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Sand, Gravel, and Crushed Stone: Their Production and Use in Kansas

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Introduction

The average American uses more than a million pounds of cement, sand, gravel, and crushed stone over the course of a lifetime. These geologic materials are used throughout society, from concrete in buildings to crushed stone for roads. Much of the demand for these materials comes from areas of growing population where new construction and road building are most common. Because sand, gravel, and other geologic commodities come from the earth, their production often raises a conflict between people's desire for an undisturbed landscape and the demand for these resources.

Mines and quarries that produce sand, gravel, and crushed stone are extremely common in Kansas. However, most people know very little about such operations. To help provide information about these resources, this circular discusses sand, gravel, crushed stone, and lightweight aggregate, a man-made material manufactured from shale. This publication describes the type and amount of these materials used in Kansas; their source, processing, and usage; and environmental issues related to their production.

These materials — sand, gravel, crushed stone, and lightweight aggregate — are known collectively as aggregate. By definition, aggregate is a construction material that is hard and inert (that is, it does not react chemically with materials around it). It is used to make concrete, mortar, asphalt, or similar products. Buildings nearly always include concrete, concrete block, and mortar. Most roads are constructed from concrete or asphalt that contain sand and crushed stone. Alone, aggregate is used as the support for railroad beds, road covering, or fill; large quantities of sand and gravel and crushed stone are used on unpaved county roads throughout the state.

Limestone, dolomite, and sandstone — the rocks used to make crushed stone — occur naturally, as do sand and gravel. Lightweight aggregate is manufactured from shale, a soft rock composed mostly of clay minerals that occurs naturally. Sand, gravel, and crushed stone require little processing compared to many commodities, but vast quantities are used in construction. Thus, they are high volume/low-unit-cost commodities. That is, sand, gravel, and crushed stone are sold in large quantities at a low cost per ton. Over two billion tons of sand, gravel, crushed stone, and lightweight aggregate were used or sold in the U.S. during 1994. In Kansas, nearly 23.6 million tons of crushed stone and 12.3 million tons of sand and gravel, worth over $130 million, were produced in 1994; that's an average of about 14 tons of aggregate per person in the state.

Crushed Stone

Crushed stone is used throughout Kansas, but most of it is quarried from limestone in the eastern third of the state. Smaller amounts are also produced from dolomite (a rock that looks similar to limestone) and sandstone in central Kansas and from relatively soft limestones in northwestern and north-central Kansas. In addition, some crushed stone is produced in northwestern Kansas where the Ogallala Formation is naturally cemented together. In general, Kansas counties with larger annual production of crushed stone are found around the state's larger cities, especially in the highly developed corridor from Topeka to Kansas City and in an area east of Wichita (fig. 1).

Crushed stone is produced by blasting rock from quarry or mine walls and then crushing and screening the rock to the desired sizes for different applications. Many producers collect the extremely fine, dust-like material remaining from the crushing operation and sell it to farmers for agricultural lime, which helps reduce the acidity of their soil.

Crushed limestone, crushed clay or shale, and other ingredients are mixed together and baked in kilns to produce a coarse material that is ground, then bagged for sale as cement (fig. 2).

Gypsum is often added to cement as a retarding agent to keep it from setting too rapidly. About 1.8 million tons of cement, valued at more than $100 million, were produced in Kansas in 1994. Water, crushed stone, sand, and gravel are added to the cement to make concrete. To make mortar

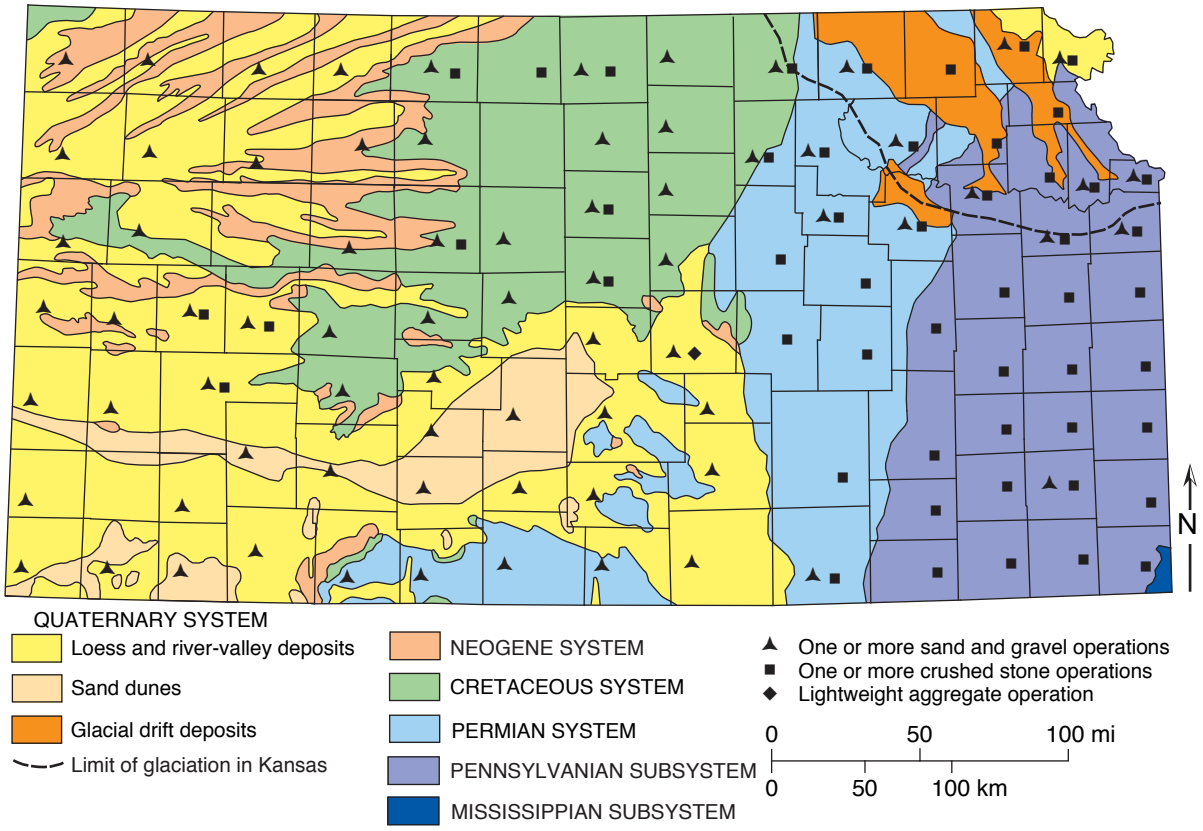

Figure 1. Surface geology of Kansas, showing counties producing aggregate.

(the material that is used to cement bricks or concrete blocks together), finer grains of sand are used instead of gravel in the mixture, producing a smoother finish.

Over time, the state has used more and more crushed stone, although the amount varies depending on economic and construction activity. Based on annual production reported to the U.S. Bureau of Mines and census figures, consumption of crushed stone in Kansas has risen from about 800 pounds per person in 1920 to about 18,500 pounds in 1994, more than a tenfold increase. At the same time, the state's population has grown, so that total production has jumped from about 700,000 tons in 1920 to 23.6 million tons in 1994.

Lightweight Aggregate or Expanded Shale

Lightweight aggregate is manufactured from certain types of shale. After mining and crushing, the shale is fed into a kiln where it is heated to temperatures that cause it to swell. Although best known to the average Kansan as the lightweight, red to brown, volcanic-looking rock that is often used for landscaping, its main use is as an aggregate in lightweight concrete, such as in the terminal buildings at the Kansas City International Airport in Missouri, and in lightweight concrete blocks. The only active plant is located near Marquette in McPherson County.

Sand and Gravel

Sand and gravel are formed by the weathering of rocks. Most of the sand in Kansas river systems, such as the Kansas or the Arkansas, comes from rocks that have been washed out of the Rocky Mountains to the west. These rocks are weathered (broken, ground up, and rounded) as they are carried along by the rivers, producing sand and gravel. Kansas rocks also contribute to sand deposits in some locations. For example, chert (or flint) from rocks in the Flint Hills weathers and forms sand that is carried into the Neosho River, which drains part of the Flint Hills.

Much of the sand and gravel production in western Kansas comes from small, dry pits where front-end loaders are used to fill trucks (fig. 3). Other operations, particularly in central and eastern Kansas, produce large amounts of sand and gravel by dredging the channel or neighboring floodplains of the larger rivers, especially the Kansas and Arkansas.

River dredges operate by suctioning sand from the river bed and moving it to a plant on the river bank for washing and sorting. River dredging is a relatively inexpensive method of producing sand because it does not require the removal of overlying rock and soil, called overburden. River dredging is also considered, by some, to be self-healing, because the space left by sand removal is gradually

filled by sand from upstream or sediments that settle out when the river is moving slowly, a process called recharge. This material may be dredged later.

Other dredges operate on the floodplain — the land space neighboring the river that is inundated during flooding — which may contain considerable deposits of sand and gravel. In floodplain dredging, a pit is dug in land on the floodplain. Groundwater fills the pit, and a dredge is floated on the water, again removing sand from the bottom for processing. Sand produced by a floodplain dredge may cost about 50% more than sand produced by river dredging because floodplain dredging has greater start-up costs. Land must be purchased or leased, and a large, shallow, sloped pit must be excavated to the water table before putting the dredge in place. Also, floodplain dredging usually requires the removal of up to 20 feet of overburden, adding to production expenses. Pits have a limited lifetime because the deposit usually changes to a less sand-rich body or the sand becomes too fine. Pits are not refilled with new material, as are river bottoms, and they require reclamation when mining is complete.

Nearly all Kansas counties have at least one sand and gravel operation (see fig. 1). As with crushed stone, most sand is produced in counties with large populations, where both the source and the demand are located. Between 1984 and 1994, for example, the population of the 12 counties along the Kansas River grew by over 125,000. This growth increased the demand for aggregates, particularly sand and gravel, for use in building roads, schools, homes, and other buildings.

Across the state, use of sand and gravel has increased dramatically, from about 1,200 pounds per person in 1920 to 9,200 pounds in 1990.

Figure 2. Cement plant in Allen County.

Figure 3. Small gravel pit in geologically recent materials near Sand Canyon in Cheyenne County.

Total statewide production grew from about 1,000 tons to about 11.5 million tons today. Production may have dropped slightly since the 1980s, in part because the U.S. Army Corps of Engineers gradually implemented limits on Kansas River dredge operations during 1991–94. These restrictions limited the removal of sand to the amount that was recharged. This is to stabilize the elevation of the riverbed to prevent the exposure of features such as pipelines.

Regulatory and Environmental Issues

Until recently, individual counties regulated sand and gravel, crushed stone, and lightweight aggregate

operations in Kansas. In 1994, the State Conservation Commission was charged with such responsibilities, providing a uniform set of rules for all non-fuel mining in Kansas, including reclamation. The exception is river dredging, where the U.S. Army Corps of Engineers remains responsible for permitting and production limits.

Most sand, gravel, and crushed stone operations in Kansas do not create significant safety, health, and environmental problems. Improvements in blasting technology now allow smaller charges at stone quarries, eliminating potential damage to nearby structures. Federal Mine Safety and Health and Occupational Safety and Health agencies monitor all mining operations in Kansas. Environmental impact statements are required for all proposed operations. Probably the biggest objections to such mining are concerns about traffic, noise, and dust when an operation is located near residential areas. Because the demand for these resources is often near highly populated areas, the potential for conflict over these issues is great. To deal with these concerns, planners and managers can restrict mining to less populated areas, though that increases the distance from mining operations to the market. Those costs now amount to about $0.10 per ton per mile.

Recently, the environmental consequences of dredging on the Kansas River have become a contentious issue. Environmental organizations and individuals have raised issues related to damage that dredging may cause to the river, such as bank erosion, lessened water quality, and the effect on wildlife. They have also expressed concern about the impact of dredging sites on canoeists and other recreationists and raised issues related to safety, traffic, and noise. Interest in the Kansas River is especially high because it is one of a handful of rivers in the state that are open to the public for recreation.

The consequences of dredging depend, in part, on the nature of the river. Muddy river beds contain large amounts of clay that can absorb chemicals — such as herbicides, pesticides, and fertilizer — that run off into the river, and the agitation associated with dredging might release those chemicals into the river. Because the Kansas River bed is predominantly sand, the chemicals are not absorbed and dredging does not have a significant impact on water quality. Also, because of the lack of clay, very little material collected by dredging, perhaps as little as one percent, is returned to the river, minimizing the amount of turbidity caused by dredging.

State agencies in Kansas are currently studying the recreational potential of the Kansas River and will undoubtedly consider the role of dredging and other issues. It is important to remember that people in the Topeka–Kansas City corridor use more than two million tons of sand and gravel each year. Decisions about the river and mining operations have both economic and environmental consequences. Limiting the amount of sand dredging in the river, for example, may create environmental conditions that society desires. But such measures have an economic cost. Society must decide if those are costs that it is willing to pay.

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The Kansas Geological Survey (KGS) is a research and service division of the University of Kansas that investigates and provides information about the state's natural resources. KGS scientists pursue research related to surface and subsurface geology, energy resources, groundwater, and environmental hazards. They develop innovative tools and techniques, monitor earthquakes and groundwater levels, investigate water-quality concerns, and map the state's surface geology.

The KGS has no regulatory authority and does not take positions on natural resource issues. The main headquarters of the KGS is in Lawrence in the West District of the University of Kansas, and the Kansas Geologic Sample Repository of the KGS is in Wichita.

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