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Sand and Gravel Resources of Indiana

By DONALD D. CARR and WILLIAM M. WEBB

Introduction
Sand and gravel are unconsolidated granular materials resulting from the natural disintegration of rocks. Unlike most other mineral commodities they are defined in terms of particle size rather than mineral or chemical composition. In general, sand is a detrital material consisting of rock and mineral fragments that are less than 2 millimeters and greater than one-sixteenth millimeter in diameter. Gravel is a coarse detrital material consisting of rounded or partly rounded fragments of rocks and minerals greater than 2 millimeters in diameter. The upper size range, although variable, is considered to be 3% to 4 inches. Sand and gravel are used in large quantities as a base or subgrade material for highways, as roadstone on unpaved roads, and as fill material. Another important use is as aggregate or the framework component in concrete, mortar, or bituminous mixes. Each year vast quantities of sand and gravel are used in making highways, bridges, dams, runways, foundations, and buildings. During 1968 sand and gravel production in Indiana, exclusive of specialty sands, was 25,774,000 tons and was valued at $26,160,000.

Types of Deposits
The major sand and gravel resources in Indiana are found within deposits formed directly by glaciers or by glacial meltwater streams during the Pleistocene Epoch or Ice Age of earth history. Although glacial deposits cover about five-sixths of the state (fig. 1), commercial deposits of sand and gravel are restricted to, and are associated with, sediments that were deposited from meltwater streams. In addition, minor amounts of sand and gravel are obtained from glacial till and postglacial or modern stream deposits.
The origin of many glacial deposits is difficult to interpret because of a complex history of deposition and reworking. But depositional processes leave behind clues to their origin. Topographic and stratigraphic relationships, along with compositional and textural variation, provide a basis for interpreting the genesis of deposits (fig. 2).

GLACIAL TILL
Material deposited directly by a glacier is called till. Texturally, this material is poorly sorted, consisting of varying proportions of clay, silt, sand, and gravel. The component particles are usually densely
packed but lack orientation, so that the till has a massive rather than a bedded or banded appearance (fig. 3). Lithologically, till is extremely heterogeneous and consists of particles from many or all of the bedrock and unconsolidated units that were overridden and eroded by the glacier.

Because they are compact unsorted mixtures of fine- and coarse-grained rock and mineral fragments, the tills in Indiana offer little potential as sources of aggregate. Small lenses of outwash sediments are present within some till deposits and have been used locally as a source of gravel and sand. Such lenses are too small to be mapped as separate units, and thus on geologic maps they are included as part of the till itself.

MELTWATER DEPOSITS

Sediments deposited from meltwater streams fall into two classes that are considered separately because of differences in origin and physical characteristics. One class consists of deposits formed beyond the glacier margins (outwash), and the other class consists of deposits formed in immediate contact with the ice (ice-contact).

Outwash deposits are generally found either as broad plains or as fill in valleys. Texturally these sediments are moderately to well sorted, medium to coarse grained and segregated into distinct lenses, layers, or beds; as a result, they have a bedded or banded appearance (fig. 4). Most clay and silt carried by glacial meltwater were carried farther downstream, but some may have been deposited as layers or lenses or, rarely, as a fine-grained matrix filling voids between the larger particles. Most of the large commercially workable gravel deposits in Indiana are found in valley outwash deposits (fig. 5), although some, particularly in the northern quarter of the state, are in outwash plains.

Ice-contact deposits are designated as kames (fig. 6) and eskers on geologic maps and are distinguished from outwash by the following characteristics (Flint, 1957, p. 146): (1) In ice-contact deposits grain sizes are more variable and may have extreme range; (2) till masses
Figure 3. Till showing heterogeneous, massive appearance.

Figure 4. Outwash gravels showing coarse, stratified texture.
Figure 5. Large plant extracting sand and gravel from outwash deposits near Patriot.

Figure 6. Gravel pit in a kame about 15 miles northwest of Wabash.
are more likely to be present within or above the deposit; (3) structures that indicate slumping after deposition are common; (4) grains are likely to be more angular; and (5) nondurable rock types are likely to be more common. Because of these characteristics, ice-contact deposits are less likely to provide suitable raw material for a large modern gravel plant than are outwash deposits.

POSTGLACIAL STREAM DEPOSITS
Recovery of sand and gravel from modern stream deposits, such as river bars, bottoms, and floodplains is largely restricted to the Ohio River and the lower reaches of the Wabash River.

These sediments are generally finer grained than the Pleistocene outwash and are restricted to narrow bands bordering the major streams. Coarse material is encountered in some dredging operations, but this material is probably from the underlying Pleistocene outwash rather than from modern stream deposits.

Characteristics of Indiana Gravels
The size of gravel found in the deposits of Indiana differs considerably from place to place (fig. 7) and is a function of several variables. Of particular importance are the size of the particles supplied by the bedrock source and carried by the glacial ice, the characteristics of the water currents that transport the rock particles, and the hardness of the rock types and their resistance to abrasion. In general, the size of gravel tends to decrease downstream within a drainageway mainly because at any given stream velocity the finer grained, lighter particles are carried farther downstream than the coarser, heavier particles. However, abrasion and breaking of the particles also contribute to the decrease in size of the rock particles as they are transported downstream.

The decrease in size of gravel downstream in a drainageway is illustrated by the outwash drainageways of the Wabash and the East Fork White River (fig. 8), where the percentage of coarse gravel decreases markedly within about 50 miles. Other drainageways in Indiana show similar characteristics.
Figure 7. Size gradation of selected gravel deposits in Indiana. From Patton, 1953, fig. 1.
Figure 8. Graphs showing decrease in amount of gravel greater than 1 inch along parts of the drainageway of the Wabash River (A) and the East Fork White River (B).
The composition of a gravel deposit seems to be a bewildering array of rock and mineral types, and in many samples 10 to 20 varieties can be found. Of particular importance to the sand and gravel operator is the amount of deleterious material in the deposit or material that is not likely to stand up well when used in concrete. The amount of deleterious material, such as porous chert, siltstone, sandstone, and shale, varies considerably among deposits (fig. 9) and depends largely on the bedrock source of the gravel and the history of deposition. Composition of the nondeleterious part of the gravel is becoming increasingly more important because rigid specifications are now being used to control the hardness, durability, soundness, and other physical and chemical properties of the particles that are used in road building and construction aggregate.

Most gravel in the glacial outwash of central and southern Indiana is sedimentary rock similar to bedrock found near the gravel deposits. This fact suggests that these rocks were transported by ice and water only a short distance. In some gravel deposits in Indiana as much as 96 percent of the coarse fraction is similar to bedrock near the gravel deposit (McGregor, 1960, p. 49). Rock types in gravels in the northern part of the state, where bedrock is several hundred feet beneath the surface, are similar to those exposed in Michigan and Canada.

Other rocks in the gravels of central and southern Indiana, such as quartz- and feldspar-rich igneous and metamorphic rocks, are not exposed in Indiana and are believed to have been transported from as far north as Canada. These rocks were not destroyed by transportation over such a great distance because they are hard and durable. Softer rocks, such as marble and slate, were not able to stand harsh treatment, and most of them were pulverized into silt- and clay-sized particles before they could be deposited. One can see the control of parent rock type on gravel composition by examining the gravels along the drainageway of the East Fork White River.

Typical igneous and metamorphic rock types in the gravels of the drainageway of the East Fork White River are granite, gneiss, and schist. Granite and gneiss have similar physical properties: medium
Figure 9. Relative amounts of selected deleterious materials. The number beneath each bar graph is the total percentage of the entire sample that falls in the four categories: chert, siltstone, sandstone, and shale. From Patton, 1953, fig. 2.
Table 1. Physical properties of some rocks commonly found in Indiana gravels
[Data from tests by U.S. Bur. Mines in Repts. Inv. 4459, 4727, 5130, and 5244]

<table>
<thead>
<tr>
<th>Rock type</th>
<th>Compressive strength(^1) (psi)</th>
<th>Hardness(^2)</th>
<th>Impact toughness(^3) (isi)</th>
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<td>Carbonates (limestone and dolomite)</td>
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<tr>
<td>Chert</td>
<td>High</td>
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<td>Clastics (sandstone, siltstone, and shale)</td>
<td>Low</td>
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</table>

\(^1\)High: >30 psi (pounds per square inch); medium: 20 to 30 psi; low: <20 psi.
\(^2\)High: >70 scleroscopic units; medium: 50 to 70 scleroscopic units; low: <50 scleroscopic units.
\(^3\)High: >6 isi (inches per square inch); medium: 3 to 6 isi; low: <3 isi.

The typical sedimentary rocks in the gravels of the drainageway of the East Fork White River are carbonates (limestone and dolomite), chert, and elastics (sandstone, siltstone, and shale). Carbonate rock generally makes good aggregate, but some chert and some elastic rocks are considered deleterious.
Figure 10. Graphs showing changes in percentages of rock types in gravels along the drainageway of the East Fork White River.
Carbonate rock in the gravel fraction is relatively abundant throughout the drainageway of the East Fork White River. In general, carbonate rock makes up more than half of the gravel fraction throughout this area and nearly 90 percent of the gravel in part of Shelby County (fig. 10). Where the gravels have a high carbonate rock content, the nearby bedrock consists mainly of similar material (fig. 10). In the lower reaches of the drainageway, in southern Bartholomew County and in Jackson County, the amount of carbonate rock in the gravel fraction decreases near the place where the bedrock changes from mainly carbonate to mainly clastic rock (fig. 10), an illustration of the close relationship between the composition of the gravels and the bedrock source.

Chert is a relatively small part of the gravels in the upper part of the drainageway, but the percentage of chert increases in the lower part (fig. 10). The increase may be due to an increase in the amount of chert in the bedrock, but more likely it results from the high compressive strength, hardness, and impact toughness of the chert (table 1). Because of its toughness, chert decreases in size at a slower rate than other sedimentary rock types when it is subjected to abrasion and breaking action by streams.

Shale, siltstone, and sandstone generally have low compressive strength, hardness, and impact toughness (table 1). When these rocks are transported by streams or ice, they are broken rapidly and abraded into finer particle sizes and are found in appreciable amounts in the gravel fraction only near a source of clastic bedrock. Thus the proportion of clastic rocks is greater in the gravels in the lower reaches of the drainageway of the East Fork White River, where the nearby bedrock is mainly clastic, than it is upstream (fig. 10).

**Specifications**

Nearly all sand and gravel presently being consumed by the road-building and construction industries must conform to specified particle-size distribution, lithologic composition, durability, and soundness. Details of specifications and testing procedures pertinent to the Indiana Highway Commission can be found in the publication,
"Indiana State Highway Commission Standard Specifications," which is periodically revised. Copies can be obtained by writing to the Engineer of Specification, Indiana State Highway Commission, State Office Building, 100 North Senate Avenue, Indianapolis, Ind. 46204.

The fact that the behavior of a bonded aggregate mass is largely controlled by the characteristics of the aggregate itself has led to a great number of specifications, each one calling for an aggregate of a distinctive particle-size distribution and particle composition. Twenty-three different size gradations of aggregate are listed by the Indiana Highway Commission for road building and construction (table 2). Modern sand and gravel operators are no longer simply miners but true materials specialists employing a battery of processing machines in order to produce the wide variety of aggregates necessary to meet today’s demands.

Figure 11. Sand and gravel production and dollar value in Indiana, 1936-68. Data from U.S. Bureau of Mines Yearbooks and Preprints.
**TABLE 2. TABULATED SIZES OF COARSE AND FINE AGGREGATE**

[AFTER STATE HIGHWAY COMMISSION OF INDIANA, 1969, P. 415, 419]

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Figure 12. Percentage of increase in sand and gravel production (dollar value) for Indiana and the United States, 1950-68. Data from U.S. Bureau of Mines Yearbooks and Preprints.

History and Present State of Development and Economy

Early geologic reports on Indiana mention the abundance and widespread distribution of sand and gravel deposits and recommend their use for railroad ballast and road metal (for example, Owen, 1859, p. 24, 53-54; Owen, 1862, p. 192-221; Collett, 1874, p. 243). Gravel was first used in large amounts as road metal for constructing all-weather roads and pikes, and the industry grew rapidly soon after the organization of county governments, which had the responsibility of building and maintaining road systems. Many of the small abandoned gravel pits throughout Indiana were operated by the counties, which maintained their own pits and processing equipment in order to supply their needs. Today most road material is supplied by private aggregate producers.

Nearly a half billion tons of sand and gravel have been mined in Indiana. Indiana’s 1968 production of 25.8 million tons of sand and gravel valued at 26.2 million dollars ranks 10th among states in total production. Growth of the sand and gravel industry in Indiana has
increased steadily during recent years, and dollar value has closely followed the quantity of materials produced (fig. 11). The growth rate of Indiana’s sand and gravel production fell below the growth rate of the total U.S. sand and gravel production from 1961 to 1966, but it increased above the total U.S. growth rate in 1967 and 1968 (fig. 12). Years of greatest gravel production can be related to periods in the national economy in which new construction was large (fig. 13). Within areas of Indiana that have abundant reserves of sand and gravel, the most active gravel production is in areas that are experiencing population increases (Carr, 1965, p. 8-9).

Because of the predicted growth of the national economy and the increase in population, sand and gravel production in Indiana is expected to continue to increase at least until surface deposits near the consuming centers have been depleted. At that time crushed stone may assume a greater share of the aggregate market. More than a threefold increase in the construction industry by the year 2010 in the Ohio River Basin area has been predicted (U.S. Army, Corps of
SAND AND GRAVEL

Engineers, 1964, p. 10), and this increase should result in a corresponding increase in the demand for aggregate in Indiana.

**Transportation**

The location of a sand and gravel pit with respect to its market is one of the most important economic factors in the success of a gravel plant. The distance gravel must be transported often determines how profitably a plant can be operated. Sand and gravel are heavy, bulky products that must be transported in large volumes; thus the most desirable location for a pit is as near as possible to its principal market area. Sand and gravel deposits are also widespread and relatively abundant in Indiana, which accounts for the low unit price that cannot absorb high transportation costs.

Trucking is a practical means of transporting sand and gravel because trucks move over the highway network to carry large quantities of material directly to wherever the market may be at the time the material is needed. During recent years, trucks have been used

![Figure 14. Comparison of different types of transportation used for sand and gravel in the United States, 1952-68. Data from U.S. Bureau of Mines Yearbooks.](image-url)
Figure 15. Loading barges with gravel near Patriot.

Figure 16. Dredging, processing, and loading barges with gravel on the Ohio River near Evansville.
more widely for transporting aggregate than have railroads and waterways (fig. 14).

Transportation costs make up one-fourth to three-fourths of the selling price of most sand and gravel used for aggregate. Although costs vary in different parts of the state and at different times of the year, they are about 4 cents per ton-mile for trucking distances more than 10 miles. The rates are higher for shorter distances. Most gravel producers in areas of abundant gravel supply find it difficult to transport gravel profitably more than 15 miles.

Water transportation is limited to the only navigable year-around stream, the Ohio River (figs. 15 and 16). Dredging sand and gravel from the river and then barging them to market points are economical means of supplying sand and gravel, for it is reported that these materials can be transported by barge for half a cent or less per ton-mile. Some barging is done on the lower reaches of the Wabash River, but it is not practical because of frequent low-water levels and river obstructions. If the Wabash were navigable, it might be a practical means of transporting good-quality gravels from northern Indiana to the gravel-poor areas of southwestern Indiana.

**Problems and Programs for Future Development**

The genesis and areal distribution of sand and gravel deposits have been problems of interest to the geologist for many years. Recent sedimentary studies of sand and gravel deposits have included different aspects, such as petrography, stratigraphy, geochemistry, internal structures and fabrics, and geometry or form of the bodies. Also, the mechanics of deposition and the environments in which sand and gravel were deposited have received considerable attention. These studies are important in that by knowing how sands and gravels are deposited, we can predict where to look for new deposits.

Techniques of exploring for sand and gravel are essentially those that have been used since the 1930’s. (See McGregor, 1960.) These techniques have generally been adequate, especially because gravel reserves have been abundant and relatively easy to find, but more
Figure 17. Gravel excavation site near Muncie reclaimed for recreation.

Figure 18. Gravel excavation site near Martinsville reclaimed for a housing development.
detailed geologic mapping is needed. When known reserves of high-quality gravel deposits become worked out, new techniques may be needed in order to locate acceptable deposits that can supply the increasing demands. Improved sampling tools and geophysical methods will facilitate the exploration for new gravel deposits. Remote sensing techniques, such as airborne thermal detection of near-surface soil temperatures and data processing of the resulting imagery, may provide an inexpensive and rapid way of exploring for sand and gravel deposits (Carr and Blakely, 1966).

Many very real technical problems that result from different and rigid specifications by agencies that use sand and gravel exist within the sand and gravel industry. In 1969, the Indiana Highway Commission listed 23 grades of fine and coarse aggregate for highway and construction use. Other governmental agencies have about as many specifications. Automatic and semiautomatic processing plants help meet the variety of specifications that are needed, but these processing plants are expensive and not feasible for the small operator. Studies on standardization of aggregate sizes, improved methods for sampling and testing, beneficiation methods to remove deleterious materials, and chemical and physical properties of concrete aggregate will pay dividends to the sand and gravel industry in the future.

The rapid expansion of our metropolitan areas poses many problems for the sand and gravel producer because of the concurrent growth of suburban areas. Gravel pits that were once in farmland are now surrounded by growing residential areas. Suburbanites object to the noise, heavy trucks, traffic, air pollution, stream pollution, and ugliness of the gravel pit. Some gravel producers have been unable to expand to utilize nearby reserves and thus have been forced to curtail or shut down their operations and to look elsewhere for new deposits of sand and gravel.

Zoning can aid in the continuing production of sand and gravel near enough to a community to keep transportation costs low. For this to be accomplished, however, high-quality deposits must be outlined and preserved as mineral districts where gravel can be mined.
Figure 19. Cedar Lake near Richmond. Gravel excavation site reclaimed for waterfront homesites, recreation, and conservation. Photograph courtesy American Aggregates Corp.

Figure 20. Capitol Lake, Indianapolis, home of the Capitol City Conservation Club. Gravel excavation site reclaimed for recreation and conservation. Photograph courtesy American Aggregates Corp.
The gravel producer can study his local zoning ordinance to help predict what areas will have the greatest economic growth and where construction materials will be needed. By using zoning most advantageously in this way and by working actively with local plan commissions, the sand and gravel producer can plan the proper location for his plant for optimum growth.

Reclamation of the pit after the sand and gravel have been exhausted is proving to be a benefit both to the community and to the gravel producer. A properly reclaimed gravel pit affords an ideal recreation, housing, or industrial development area for a community (figs. 17, 18, 19, and 20). In some places, the gravel producer has found the reclaimed land more valuable than the gravel that was produced from it. When a gravel producer informs a community of his reclamation plans, antagonism toward opening a new pit is generally less because the neighbors are assured that the worked-out deposit will not be left as an eyesore or dangerous nuisance but that it will become an asset to the community (Bauer, 1965; Carnes, 1966; Schellie and Rogier, 1963).

Selected Bibliography

Ahem, V. P.

American Association of State Highway Officials

American Society for Testing and Materials

Bauer, A. M.
Bauer, A. M.
6. 1966 - How to make more than holes in the ground: Landscape Architecture, v. 56, p. 115-119.

Belcher, D. J.

Bieber, C. L.

Blatchley, W. S., and others

Bloem, D. L.

Bushnell, T. M.

Carnes, W. G.

Carr, D. D.

Carr, D. D., and Blakely, R. F.
Carr, D. D., and Webb, W. M.

Collett, John

Conrades, O. S.

Cressey, G. B.

Deiss, C. F.
21. 1952 - Geologic formations on which and with which Indiana’s roads are built: Indiana Geol. Survey Circ. 1, 17 p.

Fidlar, M. M.

Flint, R. F.

Flint, R. F., and others

French, R. R., and Carr, D. D.

Gallaher, J. T.

Gray, H. H., Wayne, W. J., and Wier, C. E.
27. 1970 - Geologic map of the 1º X 2º Vincennes Quadrangle and parts of adjoining quadrangles, Indiana and Illinois, showing bedrock and unconsolidated deposits: Indiana Geol. Survey Regional Geol. Map 3.
Harrison, Wyman

Indiana State Board of Health

Johnson, C. W.

Johnson, G. H., and Keller, S. J.
31. - Geologic map of the 1° X 2° Fort Wayne Quadrangle, Indiana, Michigan, and Ohio: Indiana Geol. Survey Regional Geol. Map-[in preparation].

Key, W. W.

Lenhart, W. B.

Leverett, Frank, and Taylor, F. B.

Lewis, D. W.
35. 1952 - Heavy liquid media for separating aggregates with different durability characteristics: Purdue Univ. Eng. Bull. 78, p. 52-65.

Lewis, D. W., and Venters, Eduards

Logan, W. N.
McCammon, R. B.


McGraw-Hill Book Co., Inc.
42. 1893-1942 - Mineral industry, its statistics, technology, and trade, 1892-1941: New York, [annual publication].

McGregor, D. J.

Malott, C. A.

Mintzer, O. W., and Frost, R. E.

Moore, R. W.

Owen, D. D.
47. 1859 - Continuation of report of a geological reconnaissance of the State of Indiana, made in the year 1838, in conformity to an order of the legislature: Indianapolis, Ind., John C. Walker, 69 p.

Owen, Richard
Patton, J. B.

Pit and Quarry Publications, Inc.
50. - Handbook: Chicago, [annual publication].

Protzeller, H. W.

Ray, L. L.

Schellie, K. L., and Rogier, D. A.

Schneider, A. F., and Gray, H. H.

Schneider, A. F., and Keller, S. J.

Shaler, N. S.

Smith, Rockwell

Stanley, W. E., and others

State Highway Commission of Indiana

Straw, W. T.
Sweet, H. S., and Woods, K. B.


Swenson, E. G., and Chaly, V.


Thoenen, J. R.


Thornbury, W. D.


Thornbury, W. D., and Deane, H. L.


Treadway, K. R.


Truesdell, P. E., and Vames, D. J.


U.S. Army, Corps of Engineers


U.S. Bureau of Census

73. - Statistical abstracts: Washington, D.C.

U.S. Bureau of Mines

74. - Minerals yearbooks: Washington, D.C.
U.S. Department of Agriculture
76. - [Soil surveys of Indiana counties].

U.S. Department of Commerce

U.S. Department of Defense

Veatch, A. C.

Walker, E. H.

Walker, Stanton, and Bloem, D. L.

Wayne, W. J.
82. 1956 -Thickness of drift and bedrock physiography of Indiana north of the Wisconsin glacial boundary: Indiana Geol. Survey Rept. Prog. 7, 70 p.

Wayne, W. J., Johnson, G. H., and Keller, S. J.
85. 1966 - Geologic map of the 1º X 2º Danville Quadrangle, Indiana and Illinois, showing bedrock and unconsolidated deposits: Indiana Geol. Survey Regional Geol. Map 2.

Wayne, W. J., and Thombury, W. D.

Webb, W. M.
Wier, C. E., and Gray, H. H.

1961 - Geologic map of the Indianapolis 1” X 2° Quadrangle, Indiana and Illinois, showing bedrock and unconsoldated deposits: Indiana Geol. Survey Regional Geol. Map.

**Subject Index of Selected Bibliography**

Detailed information on various aspects of Indiana sand and gravel resources is plentiful but is scattered through a vast literature. To assist the reader in locating available information, a subject index of selected bibliography is given below.

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