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Salt in Kansas

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By Earl K. Nixon, Geologist, State Geological Survey of Kansas*

INTRODUCTION

Salt, a mineral indispensible to civilization since Bible times [1]; used

1/ Bible, Leviticus, ii, 13.

by the Romans as part payment for soldiers' wages (the practice yielding our English word salary), and seemingly as necessary in agriculture as in industry — is so ordinary a substance that it is actually called common salt. Its ready availability almost anywhere is now taken for granted, as present day children take automobiles for granted. It was not always so.

Only since 1900 or thereabouts, has salt become a really important raw material for the chemical industries which currently consume fully two-thirds of the United States production.

The present Kansas salt industry is 63 years old, although its beginnings go back another 20 years. It is a pioneer which started almost as a "dead end kid," and weathered its hectic, adolescent years among the quarrels and bickerings of land, cattle, and railroad interests of the frontier state. It has now leveled off in its early middle age into a stable, competent, and respected industry . . . a credit to the men who have made it as well as to the state which embraces it.

This brief story is about the Kansas salt industry.

HISTORY

On September 18, 1806, Zebulon Pike, the noted early day explorer for whom Pike's Peak was named, wrote in his diary [2], ". . . marched at our usual hour,

2/ Elliott Coues, ed., The Expeditions of Zebulon Montgomery Pike,

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and at twelve o'clock halted at a large branch of the Kansas (Smoky Hill River) which was strongly impregnated with salt."

During the 81 years that followed Pike's observation, salt from Kansas salt marshes and springs was eaten raw or boiled down in kettles, sold, bartered, and fought over by Indians, frontiersmen, missionaries, renegades, explorers, and later ~~by~~ immigrant colonists and merchants. Some crude stills and even solar evaporators were built.

As early as 1867 production of evaporated salt from a brine well near Solomon City in western Dickinson County reached about 10,000 barrels per year.

But the real Kansas salt industry was started, almost with a "whoosh," in September 1887 when a well drilled for petroleum near Hutchinson cut beds of rock salt nearly 300 feet thick. With 250,000 immigrants entering the State the preceding year, 1886 [3], ~~with~~ a land boom ~~on~~, and with five railroads

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3/ Carl R. Zerger: Historical Notes on Kansas Salt, Master's thesis, University of Kansas, pp. 175, 1945. New York Sun as cited by Zerger.

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under construction, the finding of salt at Hutchinson ~~occurred at a time which~~ magnified the trend to runaway proportions. Men, mainly from New York state, who knew the business of brine wells and salt manufacture, began immediately to build plants in the Hutchinson area. Thirteen salt plants are said to have been built following the Hutchinson discovery in 1887. Thirty-six companies were organized in the 6-year period from 1887 to 1892 [4].

4/ Zerger, op. cit., 1945.

Within two decades following the discovery, salt production zoomed to high figures, competition was described as "cut-throat," and the price reportedly went as low as a few cents per barrel. The weaker companies failed or were bought up by the stronger. The industry became stabilized soon after the turn of the century and neither production nor industrial policies nor the producing companies have changed greatly since. Today, methods and plants are modern and the operations are models of the domestic mineral industry.

GEOLOGY

Two known salt zones of significant thickness — a dozen feet, say, as a minimum — are distributed over more than 30 counties in the western two-thirds of Kansas. The two zones are: the more important Hutchinson salt member of the Wellington shale, and a salt member lying roughly 1,000 feet higher stratigraphically in the Nippewalla group. Both zones are of Permian age, which also is the geologic age of the salt deposits of northern Texas and of the important Stassfurt deposits in Germany.

In Kansas, the salt zones lie within a thick sequence of shales predominantly of continental origin, locally gypsiferous, and containing some rather thin marine limestone layers.

The salt beds, or "sections" as they are recorded in the logs of numerous holes drilled for petroleum, are those thicknesses which seem to be composed largely of rock salt. In detail, the salt members (so far as present information goes) consist, essentially from top to bottom, of flat-dipping halite, sodium chloride, interbedded or interlaminated with shale bands. The latter vary in thickness from that of a pencil line to many feet, the boundaries being either knife-edge or, locally, gradational. Numerous beds within the salt sections are depositional mixtures of salt and silt in which the variation in content, as one scans a vertical section, may run from almost pure salt to almost pure shale, or the reverse.

Seemingly, the only impurity of consequence noted to date in Kansas salt, aside from the shale, is anhydrite (or gypsum, the hydrous form of calcium sulfate) which commonly represents no more than a few percent of the rock.

Judging by the salt bed being mined near Hutchinson and Kanopolis, a section 9 to 12 feet thick near the base of the member, horizontal laminations of the salt in the form of tiny shale bands is the most obvious characteristic of the sedimentation of Kansas salt. These thin bands or laminae, which in many cases are merely dark layers of salt discolored by a small silt or shale content, are not wavy, but very straight and uniform laterally, suggesting deposition in quiet water. Some geologists regard these individual salt bands as probably being the deposits of a single year, the shale bands corresponding to seasonal surges of muddy water into the basin.

Bass [5] discussed the general structure of the salt beds and noted that the

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5/ N. W. Bass: Structure and Limits of the Kansas Salt Beds. State Geol. Survey of Kansas, Bull. 11, pt. IV, pp.   , 1926.

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eastern boundary of the Hutchinson salt member, passing through Sedgwick, Harper, and McPherson Counties, is very abrupt and seems to be an erosional or solution contact. At Hutchinson the salt bed being mined exhibits what seems to be a definite system of incipient fractures, analogous to the "cleat" in coal. Whether or not the incipient fractures noted are definitely related to local or regional structural pattern -- the anticlines, uplifts, and basins -- is not known.

As to origin, the Kansas salt beds doubtless were deposited in a relatively shallow, quiet sea by evaporation and concentration of saline waters or bitterns. Probably the sea occupied an inland basin not connected (at least at the time of deposition of the Hutchinson salt member) with the larger Permian sea which deposited salt beds in northern Texas and New Mexico. Also, the Kansas salt beds (judging by the rather limited available information on their nature and composition) probably represent largely chlorides that have been redissolved, transported by streams, and laid down with modified composition in their present form and location. This could happen if streams carrying in solution, mainly the more soluble sodium chloride from an exposed or upwarped salt area, drained into the broad, shallow, closed basin — the Kansas area — where concentration and precipitation of brines formed thick salt beds carrying little sulfate. Evidence for these tentative conclusion is contained in the fairly well-known reactions that take place during precipitation of salts from sea water, and from the lack of conformance of the Kansas deposits with the established principles.

MINING

Salt production in Kansas is by two methods: by evaporating of brine from wells and by underground mining. Three mines, one at Hutchinson belonging to The Carey Salt Company, one at Lyons of the American Salt Corporation, and one at Kanopolis of the Independent Salt Company are operating in the State at this time. The Carey company has an idle underground mine at Lyons. Four salt companies have operating salt brine and evaporating plants. They are the Morton Salt Company of Hutchinson, the Barton Salt Company of Hutchinson, The Carey Salt Company of Hutchinson, and the American Salt Corporation of Lyons. Only the American Salt Corporation at Lyons has both its brine evaporating plant and its rock salt operation "on one lot." All operating companies were most cooperative in supplying details for this paper.

It has become the practice at Hutchinson to drill brine wells as 8-inch holes to a depth of about 65 feet and there to set and cement casing. The hole, reduced to 5 5/8-inches, is continued to about 160 feet, and another string of casing is set and cemented. The hole is then drilled on to the bottom of the salt section, at approximately 715 feet in the Hutchinson area. From the bottom of the casing at 160 feet to about 715 feet the hole is open. The surface spacing of brine wells is at 400-foot centers or thereabouts and the wells have a life of 30 or 40 years.

Clean water at natural temperature, about 70° F., is pumped under pressure of about 120 pounds per square inch through an inner string of 2-inch tubing which goes down inside the casing to the bottom of the hole. Pressure brings the salt-laden brine out of the well through the larger casing outside the 2-inch tubing. The brine, at about 96 or 98 percent sodium chloride saturation, is conveyed to the evaporating plants. Old wells sometimes become connected underground when their solution chambers merge. Then, water may be pumped down through one well and brine taken from the adjacent one. Each gallon of water pumped into the wells accounts for about 3 pounds of salt, each gallon of brine bringing up about 2.5 pounds of salt (2.65 pounds if the solution be completely saturated).

The underground mining of salt in Kansas reveals some features that are almost unique in mining practice. Most impressive even to mining men of broad experience is the first view of a "king-size" room more than 1,000 feet long, 50 feet wide, 8 to 12 feet high, with not a stick of timber in sight and no evidence of spalling or sagging of the roof (or of heaving of the floor). There are instances — an occasional experience at Lyons and Kanopolis — where rooms have developed roof sags after standing open 2 or 3 years. In such cases a layer of salt a few feet thick has broken to a shale parting, and the loosened layer must be taken down if the room is needed for a haulage. It can be said, however, that the roof in Kansas salt mines gives comparatively little trouble.

One may not see a drop of water in the mines although the working levels range from 700 to 1,000 feet below surface. Commonly a few gallons of water per day are caught at ledge and pumped to surface. Neither is there any seepage of natural gas into the workings although there are numerous oil and gas fields in the salt area.

Mining practice in the underground mines of the State does not vary much. The Carey mine at Hutchinson, compared with the average underground mine in the United States, would probably be regarded as a show place. It will be described as representative. A section of the salt 8 to 10 feet thick near the base of the Hutchinson salt member is mined by an ordinary panel or room and pillar method which has been changed little in detail for many years. Except near the haulageway pillars are 40 feet square and rooms or spaces between the pillars are 50 feet wide. This gives a salt recovery of 80 percent of the area mined. At Kanopolis, both pillars and rooms are 45 feet wide, giving a recovery of 75 percent. Pillars are never removed. There is no visible subsidence of the ground surface in the vicinity of any of the salt mines.

The salt beds, except for minor warps, are flat. At present mining at the face is about 1 mile from the shaft station at the Carey mine. Mining advances away from the shaft and a pillar 50 feet thick (with occasional break throughs which are later lagged up) is carried along the main entry or tramming road to control ventilation. The tramming track is turned at 90° right or left from the main entry as much as 500 feet to a temporary loading station. The latter, equipped with a Joy PL-1117-RU ramp loader or elevating conveyor, receives the salt from pneumatic-tired shuttle cars direct from the working face. When the salt has been mined to one loading station from a radius of about 500 feet — seemingly the optimum haulage distance for the shuttle cars, the station is moved or advanced to a new point to cut down the average haulage distance.

Drilling of the salt face is a crawler-tread jumbo mounting four Howell drills operated by two men. The jumbo is moved by electric motor supplied by cable. Three horizontal rows of 1 5/8-inch diameter, 10 or 11 foot long holes — about 44 to the round — are drilled at approximately 54-inch centers across the 50-foot room face. It requires about 3 minutes to drill a hole, and about 2½ hours to drill a room face. Central Mine and Equipment Company detachable, throwaway bits are used.

The entire face is undercut at the floorline by a Goodman No. 12-G-3A shortwall undercutter with 10-foot bar making a 6-inch kerf. A ground cable supplies 440-volt A.C. to the machine which moves automatically by cable feed across the even floor at 4 inches per minute.

The holes are loaded with Trojan TL 503-M, 40 percent dynamite with instant detonators in the bottom holes and delays to fire the upper rows in succession. Each round of holes blasted advances the face about 9½ feet and yields a muck pile of about 250 short tons of salt. Roughly 1.9 pounds of powder are consumed per ton of product. Blasting is calculated to give a minimum of fines. Chunks that break too large are reduced with a jackhammer.

A Joy 11-BU continuous load (or "craw-dad" in the vernacular) mucks the salt into the shuttle car for delivery to the loading station on the main haulage. The shuttle car, a Joy 60-D3-MS-1 is powered by two 24-cell storage batteries which are charged daily. It carries 10 tons of salt at a speed of 5 or 6 miles per hour, and discharges its load into the hopper of the ramp loader which fills the tram cars.

Tramming to the shaft is by an 8-ton General Electric combination trolley and storage battery underground locomotive drawing a trip of 14 cars of 4 tons capacity. The loaded cars go through a rotary dump at the shaft station and the salt is hoisted through a vertical concrete-lined shaft in skips working in balance, the man cage attached under one skip.

The entire underground crew at the Carey mine at Hutchinson consists of 12 men, who work one shift, and the production runs about 600 tons per day. The crew consists of one maintenance man, one powder man, two drillers, two undercutter men, one Joy loader man, two shuttle car operators, one loading elevator man, one trammer, and one shaft station man.

At surface, the salt passes through a Kennedy Van Saun 26-by 34-inch jaw crusher set to about 1-inch opening, then to vibrating sizing screens and on to the sacking department or to bulk storage bins. Some operators mix selected mineral additives with part of the salt for sale in bulk or as 50-pound pressed blocks for stock salt or for special uses. Labor receives $1.14 to $1.34 per hour, works an 8-hour day, a 40 hour week and belongs to the United Mine Workers Union.

In Kansas, rock salt is commonly sold in 4 or 5 grades according to size. See Table . The coarse grades sell to industrial consumers for $5 to $6 per ton f.o.b. plant, and the finest sizes at about $4. At the present time, roughly one-third of the rock salt produced in the State leaves the plants by truck, and two-thirds by rail. The truck deliveries are increasing.

Table .—Screen sizes and approximate salt content of rock salt as sold in Kansas

Grade	Through mesh	On mesh	Approx. NaCl content
No. 2	5/8 inch	3/8 inch	91%-93%
No. 1 special	3/8 inch	.25 inch	95%±
No. 1	.25 inch	.158 inch	94%-96%
No. 7	.158 inch	.080 inch	97%±
No. 4	fines through .080		96%±

REFINING

The refining of salt by evaporation of brine from wells as practiced in Kansas is by two methods: by steam grainers and by vacuum kettles. Most evaporated salt is produced by the vacuum method which yields "granulated salt," commonly used in large quantities by the meat packing and soap industries, and for stock salt in bulk or pressed into blocks. Steam grainers produce so-called "flake salt" which is carefully screened to the desired sizes to effect the necessary rate of solubility demanded by certain users. The most finely-crystallized salt, almost as fine as face powder, is sold to mixers of patent cake and pancake flour; ~~that with~~ the next larger sized crystals ~~goes~~ go to the butter makers. Grainer salt is used mainly in food processing and costs considerably more to manufacture than vacuum kettle salt although the two are substantially of the same quality.

In the vacuum process, brine which is near the saturation point in salt concentration is pumped into vertical tanks or kettles about 20 feet in diameter and 60 or 70 feet high with cone-shaped tops and bottoms. Brine enters midway of the kettle; low pressure steam — exhausted from the turbine-electric generator or engine at the power plant, enters through the side of the first kettle and heats the brine which is circulated around hot tubes by a down draft propeller; and the salt crystallizing as individual grains with little chance to form aggregates, is drawn out of the bottoms of the kettles as a slurry to be filtered, dried, and packaged or stored for bulk shipment. Standard drum-type Oliver filters and rotary driers are used. Additives such as .01 percent of potassium iodide and suitable stabilizers are mixed with portions of the salt at suitable points in the circuit to make certain desired products.

To obtain high over-all thermal and power efficiency in the salt plant, natural gas is burned to produce steam which is converted to electrical power in a steam turbine or engine. Exhaust steam from the power plant at about 10 pounds pressure is used to heat the brine in the first vacuum kettle; the vapor from the boiling brine in the first kettle is used to heat the brine in the second kettle in the series; vapor from that kettle goes to heat the third, and so forth. The kettles, commonly four to the plant, are connected either in a series or parallel arrangement. By maintaining a higher vacuum in each succeeding kettle, the brine is made to boil — although at a lower temperature than in the preceding kettle. In the last kettle in the series, the brine which is under the highest vacuum, may boil at a temperature as low as 110° or 120° F. Salt precipitation is continuous during the runs which vary from one to several deep. After each run the kettles are emptied to remove salt that adheres to the flues. Periodically the kettles are chemically treated to remove scale.

Steam grainers are shallow, open tanks about 2 feet deep by 12 to 20 feet wide by 125 to 150 feet long, with immersed steam pipes for heating the brine and fitted with mechanical rakes for removing the salt. Grainers are filled with brine which is evaporated without agitation or vacuum. Salt crystals forming at the surface of the brine gather into aggregates and sink to the bottom as their increasing weight breaks the surface tension of the liquid. Although the salt always crystallizes in tiny cubes, the cubes make both irregular and cup-shaped crystal aggregates which supply also a coarser product desired by some users. The salt, moved to the hot end of the grainers by rakes, is pumped carefully or conveyed to avoid breaking up the crystals, and is then dried, screened to size, and packaged or stored for shipment.

Constant and careful laboratory control is maintained to assure the uniformly high quality of salt produced in these evaporating plants. The fine salt from Kansas plants commonly runs more than 99.2 percent sodium chloride. Table salt carefully screened to uniform grain size receives a bit of inert additive, usually magnesium carbonate or perhaps a phosphate, to prevent lumpiness and to promote free flowing.

The analyses of Kansas rock salt, evaporated salt, and brine vary through small limits. Average figures are given in Table .

Table .—Approximate average analyses of Kansas salt and brine

Chemical	A Grams per liter	B percent	C percent
Sodium chloride, $NaCl$	304.24	99.34	96.505
Calcium sulfate, $CaSO_4$	5.261	0.61	3.234
Magnesium chloride, $MgCl_2$	1.233	0.03	0.151
Calcium bicarbonate, $Ca(HCO_3)_2$	0.272		
Calcium chloride, $CaCl_2$	0.260	0.02	0.002
Ferric oxide, Fe_2O_3	0.0001	0.001	0.008
Acid insolubles		0.001	0.100

A is an average analysis of brine from wells in the Hutchinson area.

B is an approximate average analysis of Kansas evaporated salt as produced at Hutchinson and Lyons.

C is a typical analysis of rock salt as it is mined at Hutchinson.

Spectrographic analyses made by the Geological Survey of Kansas laboratory show no significant trace elements in the salt.

RESERVES

As a minimum figure, Kansas salt reserves are ample to supply the present needs of the entire United States for more than 30,000 years. That would be the reserve if a bed 10 feet thick, as is mined in Kansas at present, were to be calculated over the known salt area in the State. Actually, as the isopachus map, Figure indicates, the average thickness of the salt over the area is more than 100 feet.

The calculation of salt reserves is as follows: 640 (acres) x 36 (sections/twp.) x 25 (twps./county) x 30 (counties underlain by salt) x 3,000 (tons salt-acre-foot) x 10 (salt thickness) = 518.4 billion tons of salt.

ECONOMIC ASPECTS

Salt, the one item in the entire mineral kingdom with which all human beings are familiar, is so widely distributed over the earth that its value in the ground or as ocean brine is almost nil. Reserves are almost unrelated to value or price.

Rock salt at the plant is worth (say, in ton lots) $5.00 per 2,000 pounds. But the evaporated variety, purified, carefully screened, treated to make it flow freely, perhaps iodized, packaged, labeled, shipped in cartons to the distributor and on to the retailer, and purchased by you from the grocer's shelf — costs 10 cents per pound package. The value is increased 40 times by manufacture. This increment is not excessive.

Salt mining is so comparatively simple, both as brine and by underground mining, that its produced value should be low. It is low, indeed, when one considers the host of users each of whom requires a slightly different product. The difference may be grain or screen size, shape of crystal (some want a flat flake), rate of solubility, the amount of shale, gypsum or anhydrite permitted, or in the purity of the sodium chloride itself. The sale or disposal of salt fines which contain a visible amount of inert but dirty-looking shale — the so-called "No. 4 salt problem" — plagues the industry to some degree. Research to satisfy consumers on both quality and price of the salt, continues on the various problems.

The market will only consume so much salt; people don't buy extra quantities anticipating price changes or, like an extra radio set, because it's nice to have around. Competition follows a pattern, nevertheless. The salt industry is that way.

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