | | | c | R | C | | | | | | | R | | | | | | | | | F | | | | |
| 3009 | a | A | S | R | X | C | | | | c | | S | | R | | | | | R | | | | | | | P | | F | R | | | |
| 3010 | a | A | s | | X | C | | | | c | | s | | | | | | | | | | | | | | | | F | | | | |
| 3011 | a | A | | | X | C | | | c | c | | c | | R | | | | | R | | | R | | | | | | F | | | | |
| 3012 | a | A | S | R | X | C | R | | | c | | C | R | R | | | | | | | | | | | | | | F | R | | | |
| 3013 | a | A | | | X | c | | | | | | c | | | | | | | | | | | | | | | | F | | | | |
| 3014 | C | r | c | | X | C | c | s | r | c | R | | C | A | C | s | s | P | r | R | | | | s | R | | | F | c | r | r | s |
| 3015 | Sample of Glacial Pebbles | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 3016 | C | r | c | | X | C | c | [s] | r | c | R | | C | A | C | s | s | P | r | R | | | | s | R | | | F | c | r | r | s |
| 3017 | F | | | | X | F | | | | c | r | c | | | | | | | P | | | | | | | P | | F | | | | |
| 3018 | Sample Contaminated | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 3019 | c | s | C | | X | C | c | s | s | c | P | | C | A | C | s | | c | r | | | | | c | | | | F | c | s | s | c |
| 3020 | c | s | C | | X | C | c | s | s | c | | | C | A | C | s | | c | r | | | | | c | | | | F | a | s | s | c |

Prof. W. W. Watt's method of estimating as described by Prof. Milner.
F—Flood, A—Very abundant, a—Abundant, C—Very common, c—Common, s—Scarce, S—Very scarce, r—Rare, R—Very rare, P—Present, X—Not determined.
Amount of calcite determined by acid test, magnetite determined by magnet test.

In the microscopic determination of the mineral content of these sands it was found that all samples contained mostly quartz. In the light portions (Table 2) of the Allegheny and Ohio Rivers, calcite, orthoclase and plagioclase grains were present, while the Monongahela sands consisted almost entirely of quartz (Table 2) and shale particles.

In the heavy portions of all these river sands there were found an abundance and variety of minerals. Those of the Monongahela (Table 2) consisted of pure and impure leucoxene, zircon, muscovite, tourmaline, biotite (rare), ilmenite, and an occasional grain of rutile. These minerals are characteristic of sands derived from other sedimentary rocks.

The heavy portions (Table 2) of the Allegheny and Ohio River sands contained a much greater variety of minerals derived from both igneous and metamorphic, as well as sedimentary rocks. In order of importance they are: garnet, hypersthene, zircon, augite, sillimanite, hornblende, tourmaline, leucoxene, barite, ilmenite, cyanite, actinolite, epidote, muscovite, enstatite, biotite, titanite, chlorite, pyrite, and rutile. During the acid treatment the presence of calcite was noticed. By using a magnet magnetite was found present in all sands of the Ohio and Allegheny Rivers. The Beaver River samples were examined to compare the sands of deposits along a river which drains a region wholly of morainic material with those from a river draining an area of which only a fractional part is derived from moraines. A casual examination of these samples showed about 30% of the heavy portion to contain the same minerals as the Allegheny and Ohio River samples (Nos. 3005-6-7-14-19). The remaining 70 per cent was found to be metallic iron which was carried from the slag dumps found along this river. The light portions contained chiefly quartz and orthoclase feldspar with many of the quartz grains showing secondary growths. The heavy portions being contaminated by metallic iron they were not studied in detail.

It was found by these analyses that the sediments of the Allegheny and Ohio Rivers differ greatly from those of the Monongahela and Cheat in mineral composition. The minerals of the two latter named rivers are quite characteristic of a sedimentary rock region but those minerals from the Allegheny and Ohio show a more nearly direct derivation from igneous and metamorphic rocks. It is known that all of these rivers drain regions in which bed rock is of Paleozoic age. Although these rocks are of sedimentary origin

TABLE III. MINERAL ANALYSIS OF FIVE REPRESENTATIVE SAMPLES

| Minerals Present | Sample Number | | | | |
|---|---|---|---|---|---|
| | 3001 | 3004 | 3007 | 3014 | 3019 |
| Total Grain Count | 498 | 1764 | 885 | 1478 | 649 |
| | Percent Present | | | | |
| Brown opaque | 62.4 | 39.0 | 7.10 | 37.3 | 19.8 |
| Black opaque | 4.6 | 1.8 | 12.3 | 10.3 | 15.1 |
| Leucoxene | 23.0 | 20.6 | 2.7 | 7.0 | 8.9 |
| Zircon | 8.4 | 32.6 | 2.2 | 6.3 | 5.2 |
| Tourmaline | 1.0 | 2.4 | 1.7 | 2.6 | 1.5 |
| Garnet | | | 52.0 | 2.9 | 21.2 |
| Hornblende | | | 8.7 | 16.7 | 6.1 |
| Sillimanite | | | 5.3 | 6.1 | 9.4 |
| Hypersthene | | | 3.4 | 2.2 | 2.3 |
| Augite | | | 1.5 | 1.6 | 2.4 |
| Cyanite | | | 0.9 | 1.1 | 1.5 |
| Epidote | | | 1.2 | 0.9 | 0.6 |
| Muscovite | X | 0.7 | X | 2.7 | 4.9 |
| Titanite | | | 1.1 | 0.7 | X |
| Rutile | X | 0.5 | 0.0 | 0.5 | X |
| Pyrite | X | 0.5 | 0.0 | 0.0 | 0.1 |
| Tremolite | | | X | 0.8 | X |
| Enstatite | | | X | X | X |
| Barite | | | X | X | X |
| Xenotime | | X | | | X |
| Biotite | | | | X | X |
| Andalusite | | | | | X |
| Anatase | | | | X | |
| Actinolite | | | | | X |
| Metallic iron | | 1.7 | | | |

X—Represents a count of less than 0.5%. Muscovite loss due to floating during washing.

we must not overlook the morainic deposits which were left in the northern parts of Pennsylvania and Ohio as the great ice sheet melted. This morainic material contains igneous and metamorphic debris which the glacier picked up and carried in its southward advance. Since these morainic deposits were the last to be formed and since they are covering the country rock, they must be the first to weather and be carried away as sediments. Although an abundance of igneous and metamorphic material (Table 3) is found in the heavy portions of these sands it should not be thought that they tend to make up the greater part of the total sand. In reality only about 4 per cent of the total combines to make the heavier concentrates, while approximately 95 per cent is quartz. Of the sands in the Monongahela and Cheat Rivers, less than 2.5 per cent comprises the heavy portion of the cleaned sand, while 97 per cent is quartz.

Minerals similar to those found in the Ohio River are carried by the Great Kanawha which has its head waters in the pre-Cambrian rocks of Western North Carolina, and flows westward to meet the Ohio at Point Pleasant, West Virginia. This river carries no new minerals of igneous derivation into the Ohio but slightly increases the abundance of those already found.

Another factor influencing the composition of the sands is the composition of the river water in which it occurs. The waters of the Monongahela drainage system are known to be contaminated by sulphuric acid. This acid in the water may account for the complete loss of calcite in the samples taken from this particular region and for its scarcity in the Ohio sediments. Calcite is found most plentifully in the Allegheny River sands.

The abundance of leucoxene (Table 3) is a noticeable factor to be considered in the comparison of these stream deposits. Pure and impure leucoxene is most abundant in the Monongahela and Cheat River sediments, and is found to diminish in importance in the Allegheny sands but is of a purer grade than in the other sands. The increased amount in the Ohio sands is caused by the large quantity carried in from the Monongahela. This abundance of leucoxene in the river sediments is not due to any action of the stream water for it is found to be plentiful in the rocks of this region.[1]

A great loss of minerals in the Cheat and Monongahela River sands can be accounted for by the difference in conditions of the rock mass of the area. These rocks are more weathered than those of the northern parts in Pennsylvania and Ohio. A greater part of the sediments of these rivers is from the residual soils caused by this increased weathering of the country rock.

Of the samples taken from stock piles it is to be considered that dredged material will not give the true size of grain nor the true mineral composition of the sands. While nothing is added to the sand there is a great loss of mineral content especially muscovite (Table 3). This is caused by much of the finer sand being washed away during the dredging process.

[1] James H. C. Martens, Personal communication and comparison of our studies.