Industrial Minerals-Mines, Quarries,
and General Resources in Kansas
2008

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Kansas Geological Survey
Open-File Report 2016-24

ABSTRACT

Industrial mineral production in Kansas based on tonnage mainly involves those commodities that are important to the construction industry. Among those commodities with large tonnage are sand and gravel and stone—both crushed and dimension, mainly limestone but also with a limited amount of sandstone. Sand and gravel are obtained primarily from pits in western Kansas and from pits and dredging in rivers and floodplains in the central and eastern part of the state. Crushed stone for aggregates and for use in cement production is mainly from limestone units of Pennsylvanian age in eastern Kansas, and the dimension stone is now cut from Lower Permian limestone units. Outstanding buildings in the past were also constructed from limestone rocks from Middle and Upper Pennsylvanian and Upper Cretaceous limestone units. Clay and shale from Pennsylvanian and Cretaceous units are used for manufacture of structural clay products, brick, and lightweight aggregate and in Portland and masonry cement manufacture.

Salt is a major industrial mineral important to the state. It is produced from the thick Hutchinson Salt Member in the Lower Permian Wellington Formation that is present in the subsurface in a large part of central Kansas. The salt is mined by room-and-pillar methods at three locations, and salt is also produced by solution mining from four different brine fields. Gypsum is mined at two locations—in both north and south areas of the state—from Lower Permian rocks.

Volcanic ash of Pliocene and Pleistocene age is widespread in the western and central parts of the state and is processed into specialized products at two locations in north-central Kansas. Two derivative products from the processing of petroleum and natural gas are sulfur and helium. Sulfur is obtained from the refining of crude petroleum, while crude and refined helium are separated from natural gas produced primarily from the huge Hugoton and associated Panoma gas fields of southwest Kansas.

INTRODUCTION

Industrial minerals in Kansas continue to be an important part of the state economic development, providing the basic materials for construction and structural products and raw materials for the chemical industry. Widespread across Kansas, deposits of sand and gravel, limestone, and limited amounts of useable sandstone provide basic materials for the construction industry. Stone products (especially limestone) for crushed stone and building or dimension stone are the largest tonnage of industrial minerals produced in the state. The important deposits of crushed stone are present mainly in the eastern part of the state. In the southwest part of Kansas are the important deposits of the inert helium gas associated with the huge natural gas deposits of the Hugoton and underlying Panoma gas fields.

Large deposits of sand and gravel are obtained from the Tertiary Ogallala Formation present at or near the surface in the high plains of western Kansas, while large volumes of sand and gravel are extracted from the floodplains and channels of Kansas rivers. Large areas of salt and gypsum exist in the central part of the state, although mines producing these commodities are limited.

Important publications on the different industrial mineral deposits of Kansas are summarized by Schoewe (1958), Hardy (1970), Hambleton and others (1962, p. 70–148) and Grisafe (1999a). Key papers emphasizing the certain industrial mineral commodities are listed under the specific commodity.

This paper provides an overview of the various Kansas industrial minerals summarized in the Annual Mineral Industry surveys for Kansas published by the U.S. Geological Survey since 1997 and by the U.S. Bureau of Mines prior to that year. The most recent summary of the non-fuel Kansas mineral industry is for 2004 (U.S. Geological Survey, 2005). A summary of the quantity and estimated value of the Kansas non-fuel raw mineral production, summarized as industrial minerals, is shown in Table 1. The total estimated value of these summarized commodities for Kansas in 2004 is $754 million.

A general overview of the areal geology of Kansas is shown in Figure 1, and a geologic timescale for Kansas listing industrial minerals present within the rocks of various geologic periods is summarized in Figure 2. Pennsylvanian, Permian, and Cretaceous rocks contain the important rock units for Kansas industrial mineral production, while Recent, Pleistocene, and upper Tertiary rock units are also important geologic units for industrial minerals.

Distribution of industrial minerals in Kansas is available as a map prepared by Grisafe (1999b), and a directory listing of active and abandoned mines and quarries for various industrial mineral products by commodity, county, and township-range location within the state, compiled by Grisafe (1998), is available on the Kansas Geological Survey website at http://www.kgs.ku.edu/Magellan/Minerals/index.html.

Formal Kansas stratigraphic units discussed throughout this paper are discussed in The Stratigraphic Succession in Kansas, edited by Zeller (1968). Informal stratigraphic terms are shown in quotation marks.

CONSTRUCTION MATERIALS

A review of Table 1 shows the importance of construction materials and products including crushed and dimension stone, sand and gravel, gypsum, and industrial products of cement (portland and masonry) and clay for bricks, structural clay products, and lightweight aggregate. These commodities make up more than 50% of the value and 90% of the tonnage of all industrials minerals produced in Kansas.

Crushed Stone

Limestone is the dominant stone used for crushed stone products in Kansas with most of the limestone obtained from limestone units of Middle and Lower Pennsylvanian rocks. These limestone units are interbedded with shale units, and the thicker limestone units are often used for surface quarries where only limited thicknesses of overburden materials need to be removed. With thick limestone units near larger populated areas, stone is often produced by shallow underground room-and-pillar mining methods, especially in the greater Kansas City area. Space resulting from these underground mines is commonly planned ahead of mining for use as storage and sometimes office areas.

Important limestone units of Pennsylvanian age commonly used for crushed stone are listed in Table 2. The limestone obtained from quarries and mines from Middle and Upper Pennsylvanian rock is used primarily for concrete aggregate, road metal, riprap, and agriculture lime. In addition, a large amount of Upper Pennsylvanian limestone is used in cement manufacture at four cement manufacturing plants in eastern Kansas. Some sandstone units are used as a source of silica in the cement manufacturing process.

Limestone units of Lower Permian rocks are also used for crushed stone in areas of the state where these units are present at or near the surface. Although the crushed rock tends to be softer stone than most Pennsylvanian rock, the Permian limestone units are widely used in the central part of the state except for those stone units with a large amount of chert present.

A lesser amount of crushed stone is obtained from limestone and sandstone of Cretaceous age. An important deposit of calcite-cemented sandstone is available from the Dakota Formation present in Lincoln County in central Kansas. This stone, often referred to as "Lincoln quartzite," can be used for high-quality concrete aggregate and represents the main stone for that purpose in the central and western part of the state.

Limestone obtained from Upper Cretaceous rocks available in many areas of western Kansas is crushed and used mainly for road metal. A much softer stone than Pennsylvanian and Permian limestone units, the crushed limestone is often obtained from the Fort Hays Limestone and Smoky Hills Chalk members of the Niobrara Chalk Formation. Crushed stone is also obtained from some of the other Upper Cretaceous chalk units. Most of the quarries in these chalk units are operated by the road departments of the counties where the rock is present.

Another source of crushed rock in western Kansas is derived from the caliche zones developed in the Tertiary Ogallala Formation. These calcareous zones formed from leaching of carbonates in the Ogallala are often referred to as "mortar beds." This material is crushed and generally used as road metal. Figure 3 shows the general distribution of active stone quarries and mines in Kansas.

Building Stone

Limestone is the dominant stone quarried for building or dimension stone in Kansas, with most of the stone used by commercial stone companies obtained from quarries in Lower Permian rocks. Some Upper Pennsylvanian rocks are quarried for building stone use, and commercial building stone quarries in Upper Cretaceous limestone units, very important in the past, are now only worked on an as-needed basis. Existing building stone quarries are shown in Figure 4, and plant locations for processing the stone are shown in Figure 5.

Among the Lower Permian limestone units, extensive use continues to be made of certain ledges of the Fort Riley Limestone Member of the Barneston Limestone Formation in Cowley County, the Cottonwood Limestone Member of the Beattie Limestone Formation in Chase County, and the Funston Limestone Formation in Pottawatomie County. The Fort Riley Limestone mined in Cowley County often carries the trade name of "Silverdale limestone" for the town near where it is quarried, and the trade name of the Funston Limestone where quarried is the "Onaga limestone."

The Cottonwood Limestone was used for the building stone for two of the best known buildings in the state: the Chase County Courthouse in Strong City, built in 1872, and most of the Kansas State capitol building in Topeka. According to Grisafe (1983, p. 106) the east wing of the capitol was built in 1867 from Fort Riley Limestone from the Junction City area, while the remaining wings, rotunda, and dome were constructed mainly from Cottonwood Limestone. Most work was completed by 1890.

A popular building stone in Upper Pennsylvanian rocks is the Fivepoint Limestone Member of the Janesville Shale. This stone is often referred to as a Lower Permian limestone (Grisafe, 1976, p. 10; 1983, p. 97, 99) but due to changes in Kansas stratigraphic nomenclature

(Sawin and others, 2006) regarding placement of the Pennsylvanian-Permian boundary, the limestone unit is now considered to be an Upper Pennsylvanian limestone.

Limestone quarried from various Middle and Upper Pennsylvanian limestone units has been used for years. Several of these earlier stone structures are pictured and discussed in Risser (1960), including buildings located at the University of Kansas in Lawrence.

The one active commercial quarry for Kansas building sandstone produces from the Bandera Quarry Sandstone Member of the Bandera Shale Formation within Middle Pennsylvanian rocks. This quarry is located in central Bourbon County in southeast Kansas.

Two popular Upper Cretaceous limestone units used for building stone include the thin limestone bed at the top of the Greenhorn Limestone Formation referred to as the "Fence-post limestone bed" (in the Pfeifer Shale Member) and the Fort Hays Limestone Member of the Niobrara Chalk Formation. The "Fence-post limestone bed" is widely used in north-central Kansas for its namesake stone fence posts for dividing up the nearly treeless prairie. Where quarried, the stone bed is generally 8 to 12 inches thick and lacks joints common to most limestone units (Muilenburg and Swineford, 1975, p. 98–99). The posts were obtained by hand drilling and splitting the relatively soft limestone when it was uncovered. The limestone quickly hardens with exposure. This thin limestone bed was extensively used for building stone in the area where it crops out. Best known of the buildings constructed mainly from the Fence-post limestone bed is the large St. Fidelis Church at Victoria, more commonly known as the "Cathedral of the Plains." This church built, by Volga German immigrants, was completed in 1911. Information from a brochure available in Victoria described the church at the time of its building as being the largest church west of the Mississippi River (Muilenburg and Swineford, 1975, p. 147).

The Fort Hays Limestone was also used extensively for building stone in its area of occurrence in west-central Kansas, west of the Greenhorn Limestone.

Grisafe (1983, p. 96) describes the limestone of this unit as a relatively soft stone that could be easily worked. However, it is best used in an arid area because the stone is susceptible to deterioration from moisture. Many of the university buildings at Fort Hays State University are constructed of this limestone.

Publications dealing with Kansas building stone, both past and present, include the work of Schoewe (1958, p. 443–457), Risser (1960), and Grisafe (1976, 1983, and 1999a). Discussion of physical tests on some of the Kansas building stones is also covered in the Grisafe (1976 and 1983) publications and in Aber and Grisafe (1982). Muilenburg and Swineford (1985) provide information specifically concerning the history and geology of the Fence-post limestone bed and its use as a building stone.

Sand and Gravel

Sand and gravel has widespread distribution in Kansas, with production of the material from Kansas River deposits of Recent and Pleistocene age and from dry pits located in the High Plains area. Production of sand and gravel was reported by Grisafe (1999a) from 77 of the 105 counties of Kansas, and this number varies each year as new pits are opened and older ones are closed, especially in western Kansas. General distribution of the sand and gravel pits is shown in Figure 6.

The 2004 estimate of sand and gravel used for construction purposes is 9.93 million metric tons (10.95 million short tons) with an estimated value by the U.S. Geological Survey of $32.8 million (Table 1). Most of the Kansas production is associated with dredging operations on the major rivers and their associated floodplains. The Arkansas River and the Kansas River are the main locations of these dredging operations, but some Neosho River gravel is dredged from that river and its floodplain in Neosho County in southeast Kansas.

Front-end loaders and other heavy equipment are generally used to obtain sand and gravel from open-pit operations from the widespread Ogallala Formation (Pliocene and Oligocene age) in the western part of the state. Most of these pit operations are by county road departments, and the sand and gravel are used as road metal in maintaining the county roads.

Increased restrictions by the U.S. Corps of Engineers on river dredging, especially on the Kansas River below Topeka, has limited production of this high quality sand in an area of the major population growth in the state and its highest construction need. The Kansas Geological Survey published a major summary report on the Kansas River corridor (Brady and others, 1998), with a later summary of the geological setting and the industrial mineral portion of the Kansas River corridor presented at the Forum on Geology of Industrial Minerals by Grisafe and McCauley (1999). Sand is also obtained from the Kansas River in the greater Kansas City area for use in manufacturing fiberglass and for sand-blasting purposes (Grisafe, 1998, p. 23).

Gypsum

Deposits of gypsum are widespread in a general north-south direction across the central part of Kansas (Fig. 7). Gypsum production now takes place in two locations: one mining and production operation in Marshall County in the northeastern Kansas and a second in Barber County in the south-central part of the state. Numerous abandoned gypsum mining locations are present across the area of gypsum occurrence and are described by Kulstad and others, 1956.

Both active gypsum mining locations are in Lower Permian rocks but in two distinctly different geologic settings. In Barber County, one company mines the gypsum by both surface and shallow underground methods from the Medicine Lodge Gypsum Member of the Blaine Formation that is part of the red bed shale-gypsum rock units of that area. The underground gypsum mining provides a higher grade of gypsum that is processed into high-grade plasters, while the surface-mined gypsum is processed mainly into plasterboard products. Thickness of the gypsum ranges up to 30 ft.

Gypsum mined in Marshall County is won from a local gypsum bed in the Easly Creek Shale Formation, which is one unit in a sequence of limestone and shale units present in a much lower stratigraphic position than the Blaine Formation but still in Lower Permian rocks. Shallow underground mining methods are used to obtain the gypsum in this area, with thickness of the mined gypsum bed at 8–9 ft. Both mines have associated processing plants nearby that produce calcined gypsum, which is used to manufacture wallboard and a variety of plasters. An extensive summary of gypsum in Kansas is included in Kulstad and others (1956).

Cement

Cement in Kansas is presently produced at four different plant locations (Fig. 5), all in southeast Kansas. Total tonnage of Portland cement from Kansas plants in 2004 is estimated at 2.69 million metric tons (2.96 million short tons) with an estimated value of $212 million by the U.S. Geological Survey as shown in Table 1. A short history of cement production in Kansas is covered in Schoewe (1958, p. 425–428). Depending on the plant location, all four plants use limestone as their main ingredient from several Upper Pennsylvanian limestone formations.

Clay and Shale Products

Among the clay products produced from Kansas clay and shale are bricks, lightweight aggregate, and structural clay tile and other formed clay products. Four brick plants operate in Kansas (Fig. 5). Three of the plants—in Cloud, Ellsworth, and Barton counties in the north-central part of the state—use clay from the Dakota Formation (Cretaceous age). About one-third of the bricks made from Dakota clays fire as white to buff colored brick, while two-thirds of the brick are dark buff to red-firing clays (Hardy, 1970, p.7). The fourth brick plant and a clay tile plant are present in Cherokee and Crawford counties in southeast Kansas. These two plants use clay and shale from the Cherokee Group, a thick unit within Middle Pennsylvanian rocks. Further information on ceramic properties of Dakota Formation clays is discussed in Plummer and Romary (1947) and Plummer and others (1960).

Lightweight aggregate or expanded shale is presently produced in one plant located in northern McPherson County in the central part of the state (Fig. 5). The shale used for this product is from the Kiowa Formation (Lower Cretaceous) and is fired in a rotary kiln to expand the shale to form an aggregate for use in concrete that results in a lightweight concrete for use in specialized construction, especially high buildings for weight reduction. Research leading to Kansas clays and shale for lightweight aggregate is discussed in Plummer and Hladik (1951).

OTHER INDUSTRIAL MINERALS AND PRODUCTS

Included in this section is salt, a major commodity, and some lesser known industrial minerals in Kansas presently under production or with potential for future production or additional areas of interest. Besides salt, industrial minerals included in this section are lamproite, volcanic ash, and diatomaceous marl.

Salt

Kansas is an important salt-producing state with thick salt beds present in the central and western part of the state (Fig. 8). Three distinct salt units present in the state are all of Early Permian age. These salt deposits are, from oldest to youngest, the Hutchison Salt Member of the Wellington Formation; a thick salt deposit commonly known as the "Cimarron salt" in southwest Kansas in the Ninnescah Shale Formation (Walters, 1978, p. 12); and a complex redbed-evaporite sequence in the Nippewalla Group in western Kansas that involves part of the Blaine Formation and the Flower-pot Shale Formation (Holdoway, 1978). General distributions of the three salt deposits are shown in Figure 8. Further geologic information on the two unmined salt deposits in Kansas can be found in Holdoway (1978) and Bayne (1972).

The Hutchison Salt has a maximum thickness exceeding 500 feet (Watney and others, 1988, p. 125, 127). Where mined at Hutchinson (Reno County), the depth to the salt mine is 645 feet, while the deepest salt mine at 1,045 feet deep is located at Lyons (Rice County). Besides the salt mines, three salt companies presently have solution mine fields, three in Reno and one in Rice county.

These solution mines use a substantial amount of the produced salt brine that is processed in evaporation plants to obtain high purity salt used for food processing, table salt, animal feeds, and water softening salt (Sawin and Buchanan, 2002). Another company mines salt by solution mining methods in Sedgwick County for use in chlorine chemical manufacturing (Figs. 5 and 8).

The amount of salt produced in Kansas in 2004 was determined by the U.S. Geological Survey (2005) to be 2.89 million metric tons (3.19 million short tons) with an estimated value of $127 million (Table 1). Part of the space remaining from mechanical mining of salt at the mine in Hutchinson (Reno County) was been developed for high security underground storage of sensitive records, i.e. banking archives, movie film archives, and other materials that require constant temperature and humidity (Sawin and Buchanan, 2002, p. 4). In 2007, the Kansas Underground Salt Museum opened to the public in part of the old salt mine workings at Hutchinson.

In areas of the Hutchinson Salt, there is both natural and man-induced subsidence at the surface due to dissolution problems with the salt bed. These areas of subsidence involve poorly developed oil wells that penetrated the salt layers, where fresh water was allowed to come in contact with the salt bed over time, and large openings developed by solution mining for salt brine or for hydrocarbon storage that were allowed to get too large in diameter and resulted in roof subsidence or collapse. Walters (1978) discusses many of these types of problems as he addresses existing and potential problems in central and western Kansas.

Lamproite

The presence of lamproite, a dark-colored hypabyssal or extrusive rock rich in potassium and magnesium, is known in Kansas only from southern Woodson County and northern Wilson County in southeast Kansas (Fig. 4). General discussion of the lamproite and its presence at the surface and shallow subsurface is discussed by Berendsen (1997, p. 9–18) and Berendsen and Blair (1988, p. 2–8). Cullers and others (1985) discuss the chemistry and petrogenesis of lamproite.

The sedimentary rocks (altered by contact metamorphism) that were intruded by the lamproite are Late Pennsylvanian in age, but the intrusive body is considered to be of Late Cretaceous age based on radiometric dating.

Berendsen (1997, p. 9) discusses the early mining history of the lamproite body and also the present mining operations by Micro-Lite LLC, which uses the weathered igneous body primarily for use as a feed additive for cattle. Berendsen further discusses in the 1997 article that the company mined 70,000 tons of the weathered lamproite in 1996. Due to the high phlogopite content (up to 25%), the company is now looking at possible industrial uses for some of the material.

Volcanic Ash

Volcanic ash derived from multiple volcanic eruptions in the western U.S. during Pleistocene and possibly Pliocene time resulted in numerous volcanic ash deposits. Research by Boellstorff (1976) resulted in multiple age dates for different volcanic ash deposits in Kansas and other areas of the Midwest. Carey and others (1952) described numerous deposits of volcanic ash in central and western Kansas, and the general distribution of the volcanic ash deposits is shown in

Figure 9. All of the ash deposits show distinct bedding, indicating reworking and deposition by water into small lakes or ponds, with the ash being generally unconsolidated although some deposits have calcite cementation (Carey and others, 1952, p. 5–18).

The ash can be bloated (expanded) by passing the ash through a flame at high temperature, resulting in a bloated ash product with a bulk density of 66 pounds per cubic foot (Bauleke, 1962). The bloated ash is used for filter applications and for specialized cement, and screened raw ash is used for abrasive products. Two small operations use the volcanic ash—one each in Norton County and Jewell County in north-central Kansas. The ash worked at these two sites is Pleistocene in age.

Diatomaceous Marl

Deposits of diatomaceous marl in Kansas consist of about 20% silica and 80% calcium carbonate, grayish white in color, with the silica consisting of diatoms (Shoewe, 1958, p. 432). The diatomaceous marl is primarily found in Wallace County but also can be found in parts of Logan and Sherman Counties in the northwest part of Kansas (Fig. 9).The deposit has a maximum thickness of 11 ft, is horizontally bedded and was deposited as part of the Ogallala Formation of Tertiary age. Mining of the diatomaceous marl started in 1949, but was discontinued in the late 1960s. Diatomaceous marl was used for mineral filler, but potential uses include as paint filler and as a mild abrasive (Hardy, 1970).

INDUSTRIAL PRODUCTS FROM NATURAL GAS AND PETROLEUM

The petroleum industry is very important to the Kansas economy. In 2007, Kansas produced 36.6 million bbl of petroleum and 370 million mcf of natural gas. Two non-fuel products from these two fuels are sulfur removed from the refining of petroleum and helium extracted from natural gas by liquefaction and purification.

Refined helium is one of the important commodities in Kansas recognized by the U.S. Geological Survey (2005). It is listed in Table 1 and discussed in a separate section of this report. Recovered sulfur from the refining of petroleum is not included in the summary by the 2004 U.S. Geological Survey Mineral Yearbook chapter for Kansas. However, it is mentioned in the 2004 U.S. Geological Survey Mineral Yearbook chapter on sulfur by Ober (2005, Table 2, p. 74.9), but the amount of recovered sulfur in Kansas is grouped with 13 other states and one province. In Kansas the recovered sulfur production comes from two refineries—one in Montgomery County and one in Butler County.

Helium

Kansas is one of the leading, if not the leading, producers of Grade-A helium in the U.S. with four refined helium plants in the state, compared to a total of 10 refined helium plants in the country. Kansas also has 7 of the 15 crude helium extraction plants in the U.S. (Pacheco, 2007,

p. 35.3). The quantity of Grade-A helium produced in 2004 was 82 million cubic meters (2.96 billion cubic ft) having an estimated value of $189 million (U.S. Geological Survey, 2005).

The important natural gas fields in Kansas from which helium is extracted and refined are the Hugoton gas field and the Panoma gas field that underlies a large area of the Hugoton field (Fig. 10). The defining difference between the two fields is the natural gas in the Hugoton field is extracted from the Chase Group of rocks, while in the Panoma field the natural gas is extracted from the Council Grove Group; both of the units are of Early Permian age. These huge natural gas fields are present in a nine-county area in southwest Kansas.

Helium in natural gas was first discovered in Kansas by Professor H. P. Cady of the Department of Chemistry at Kansas University. He analyzed a number of natural gas samples from Kansas, and one sample from the Dexter field in Cowley County was determined to have a helium content of 1.84% helium (Shoewe, 1958, p. 414–5).

Helium is recovered from natural gas by a process involving liquefaction and purification. Kansas natural gases generally are less than 1% helium, but there are some areas that exceed that amount as determined from review of 116 Kansas natural gas sample analyses in Gage and Driskill (2005).

The major domestic end uses of helium as listed by Pacheco (2007, p. 35.1) for the year 2006 are cryogenics (28%), pressurizing and purging (26%), and controlled atmosphere (13%).

CONCLUSIONS

Industrial mineral production as defined by the non-fuel mineral total for Kansas is estimated by the U.S. Geological Survey to be worth $754 million in 2004. Industrial minerals and products from those minerals generally used in the construction industry comprise about 90% of the tonnage but only about 50% of industrial mineral value for the state.

Portland cement, produced from four plants generally using limestone from Upper Pennsylvanian rocks, leads in value total for all industrial mineral commodities. Next in value and largest in quantity produced is crushed stone produced mainly from limestone of Pennsylvanian age. Crushed limestone also is produced from Lower Permian and Cretaceous age rocks. Building limestone is presently produced from Lower Permian rock and some Upper Pennsylvanian limestone. Production of building stone from upper Cretaceous limestone was important in the past, but present production is only for limited specific needs.

Sand and gravel production is also important to the construction industry in Kansas with most of the sand and gravel production from rivers and their floodplains, mainly in eastern Kansas. However, a large amount of sand and gravel also comes from pits in Late Tertiary Ogallala deposits.

Gypsum is presently mined from two locations, by both underground and open pit mining in Barber County from the Medicine Lodge Gypsum of the Blaine Formation and by shallow underground mining from a gypsum bed in the Easly Creek Shale in Marshall County. Both mining areas are in Lower Permian rocks.

Important production of commodities other than those used for the construction industry mainly comprises salt and helium. Helium production in Kansas primarily comes from the Hugoton and Panoma gas fields (Lower Permian rocks) of southwestern Kansas, and the value of refined helium in 2004 was second only to cement. Refined helium (greater than 99.99% helium) is separated at four plants in Kansas, and seven plants provide crude helium (approximately 75% helium) for storage to be used for further refinement in the future.

Salt value was the third highest among the Kansas mineral commodities in 2004, with production of mined rock salt and evaporative salt obtained from the Hutchinson Salt Member of the Wellington Formation. This salt is mined in Reno, Rice, and Ellsworth Counties, and salt brine is also mined by solution methods for chlorine chemical production in Sedgwick County.

Of the total value for Kansas estimated at $754 million, the value of commodities produced from Lower Permian rocks represented the most value, with commodities from rocks of Pennsylvania (mainly Upper Pennsylvanian) second to the Permian commodities. However, commodities obtained from Pennsylvanian rocks were dominant in total tonnage of minerals mined and products produced.

ACKNOWLEDGMENTS

Thanks to David Grisafe, who recently completed a career as a materials scientist at the Kansas Geological Survey (KGS) working with many of the industrial minerals of Kansas. Dave retired from the KGS in 2006. I also want to thank Pieter Berendsen and Maynard Bauleke, both retired from the KGS and both of whom along with Dave Grisafe have provided me with a large amount of information in many discussions over the years about Kansas industrial rocks and minerals, their mines, and products.

Special thanks to Patricia Acker (KGS) for her graphic skills in providing the illustrations for the oral presentation and the resulting paper for this Forum; and thanks to John Charlton (KGS) for allowing use of the photos from the KGS Photo Archives for use in the oral presentation of this paper. Appreciation is extended to Lea Ann Davidson (KGS) for help with the preparation of the manuscript.

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Figure Captions

Figure 1. General geologic map of Kansas with cross-section along 1-70 (Kansas Geological Survey, 2008a).

Figure 2. General geologic time table showing approximate location of industrial minerals within the stratigraphic framework of Kansas. Modified from the Kansas Geological Survey (2008b).

Figure 3. General locations of active crushed stone quarries, pits, and mines. Modified from Grisafe (1999a, p. 19).

Figure 4. Location of active industrial mineral mines—other than aggregates, in Kansas. Modified from Grisafe (1999a, p. 19).

Figure 5. Location of industrial mineral manufacturing/processing operations in Kansas. Modified from Grisafe (1999a, p. 10).

Figure 6. General locations of active sand and gravel operations in Kansas. Modified from Grisafe (1999a, p. 18).

Figure 7. General location of gypsum deposits and the two active gypsum mining operations. Modified from Hardy (1970, p. 13).

Figure 8. General distribution of salt deposits in Kansas, and general location of company salt mines and solution mining operations. Modified from Sawin and Buchanan (2002, p. 2).

Figure 9. General location of volcanic ash deposits in Kansas, and the location of the diatomaceous marl deposit. Modified from Hardy (1970, p. 16).

Figure 10. Location of helium extraction plants in western Kansas. Shaded background is oil and gas fields. The Hugoton gas field is highlighted because of the importance of this natural gas field that contains a significant amount of helium gas. Not shown on the figure is the Panoma gas field that underlies approximately two-thirds of the Hugoton gas field and also contains a large amount of helium gas. Refer to the Kansas Geological Survey (Ross and others, 1993) oil and gas field map for characteristics of the shaded oil and gas field shown.

Table Captions

Table 1. Industrial mineral production in Kansas, 2003–2004

Table 2. Important Pennsylvanian limestone units used for crushed stone in Kansas

Table 1. Industrial Mineral Production in Kansas, 2003–2004

(Thousand metric tons and thousand dollars unless otherwise specified)

Mineral	2003 Quantity	2003 Value	2004 Quantity	2004 Value
Cement, portland	2,270	173,000[e]	2,690	212,000[e]
Clays, common	632	10,000	621	7,460
Gemstones	NA	1	NA	1
Helium, Grade-A million cubic meters	77	179,000	82	189,000
Salt	2,770	123,000	2,890	127,000
Sand and gravel, construction	10,700	34,900	9,930	32,800
Stone:				
Crushed	20,700	111,000	19,800	109,000
Dimension	15	1,640	14	1,730
Combined values of cement (masonry), clays (fuller's earth), gypsum (crude), helium (crude), pumice and pumicite, sand and gravel (industrial)	xx	65,100	xx	75,300
Total	xx	696,000	xx	754,000

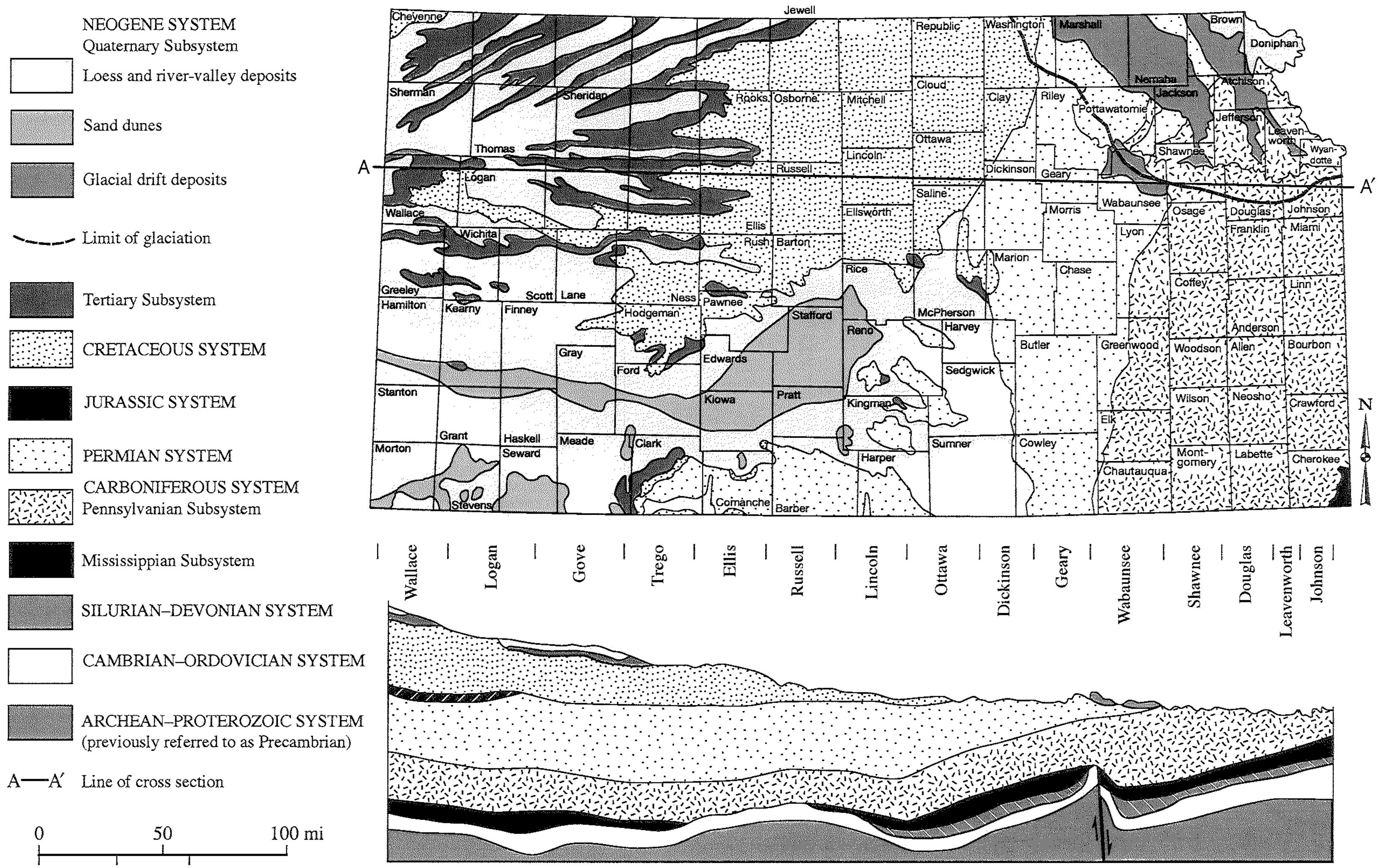
[e]Estimated. XX Not applicable.

Table modified from "The Mineral Industry of Kansas—2004," U.S. Geological Survey (2005), http://minerals.usgs.gov/minerals/pubs/state/2004/ksstmyb04.pdf.

Table 2. Important Pennsylvanian limestone units used for crushed stone in Kansas

Limestone Member	Limestone Formation
Upper Pennsylvanian Series	
Ervine Creek	Deer Creek
Plattsmouth	Oread
Stoner	Stanton
Captain Creek	Stanton
Argentine	Wyandotte
Raytown	Iola
Winterset	Dennis
Bethany Falls	Swope
Middle Pennsylvanian Series	
Laberdie	Pawnee

Generalized Geologic Map of Kansas

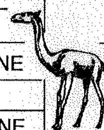


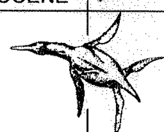
Geologic cross section below I–70

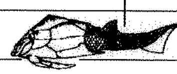
Kansas Geological Survey (2008 a)

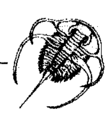
Kansas Geologic Timetable

EON	ERA	PERIOD	EPOCH	Industrial Minerals	Million Years Past
PHANEROZOIC	CENOZOIC	NEOGENE (QUATERNARY)	HOLOCENE	Sand & Gravel	
			PLEISTOCENE	Volcanic Ash	
		NEOGENE (TERTIARY)	PLIOCENE	Sand & Gravel, Volcanic Ash	
			MIOCENE		23
		PALEO-GENE (TERTIARY)	OLIGOCENE		
			EOCENE		
			PALEOCENE		65
	MESOZOIC	CRETACEOUS		Limestone*(C & D), Clays, Shale, Sandstone*(C)	145
		JURASSIC		Generally absent at surface	199
		TRIASSIC			251
	PALEOZOIC	PERMIAN		Salt, Gypsum, Limestone*(D & C), Helium*(from NG)	299
		CARBONIFEROUS: PENNSYLVANIAN subperiod		Limestone*(C), Sandstone*(C & D), Shale & Clay	318
		CARBONIFEROUS: MISSISSIPPIAN subperiod		Subsurface Only	359
		DEVONIAN			416
		SILURIAN			443
		ORDOVICIAN			488
		CAMBRIAN			542
PROTEROZOIC					2,500
ARCHEAN					4,600?



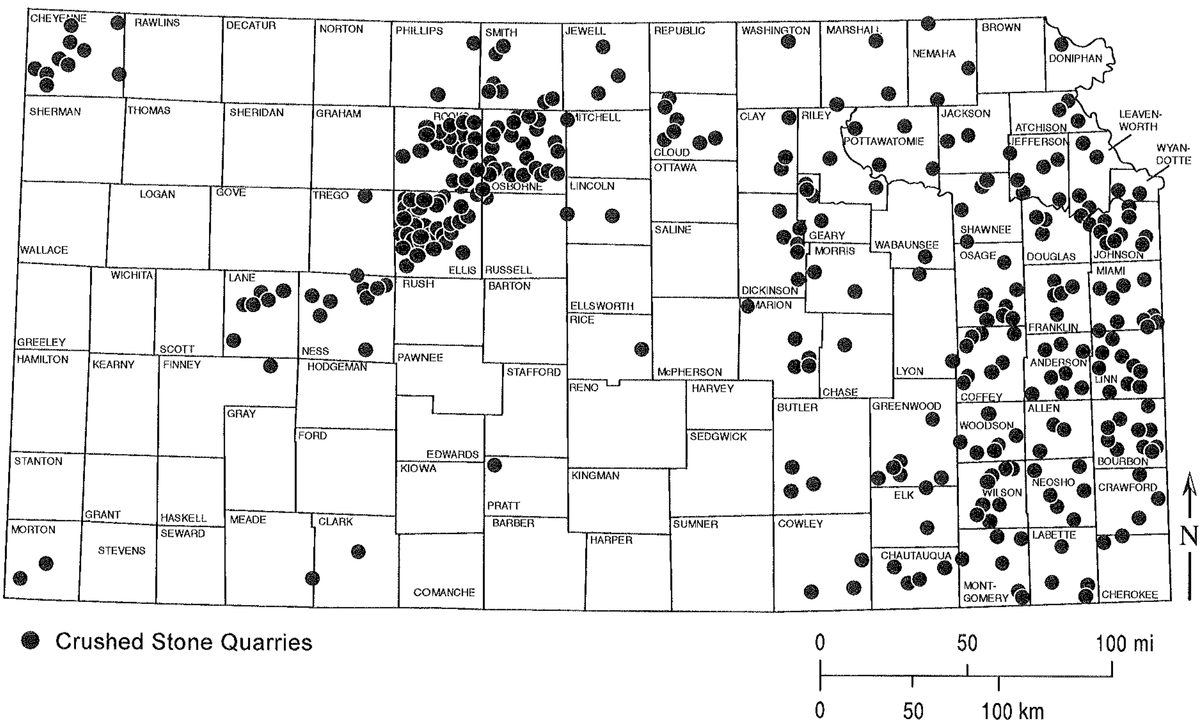






modified from Kansas Geological Survey (2008 b)

* (C) Crushed Stone, (D) Dimension Stone, (NG) Natural Gas



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Crushed Stone Quarries
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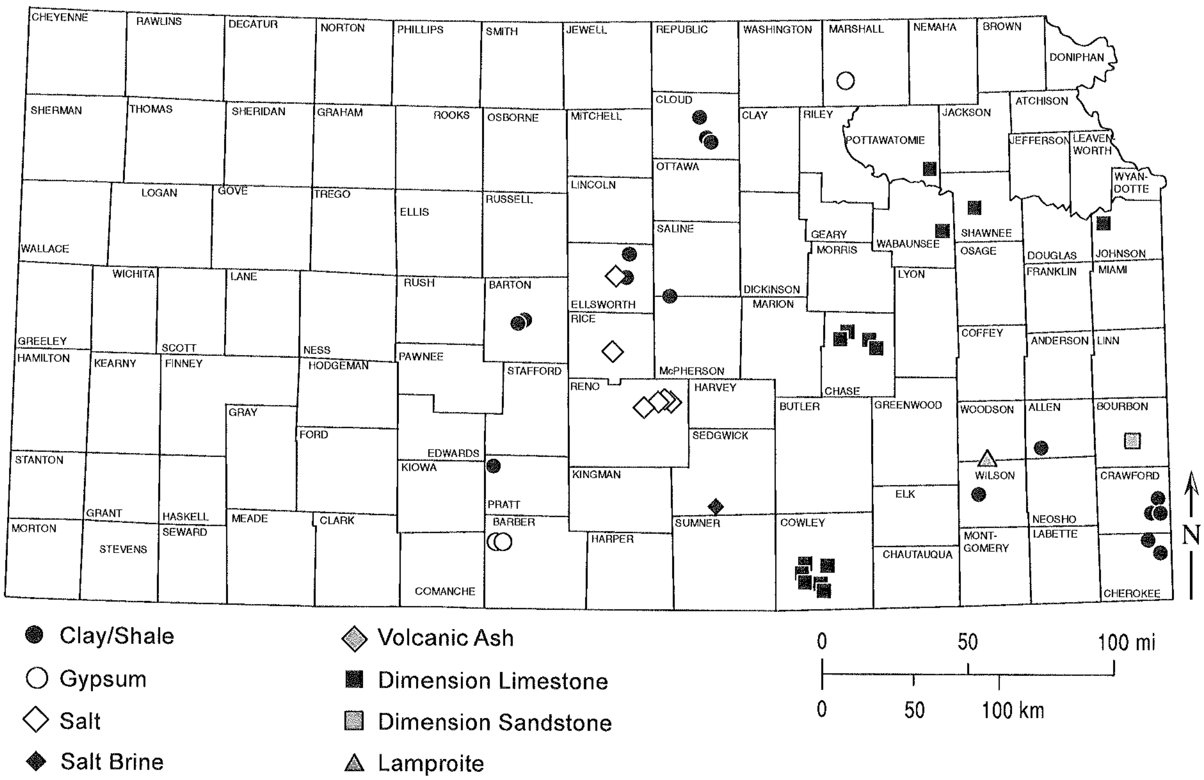

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Clay/Shale
Gypsum
Salt
Salt Brine
Volcanic Ash
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Dimension Sandstone
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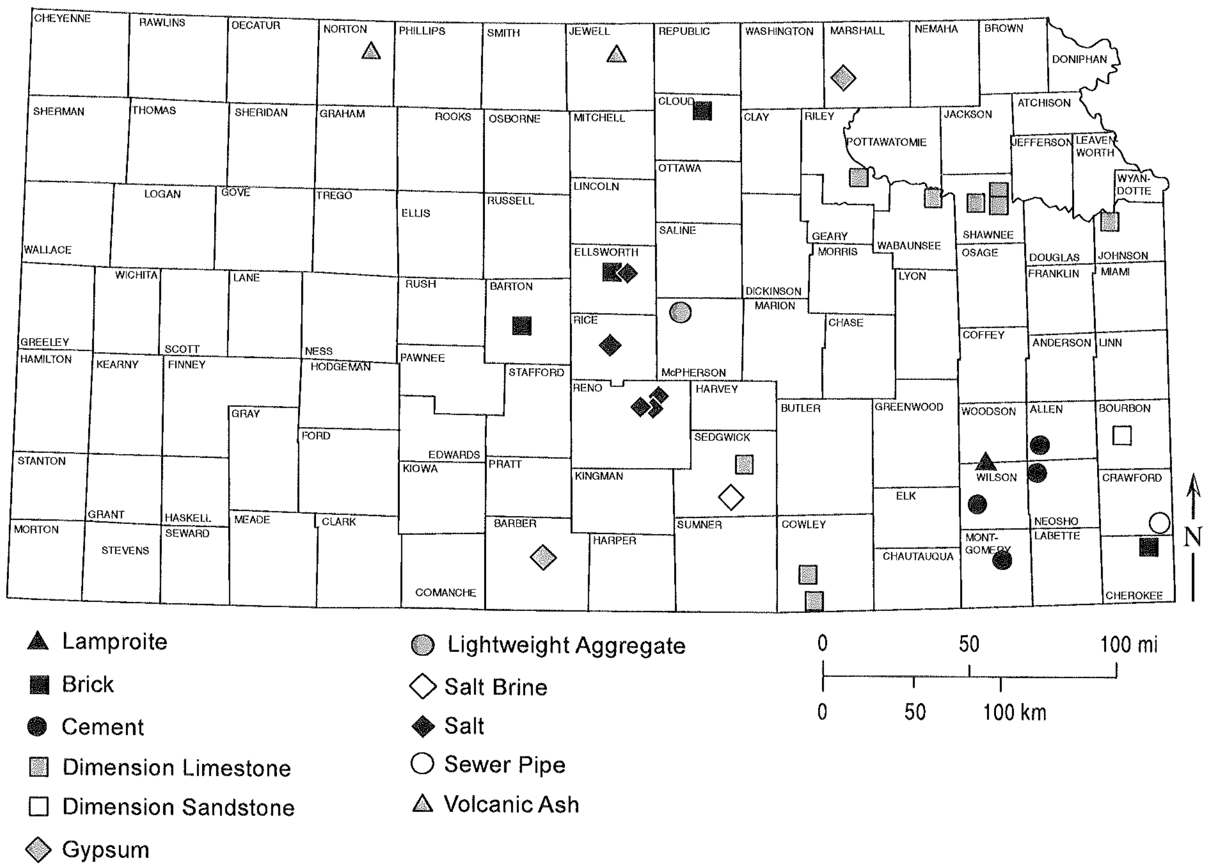
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Dimension Sandstone
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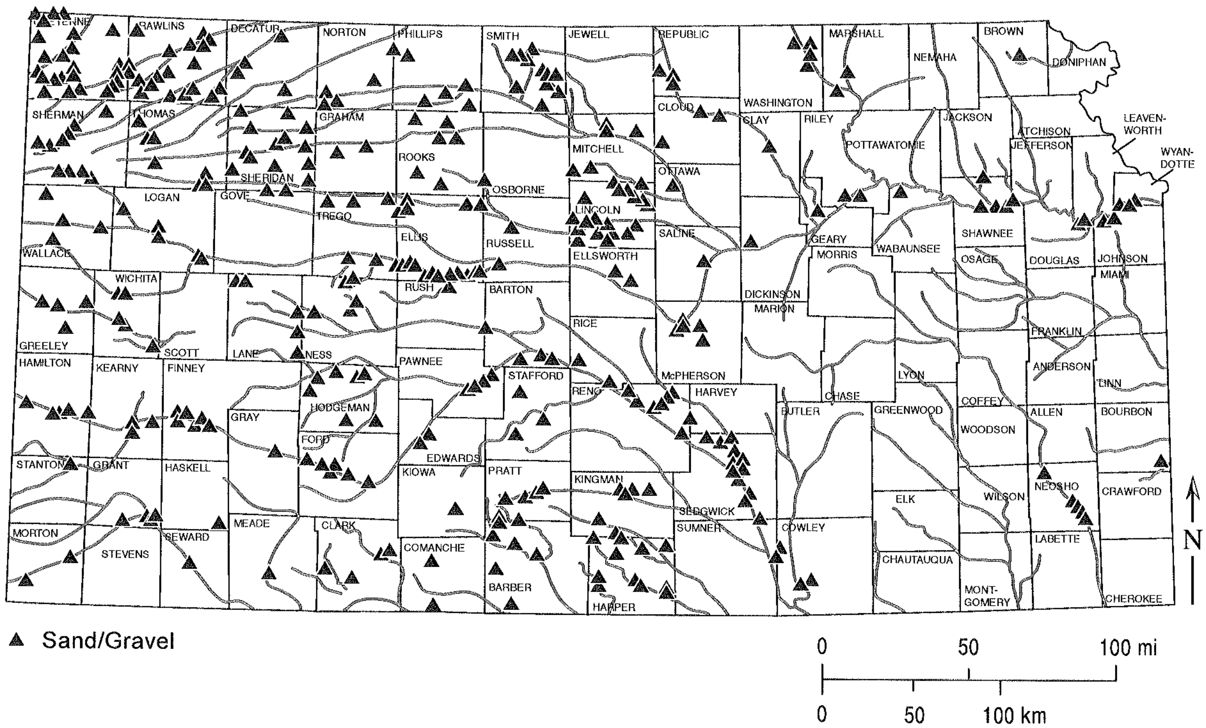

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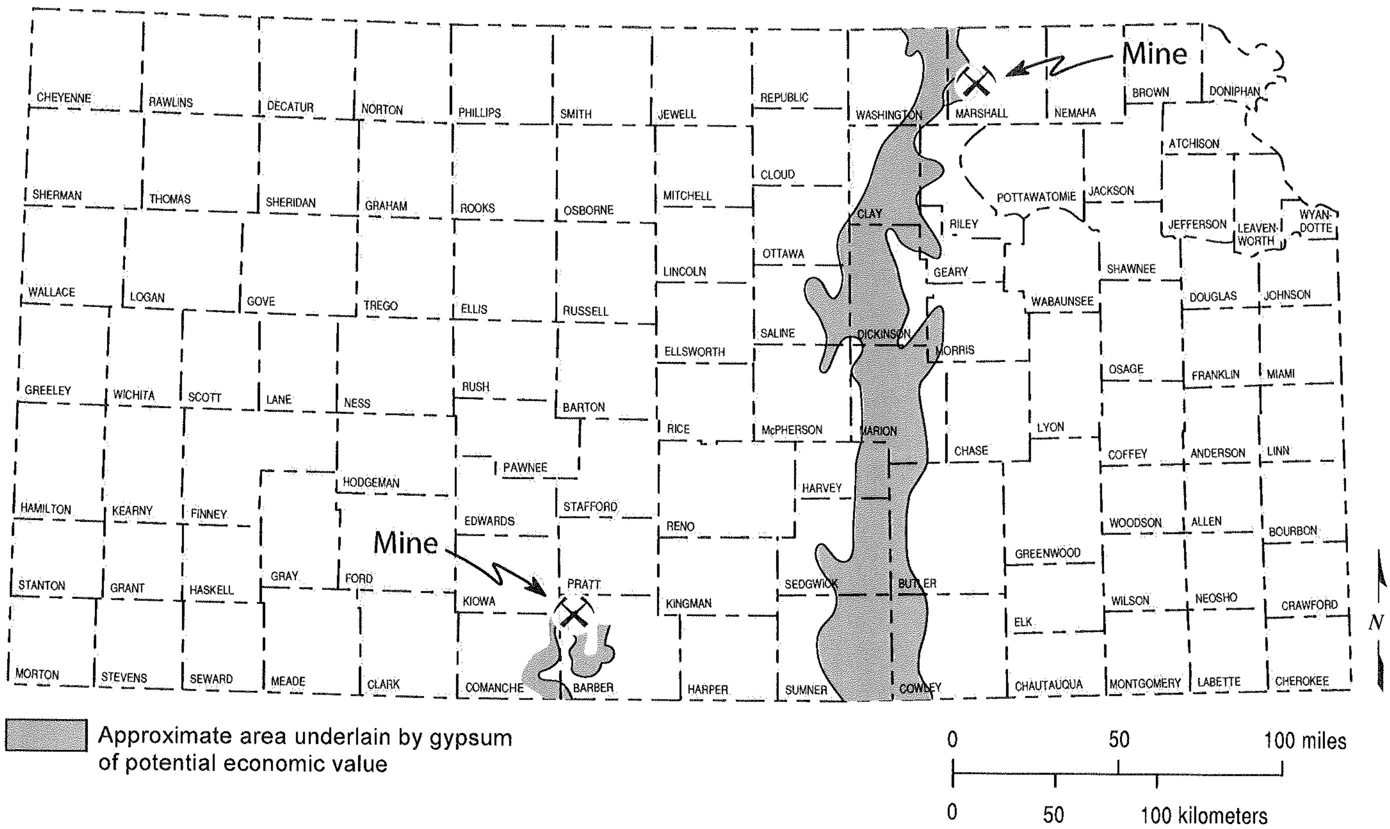

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Approximate area underlain by gypsum of potential economic value
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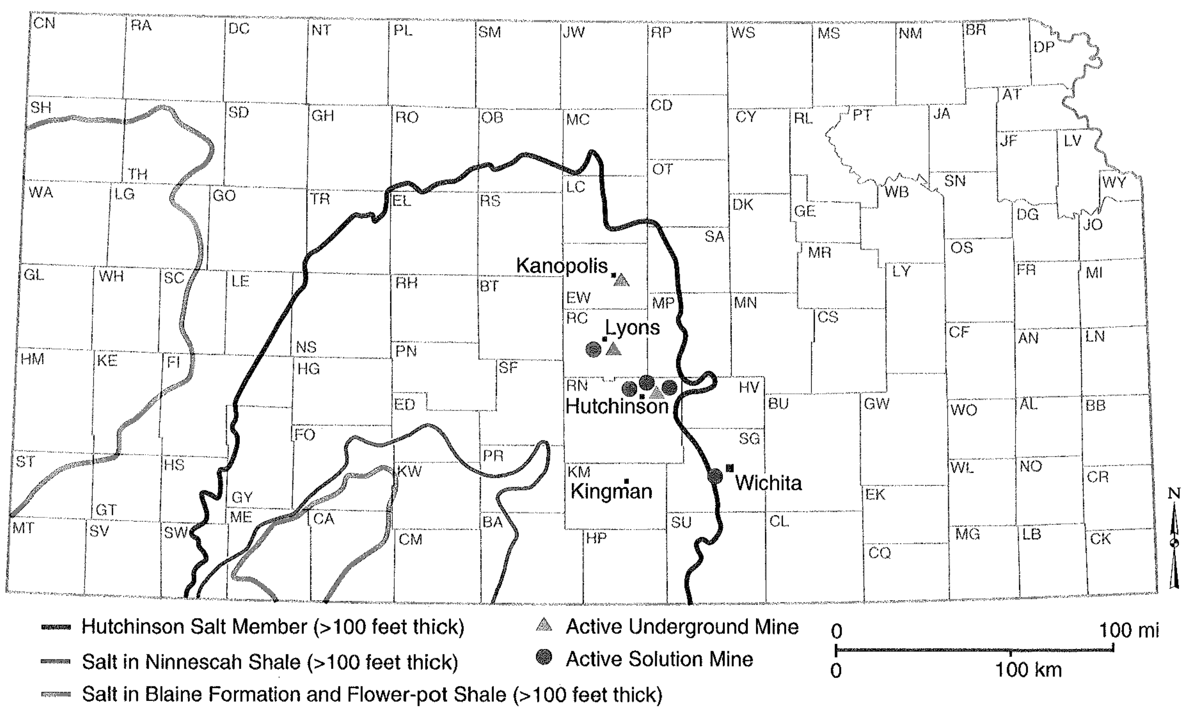
Kanopolis
Lyons
Hutchinson
Kingman
Wichita
N
Hutchinson Salt Member (>100 feet thick)
Salt in Ninnescah Shale (>100 feet thick)
Salt in Blaine Formation and Flower-pot Shale (>100 feet thick)
Active Underground Mine
Active Solution Mine
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100 mi
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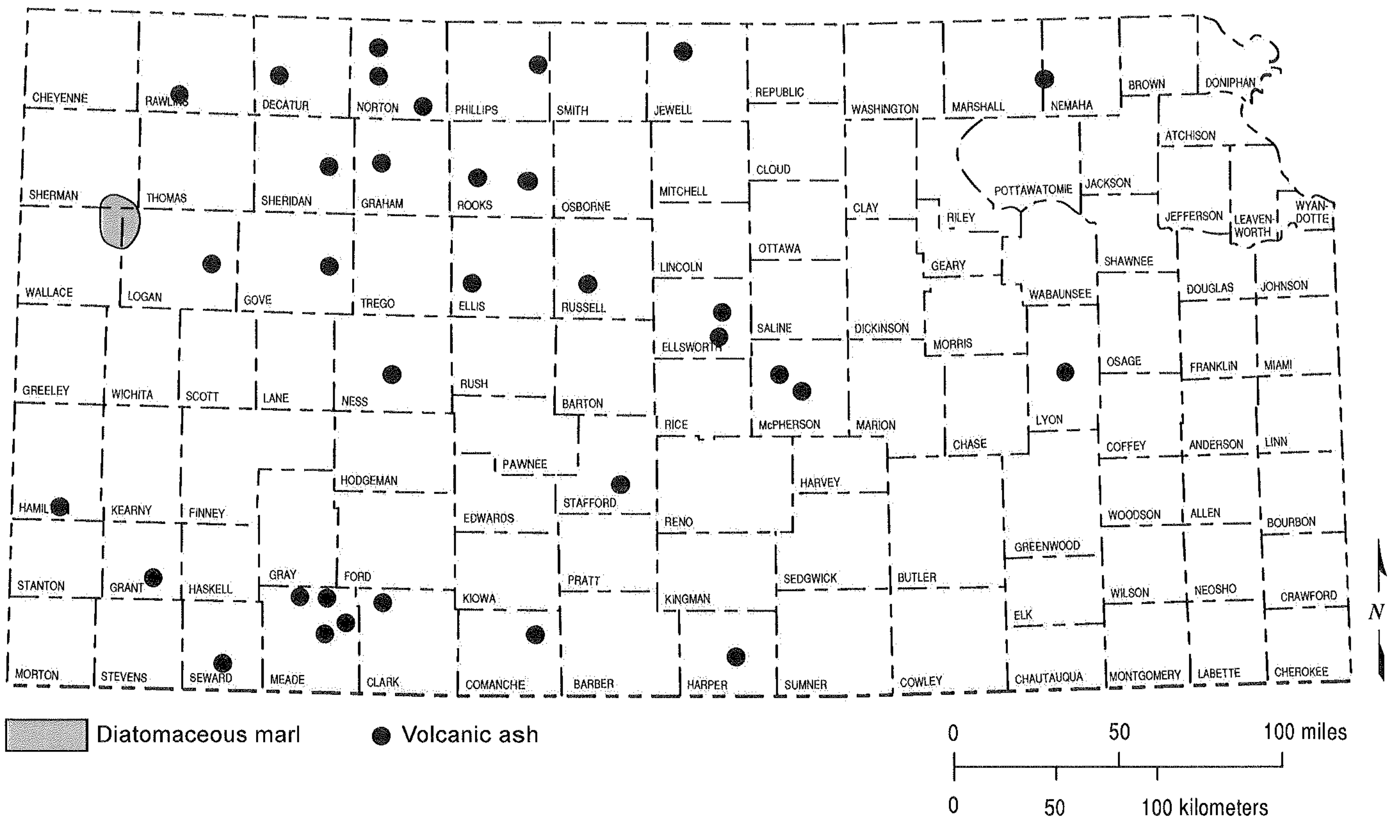
100 km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Diatomaceous marl
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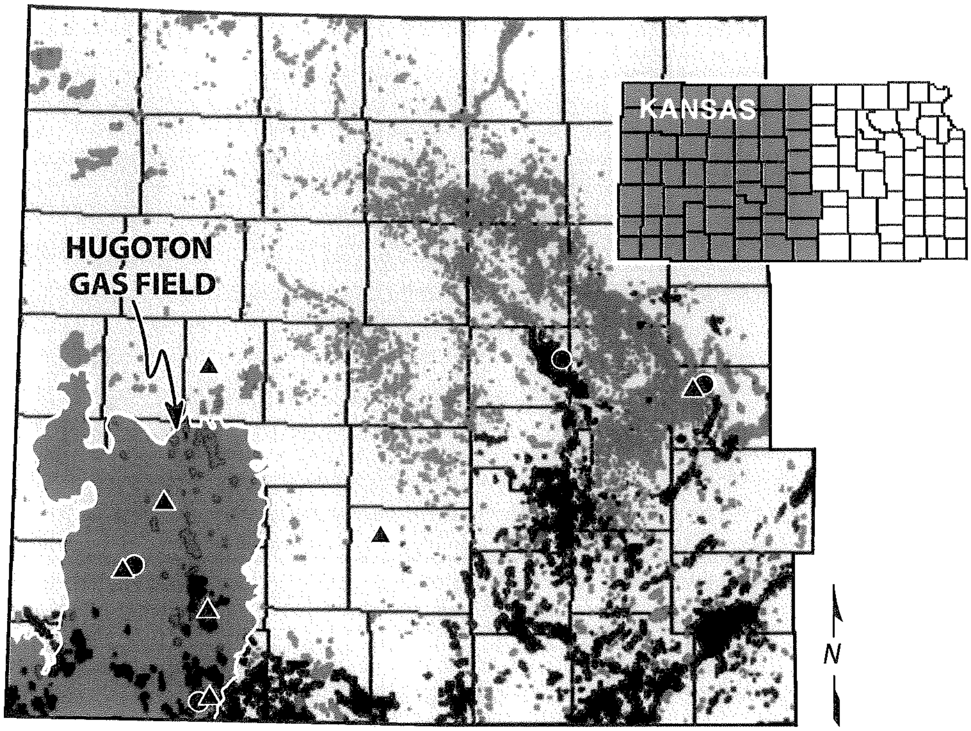

Helium Extraction Plants
● grade - A Helium
▲ crude Helium

0 50 miles
0 50 kilometers

Data - Pacheco (2007) Helium, 2006 Minerals Yearbook