KANSAS GEOLOGICAL SURVEY
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Salt in Kansas

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Introduction

Salt is an abundant and valuable natural resource in Kansas. In addition to salt's well-known uses (such as table salt or road de-icing material), large caverns dissolved out of salt beds also are used to store natural gas, natural gas liquids (such as propane and butane), and other petroleum products.

Halite (fig. 1) is the mineral name for salt. The chemical composition of halite is NaCl, or sodium chloride, which is the same as common table salt. Salt is a general term for naturally occurring sodium chloride. Rock salt is the term used for natural salt deposits composed of halite and other impurities, mainly thin beds of shale.

In Kansas, salt is mined from the Hutchinson Salt Member of the Wellington Formation (fig. 2), deposited during the Permian Period, about 275 million years ago. The Hutchinson Salt Member covers about 37,000 square miles in the subsurface of central and south-central Kansas (fig. 3), reaching a maximum thickness of more than 500 feet under Clark, Comanche, and Barber counties. About 80 percent of the rock in the Hutchinson Salt Member is salt (much of the rest is shale) — more salt and fewer impurities than most salt beds.

Thick salt layers also occur in western and southwestern Kansas in the Ninnescah Shale, Blaine Formation, and the Flower-pot Shale, which are above the Hutchinson Salt Member in younger rocks. These salt beds, which have never been mined, are much deeper below the surface than the eastern edge of the Hutchinson Salt Member, where mining occurs.

Figure 1. The mineral halite.

This circular provides a brief history of salt production in Kansas, explains the geology of the salt deposits, describes how salt is mined, and discusses environmental issues associated with salt deposits and salt mining in Kansas.

History

Before Kansas was settled by Europeans, salt marshes and salt springs were used by wildlife, Native Americans, and early travelers. Wild animals of the plains — especially bison, deer, antelope, and elk — obtained salt from places known as licks. Salt licks, or salt flats, are areas where saline groundwater reaches the surface and then evaporates during dry times, leaving salt on top of the ground. Native

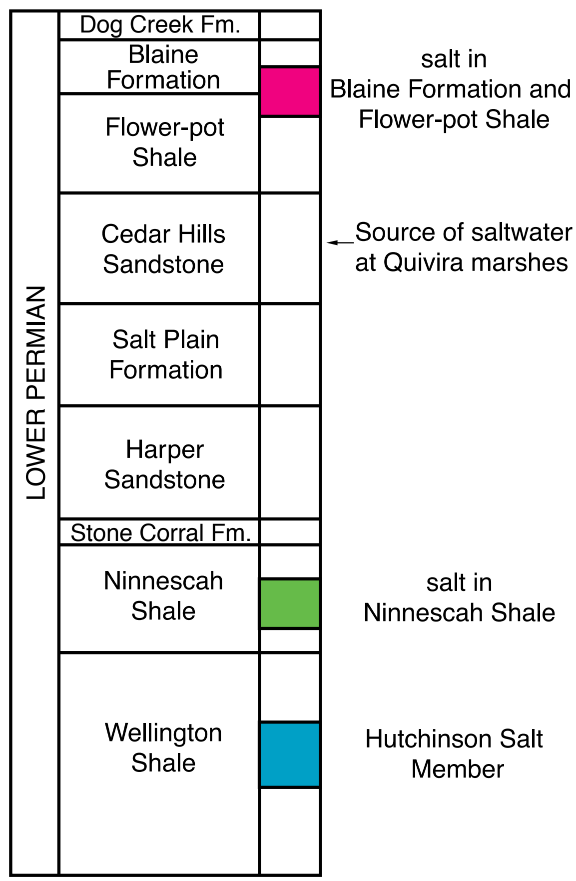

Figure 2. Sequence of rocks associated with salt deposits in Kansas.

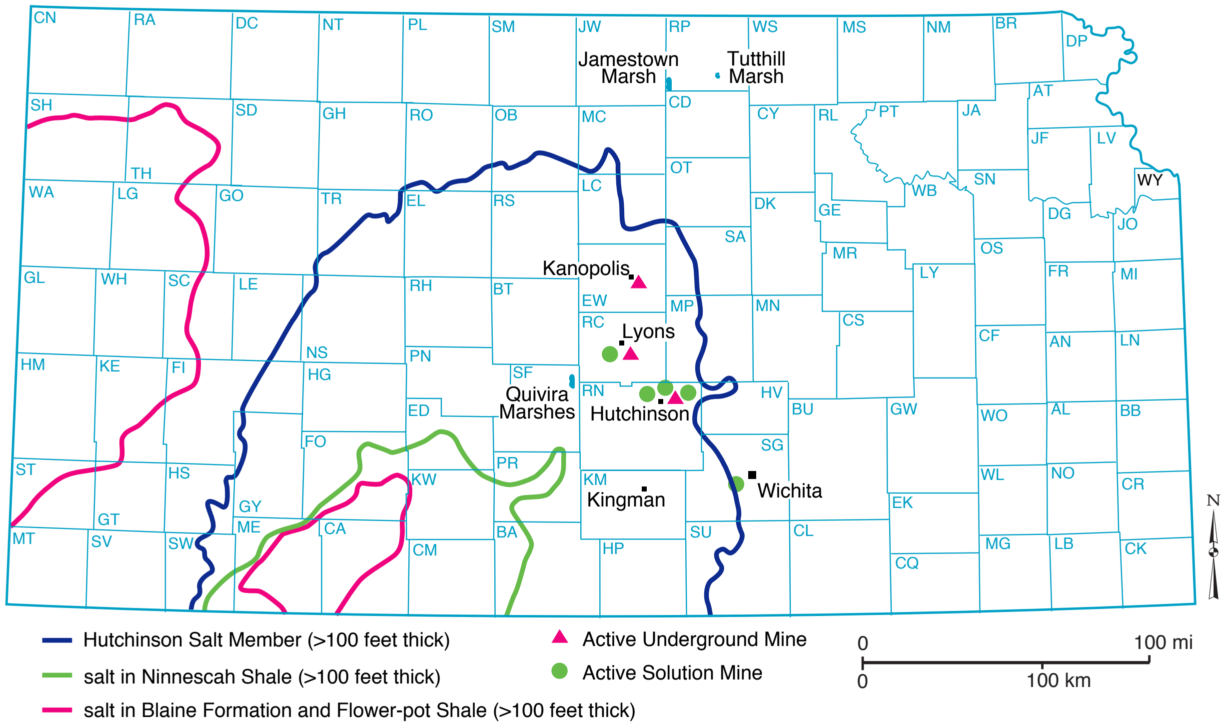

Figure 3. Approximate limits of major salt deposits in Kansas (modified from Bayne, 1972) and location of active salt mining.

Americans, explorers and hunters, and early ranchers obtained salt by evaporating water collected from salt springs. Early hunters visited the salt marshes to jerk buffalo meat. They would either evaporate brine or dip the meat in pools of strong brine and then dry it in the sunshine or by a fire.

Salt was commercially manufactured in Kansas as early as 1863 at the Osawatomie Salt Works in Miami County in eastern Kansas. Brine, produced from five wells that tapped a saline aquifer, was evaporated in 17 kettles (each holding 30 gallons) set in a single furnace; the salt sold locally for $1.40 per bushel (a bushel of salt weighs 56 pounds). About the same time, salt was produced in Republic County at the Tuthill marsh by scraping the salt scale from the marsh, dissolving it in water, and then siphoning off the clear brine. The brine was then evaporated to recover the salt. Salt was sold in nearby Seapo, and hauled to Manhattan, where it sold for as much as 10 cents per pound. Other early salt plants were established at Solomon in Dickinson County in 1867.

Rock salt was discovered in central Kansas in 1887 by speculation companies organized to drill for coal, gas, oil, or any valuable minerals they might encounter. Although the main objectives were not found in commercial quantities, drillers repeatedly encountered beds of salt several hundred feet thick occurring at shallow depths (500 to 1,000 feet). Rock salt was first mined in Hutchinson in 1888, using solution mining (a mining method that pumps water down wells to dissolve the salt), when two wells and a salt factory were put into operation. By 1891, underground mines (using a mining method similar to underground coal mining) produced salt at Lyons, Kingman, and Kanopolis. Underground mining began at Hutchinson in 1923 when the Carey Salt Mine was officially dedicated.

Geology

Salt is called an evaporite mineral because it is formed by the evaporation of water. Gypsum and anhydrite are also evaporites. Sea water contains salt in solution. When sea water evaporates, salt is deposited on the ocean floor. During most of the Permian Period, shallow seas covered what is now Kansas. Sea level fluctuated — sometimes the land was exposed and a terrestrial environment existed; at other times, mudstones (shale) and limestones were deposited in a normal marine setting.

When the Hutchinson Salt Member formed, however, the climate was hot and dry, and the sea was restricted to central Kansas — probably an isolated arm of the main ocean to the south, or cut off entirely. The rate of evaporation exceeded the inflow of water, and as evaporation continued and the salt content of the water increased, thick layers of salt built up on the sea bottom. It takes about 80 feet of sea water to produce a foot of salt, so it must have taken thousands of years to accumulate the thick salt deposits of central Kansas. Over time, the salt layer was covered by younger rocks.

The eastern edge of the Hutchinson Salt Member is actively being eroded, or dissolved, by contact with groundwater (fig. 4). This area, where the salt is closest to the surface, is known as the dissolution front. Because salt is so easily dissolved in water, outcrops at the surface are not present in Kansas.

Salt also has other unusual characteristics. It is plastic — that is, it will flow and move very slowly, over long periods of time, when it is under pressure, as it is underground. This plasticity allows salt to slowly heal or cover up small fractures or openings in the salt beds.

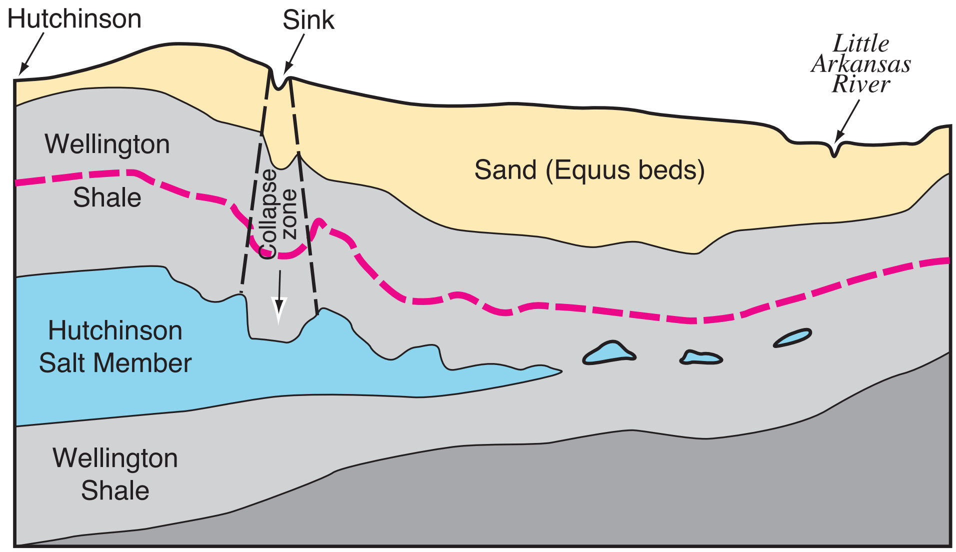

Figure 4. Generalized cross section from Hutchinson to the Little Arkansas River west of Newton (in Harvey County) showing dissolution of the Hutchinson Salt Member and related subsidence features. red line represents deformation of beds within the shale.

Salt Production

Salt is mined in Kansas using two methods: underground mining and solution mining. Underground mines in Kansas (fig. 5) range in depth from 600 to 1,000 feet. They use the room-and-pillar method of mining, which begins with a shaft sunk through the overlying rock to the salt deposit. The salt is removed in a checkerboard pattern, in which large square caverns alternate with square pillars of salt that serve as support for the rock above. Approximately 75 percent of the salt is mined, while 25 percent is left for pillars. Blasting breaks the salt into manageable pieces, which are conveyed to crushers and removed to the surface through the shaft with large buckets. Because of the impurities (mostly shale and anhydrite), rock salt is used mostly as road salt for melting ice. Active underground salt mines are found in Lyons, Kanopolis, and Hutchinson.

Figure 5. Underground salt mine at Hutchinson. Salt is mined in a room-and-pillar fashion and moved along a conveyor belt and eventually to the surface.

Early mining of the deep salt beds in central Kansas was done by solution mining, and this process continues today. Solution mining uses water to dissolve the salt. Freshwater forced down a cased well dissolves the salt and produces an artificial brine, which is then pumped to the surface and evaporated to recover the salt. As long as freshwater is added and saturated brine removed, the cavern continues to enlarge. The shape of the cavern is controlled by directing the water. A sonar tool is used to measure the shape and size of the cavern.

Evaporation plants produce a variety of salts for which purity is essential, such as table salt, food processing salt, salt for animal feeds, and water softening salt. Brine is evaporated in a series of large vessels called vacuum pans. The result is a high-purity product consisting of over 99.8% sodium chloride.

In 2000, Kansas ranked fifth in the U.S. in salt production, producing 2,944,000 tons valued at $111 million. Roughly 13 trillion tons of salt reserves, about 1,100 cubic miles, underlie Kansas. This is enough to form a salt cube more than 10 miles long on each edge.

Underground space created by salt mining is also valuable. In the Hutchinson mine, space is leased for high-security record storage. The constant temperature and humidity make an ideal environment to archive fragile items such as classic movies, paintings, furs, and collections. In the 1960s, the Atomic Energy Commission studied a salt mine in Lyons for the potential storage of high-level radioactive waste, an idea that was eventually abandoned. Today, an underground mine in Hutchinson is being developed into a salt museum. [Now open. Information at http://www.undergroundmuseum.org/ as of Aug. 2008.]

Underground Storage

Caverns in the salt beds of Kansas are also used for storing natural gas, natural gas liquids, and other hydrocarbons. Some caverns that are now used for hydrocarbon storage were originally created during salt mining; others were created by solution specifically for the storage of hydrocarbons. Salt caverns are used for storage because salt is highly impermeable, and salt beds in Kansas are thick and fairly predictable. In addition, large quantities of gas can be introduced into, and taken out of, salt caverns relatively quickly. Energy companies use salt caverns to store natural gas during times of low demand, then quickly move it out of caverns in the winter, during times of peak demand. Natural gas is also stored in depleted oil and natural gas fields in Kansas and other parts of the country, but moving gas into and out of these depleted fields takes much longer. A typical storage cavern in Kansas salt holds about 100,000 barrels, or 4.2 million gallons, of hydrocarbons, usually under pressure.

Because Kansas is in the central part of the U.S. and relatively close to major natural gas fields, a number

Why Are the Quivira Marshes Salty?

Salty surface waters and salt flats at Big and Little Salt marshes at Quivira National Wildlife Refuge in Stafford County are caused by natural saltwater in the underlying bedrock. The Quivira marshes and the surrounding area are a common discharge center (an area where groundwater moves upwards toward the surface), where freshwater and saltwater aquifers converge. The surface is capped by a veneer of wind-blown dune sand.

Water is a universal solvent, dissolving and chemically reacting with the rock formations it encounters. The longer water remains in the aquifer and the greater the distance it travels, the more mineralized it becomes (if soluble minerals, such as halite, are present). Salinity at Quivira is not related to the Hutchinson Salt Member (which underlies this area); instead, salinity here is related to the Cedar Hills Sandstone, and sandstone layers in the Salt Plain Formation (see fig. 2), which lie above the Hutchinson salt. These rocks contain salt minerals — halite (or common table salt) and anhydrite (a mineral similar to gypsum). The Cedar Hills Sandstone aquifer is recharged in southwest Kansas. Regional groundwater flow carries this water, which becomes increasingly saline, in an easterly direction until it discharges near the surface into the overlying freshwater aquifer west of the Quivira marshes. A north-south trending ridge of Permian bedrock below the marshes restricts the easterly movement of groundwater toward the Arkansas River and forces saltwater to discharge into the low-lying streams and marshes.

Salt concentrations are further increased at the surface by evaporation. The average salinity of Little Salt Marsh is approximately 2,500 parts per million (ppm) chloride, whereas that of Big Salt Marsh ranges from 5,000 to 10,000 ppm (sea water averages 19,000 ppm chloride, and drinking water about 250 ppm).

The Quivira marshes are characterized by poor drainage, springs and seeps with high salt concentrations, and salt-tolerant vegetation. Evaporation of shallow lakes concentrates salts on the bare ground, creating the white salt flats characteristic of the salt marsh.

of pipelines run through the state. These pipelines take advantage of hydrocarbon storage facilities in the salt in central Kansas. Hydrocarbons are stored in salt caverns in at least five other states in the U.S., but Kansas has more storage caverns in salt than any other state. Storage facilities were originally developed in Kansas in the early 1950s. Today hydrocarbons are stored at sites in Rice, Reno, McPherson, and Ellsworth counties. In January 2001, a rupture in a pipe in a natural-gas storage facility in Reno County was hypothesized to be the source of gas that led to a series of explosions and geysers in the city of Hutchinson. Gas may have moved from the facility, under the city, then to the surface through long-forgotten salt-solution wells. The Kansas Geological Survey worked with the city, the local utility, and the Kansas Department of Health and Environment to try to understand the movement of the gas and to locate abandoned solution wells.

Other Salt-Related Issues

In addition to being a resource, salt has created several environmental problems in the state. Particularly along the solution front in central Kansas, dissolved salt sometimes winds up in rivers, streams, marshes, and lakes. For example, salt in the bedrock beneath Saline and McPherson counties has been naturally dissolved and the brine has moved north and east into the aquifer adjacent to the Smoky Hill River, thus increasing salinity levels in the Smoky Hill. In Reno and Rice counties, saltwater produced during the early days of salt-solution mining has led to localized problems of increased salinity in the groundwater. Salinity levels in other streams and marshes in Kansas are sometimes elevated, but that salinity is the result of natural saline contamination from salty aquifers and not from the salt mining near Hutchinson (see Why are the Quivira Marshes Salty?). Saltwater from dissolution of the Hutchinson Salt Member also discharges to overlying alluvial aquifers and into streams and the Arkansas River to the south in Sumner County.

Salt dissolution, either natural or human-induced, is also responsible for surface subsidence areas (sinkholes) in Kansas (fig. 6). Salt layers in the subsurface are dissolved by water, creating underground void spaces. When the ceiling above those voids can no longer support the weight above, the rock layers collapse, causing subsidence at the surface. Natural sinkholes, such as Lake Inman in McPherson County, are common on the solution front along the eastern edge of the Hutchinson Salt Member. Human-induced subsidence areas are rare, but when they occur, they are usually attributed to salt mining or oil and gas operations. Sinkholes that suddenly collapse are called catastrophic sinkholes. Sinkholes that have formed gradually are visible along Interstate 70 at milepost 179, west of Russell in Russell County. This subsidence is probably related to an abandoned oil well. In Reno County, gradual subsidence is occurring at the intersection of U.S. Highway 50 and Victory Road, about 6 miles east of Hutchinson; it is probably the result of natural dissolution along the solution front.

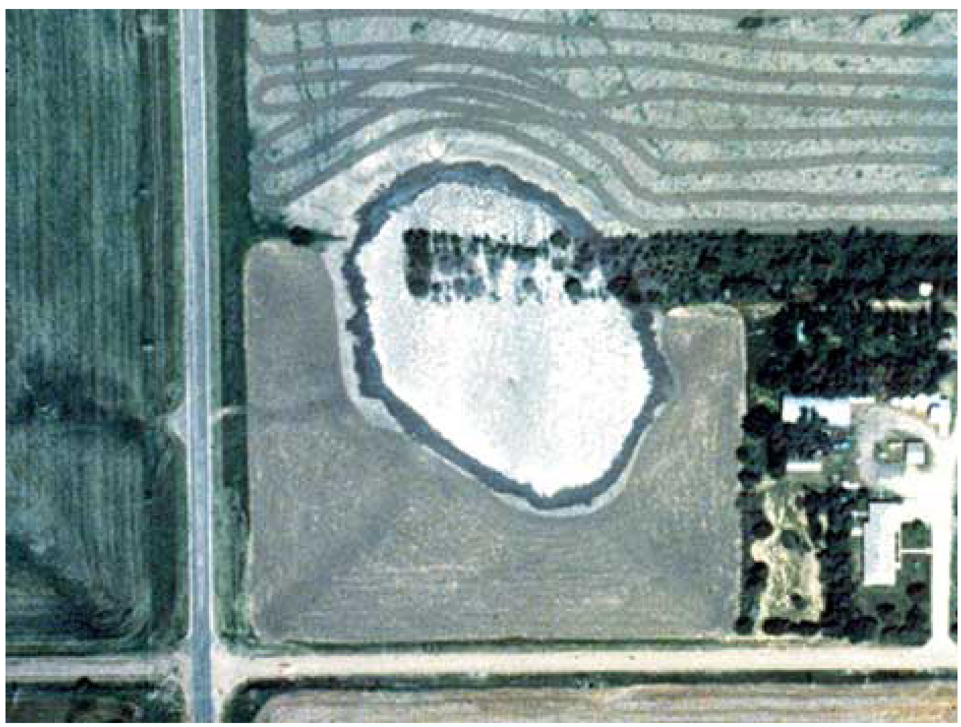

Figure 6. Aerial photo of sinkhole in Ellsworth County.

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KANSAS GEOLOGICAL SURVEY
The University of Kansas

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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