

HALITE--SALTY MYSTERY OF LIFE

Circular 11



STATE OF INDIANA
DEPARTMENT OF NATURAL RESOURCES
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1981

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Halite – Salty Mystery of Life

By R. DEE RARICK

DEPARTMENT OF NATURAL RESOURCES
GEOLOGICAL SURVEY CIRCULAR 11



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Contents

Introduction	1
Civilization and salt	2
What is salt?	4
Sources of salt	4
Saltmaking in Indiana	7
Pioneer days	7
Early Hoosier salt production	9
Improved transportation — canals and railroads	11
Industrial uses	12
Some Hoosier saltmakers	12
End of an era	15
Improved methods of producing salt	15
Salt deposits in the United States	17
Modern methods of mining salt	20
Annual production and general uses of salt	21
Conclusion	21
Acknowledgments	24
Selected bibliography	24

Illustrations

- Figure 1 Hopper-shaped cube of halite 3
- 2 Crystal structure showing arrangement of atoms in halite 3
- 3 Boiling down brines in large kettles 5
- 4 Primitive drilling machine used by the Chinese about 2,000 years ago 6
- 5 "Stomping down a well" with a spring-pole drilling rig 10
- 6 Brine from an old oil-test well at Mifflin (Crawford County, Ind.) used by Otter Creek saltmakers 13
- 7 Guests drinking mineral water at the West Baden Springs Hotel 14
- 8 Magnified cube-shaped crystals of table salt 16
- 9 Diagram showing method of recovering brine from subsurface salt deposits by injecting water and air 17
- 10 Subsurface salt deposits in the continental United States 18
- 11 Ceilings 140 feet high in a salt-dome mine at Avery Island, La. 19
- 12 Uses of salt 22-23

Halite—Salty Mystery of Life

By R. DEE RARICK

Introduction

Salt is vital to nearly all living things and has been almost since the beginning of time. Men and other animals need common salt to help maintain a critical chemical balance in their bodies. The blood and other fluids that bathe every cell of our bodies consist basically of a salt solution of almost the same proportion or composition as that of sea water. Salt regulates the exchange of water between the body's cells and their surrounding fluid, which carries food in and wastes out. When the first vertebrates crawled out onto the land to stay, these internal saline fluids enabled them to survive in that strange new environment. Salt is necessary for life. Without it man and all other animals would die.

The blood and interstitial fluids of the body contain about 4 ounces (about a cupful) of salt. We sometimes taste this salt in our tears, our sweat, or blood from a cut. The body gradually loses this salt through perspiration and excretion, and the body's salt balance must be regularly replenished. An adult human of average size and weight takes in about 6 grams (a thimbleful) of salt in a day. About half of this daily requirement comes from salt added to food; the rest comes from the natural salt content of the food we eat and the water we drink. Scientists have estimated that adult humans require an average of about 5 to 6 pounds of salt a year.

A healthy body maintains an exact balance between intake and discharge of salt. Some diseases cause the body to malfunction by upsetting this delicate balance. Persons whose systems do not maintain the sodium at the optimum level but permits it to accumulate must go on a salt-free diet. Excess sodium allows unwanted fluid to accumulate in the tissues, which causes swelling and other discomfort. Too low a level of sodium causes the body tissues to dehydrate. If this condition is not quickly corrected, the body will die.

Civilization and Salt

Primitive man, in changing his habitation, sometimes failed to realize that salt, as well as food and water, was necessary for life. Historians believe that when man finally realized that he had to have salt, trade began—and that salt was probably one of the first trade articles. Trade in salt determined the routes of the first trails, roads, and sealanes, and along these land and sea routes man built cities.

Salt has greatly influenced man's travels and explorations around the world. For without it to preserve foodstuffs, he could not have wandered so widely, to explore, to learn—and ultimately to progress. Salt draws moisture from meat, dehydrating it to delay spoilage. Until the development of refrigeration, most meat in the world's diet was salted. In cooking, the addition of salt brings out the flavor in foods. In fact, the flavor of almost all food and drink is enhanced by adding as little as .5 percent salt.

Ancient civilizations—their rise, their prosperity, and even their decline and disappearance—were greatly influenced by the availability of salt, food, and water. In the ancient world, man regarded salt as a valuable and even a sacred substance. Customs and superstitions were developed around it. People over much of the world made it part of their religious ceremonies. Beliefs in salt's supernatural powers continue in some isolated parts of the world today.

Since ancient times, salt has been used as money in Europe, Africa, and across Asia to China. Slaves were bought with it. The use of salt as money has continued into the 20th century. In central Africa until the early 1900's it could be used to purchase a bride. Even during World War II, pilots flying over China carried salt as well as money; they might be forced down in remote areas where the natives would demand salt in payment instead of money. Salt is still used as money in some primitive areas of the world.

Salt was certainly important in the daily life of the pioneers who first explored and later settled what is now Indiana. Until these people could locate licks or springs where, with much time and effort, they could make their own supply of salt, this staple was carried along with them in their packs whether they were afoot, on horseback, in a canoe, or on a flatboat. They made regular trips upriver, downriver, or overland to obtain salt—just as regularly as they were later to take their grain to a water-powered gristmill along some Hoosier river.

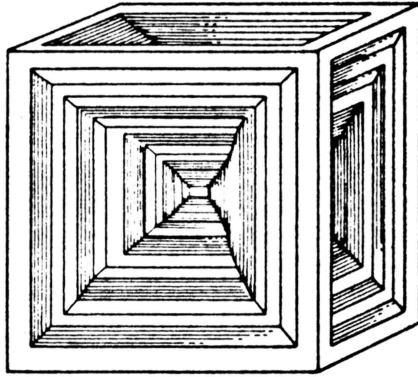


Figure 1. Hopper-shaped cube of halite. From "Manual of Mineralogy," 19th ed., John Wiley & Sons, Inc., New York, 1977.

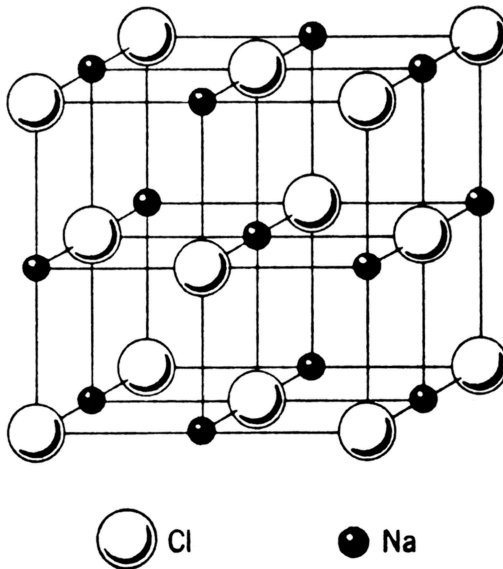


Figure 2. Crystal structure showing arrangement of atoms in halite. From "Manual of Mineralogy," 19th ed., John Wiley & Sons, Inc., New York, 1977.

What Is Salt?

For all of its importance to man and other animals, salt is a common and uncomplicated mineral. It is a blend of almost equal numbers of atoms or amounts of the elements sodium and chlorine; therefore, the chemical name sodium chloride. Sodium is a reactive and unstable metal. It combines or reacts easily with many other elements; it will even burst into flame in water. Chlorine is a lethal gas. A dramatic change takes place when these two elements combine, for they form stable and harmless white crystals of a mineral named halite. The shape of all crystals is cubic (fig. 1). The characteristic shape of salt crystals arises from the internal arrangement of the sodium and chlorine atoms. The tiny atoms, one ten-millionth of an inch in diameter, are arranged in a boxlike array known as a crystal lattice (fig. 2) that is repeated in three dimensions. The structure of halite, therefore, is simple compared with that of other minerals.

Sources of Salt

The sources of salt in ancient times were as we know them today: sea water; the salty ashes of land and marine vegetation; salty or brackish water of certain springs, streams, ponds, or lakes; salt water from wells; salty earth or rock formations; surface salt deposits; and subsurface salt deposits. As with certain other mineral resources, some areas abound with salt; others have little.

For thousands of years, salt was obtained by three basic production methods: solar evaporation in ponds, boiling brines in kettles (fig. 3), and hacking rock salt out of the earth. Besides evaporating brine, early man dug for deposits of rock salt wherever he could find them at or near the surface of the ground. These mines were more like quarries because of the primitive tools that he had available. As tools were improved, early man gradually dug deeper for salt.

The Chinese were the first to develop techniques that enabled them to drill deep wells in search of brines. Probably they were the first to discover that deep brines were saltier than sea water and yielded a better quality of salt. The Chinese used a chisel-like iron bit attached to a length of bamboo and suspended by a rope from a large walking beam or a spring pole and used hollow sections of large



Figure 3. Boiling down brines in large kettles. This was an old saltmaking method in Agricola's time. From Agricola's "*De Re Metallica*," 1556.

bamboo trunks for casing to drill 400-foot-deep brine wells as early as 250 B.C. By 400 A.D., they were drilling wells as deep as 3,000 feet (fig. 4). Medieval European travelers in China reported as many as 10,000 deep brine wells in operation in that country. Although word of the successful drilling techniques of the Chinese was brought back by early traders, drilling in Europe was not reported until the Middle Ages. When drilling was finally adopted and used on the European continent, it was used for many years almost entirely in quarrying and mining. Immigrant drillers and saltmakers, using the

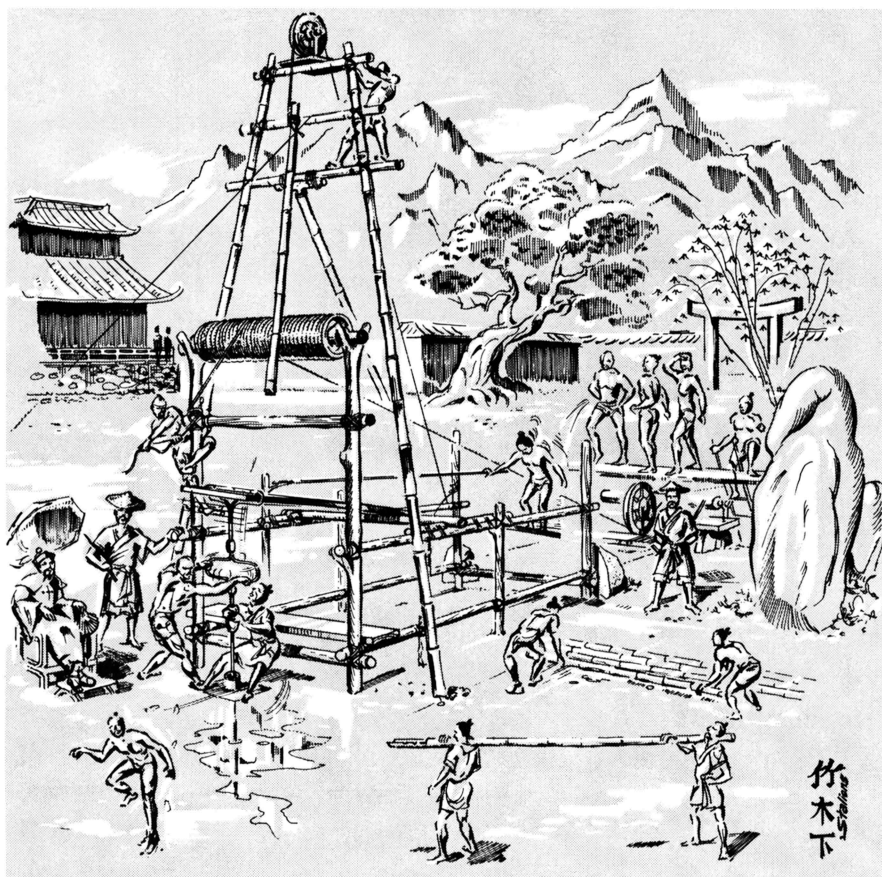


Figure 4. Primitive drilling machine used by the Chinese about 2,000 years ago.

methods of the ancient Chinese and equally primitive drilling equipment, searched for new sources of salt brines in the New World. Not until early in the 19th century did Yankee saltmen begin to develop some tools and techniques of modern cable-tool drilling.

Saltmakers were plagued by oil in the brines pumped from many wells. To them the nasty-smelling, sticky black goo was of no value or use. Later, a few enterprising persons began to bottle the oil and sell it for its “medicinal qualities.” But during the mid-1800’s, oil began to be appreciated for its potential as a source of illuminating

oil. And a little later, natural gas was eagerly sought for its great heat potential. Paradoxically, most of America's rich underground salt deposits were discovered after 1860—in Michigan, Louisiana, Kansas, and Texas—mostly by crews drilling for oil and gas. Shafts were sunk into these deposits, and so began America's rock-salt industry. Today, such deep deposits yield nearly two-thirds of the world's total annual supply of salt.

Saltmaking in Indiana

PIONEER DAYS

Today when salt is so universally used and so readily available, it is not easy to imagine that early settlers in Indiana regarded salt as a luxury and that they traveled many miles and put in hard labor to obtain even small amounts. There are no salt deposits in Indiana. The only sources for those pioneers were salt licks, some mineral springs, or brines that came from an occasional deep well. Although sodium chloride is a common ingredient, the waters of many Hoosier mineral springs were generally less suitable as a source of salt for early settlers because the quantity of sodium chloride was low in some waters and because other elements colored the salt and affected its taste.

The first settlers in the Northwest Territory found salt an expensive necessity. It was transported from the eastern states over the Appalachian Mountains on horseback or in wagons. From 1788 to 1800, salt sold in the new territory for \$4 to \$8 for an 80-pound bushel. Congress recognized that local salt supplies were important in developing the Northwest Territory and exempted the known salt-lick areas from sale.

Early explorers and travelers in the Northwest Territory noted in their journals that there were salt springs, licks, and mineral springs along the Ohio River and the lower Wabash River. One early traveler who crossed what is now Warrick County in the early 1800's was impressed by some heavily traveled game trails. Following these trails, he found that most of them led to salt licks. Even in those early days, salt-rich springs in southeastern Illinois near the place where the Saline River flows into the Ohio River became widely known. Trails from Vincennes, New Harmony, and settlements far up the Ohio River led to springs near the mouth of "Saline Creek." These trails were later known as salt routes.

Between 1795 and 1800, salt was being produced at the springs on Saline Creek. The saltworks was leased from the United States by contractors, and the work was done by Kentucky and Tennessee slaves. Under the terms of the contract, salt at the works could be sold for no more than 50 cents a bushel. It is reported that much of the salt produced was sold to "silent partners," who later resold it for as much as \$2 a bushel.

When in 1803 William Henry Harrison and the Indians signed the Greenville Treaty whereby the Vincennes tract was finally acquired by the white men, salt was an important part of that document. Article III of the treaty stated that "as a mark of their regard and attachment to the United States, whom they acknowledged for their friends and protectors, said tribes do relinquish and cede to the United States the great salt spring along Saline Creek." In return, the United States agreed to deliver 150 bushels of salt annually to the Indians. This salt was to be divided among the several tribes in any manner agreed on by their respective chiefs gathered at their general tribal council.

One account of the discovery of salt near the famous mineral springs at French Lick was reported by travelers who passed through that region in 1816. Their account described the beauty of the scenery they saw as they traveled along the valley trail. They also reported that "as we paused on the north bank, our horses began to lick the ground, and we perceived a whitish coat, like frost, and discovered it to be common salt." Later chemical analyses of the waters of the springs at French Lick and West Baden revealed that this "salt" was mostly magnesium sulfate and calcium sulfate and contained only a small amount of sodium chloride.

During their early geologic work in Indiana, State Geologists David Dale Owen and his brother Richard Owen (first survey in 1837-38; second survey in 1859-60) made a remarkably complete investigation of the state's potential mineral resources. One important economic task that confronted Owen and his assistants was to locate sources of salt. Other than by some travel on the Ohio and Wabash Rivers, most of this work was done on horseback. These geologists followed game trails through the forested hills and valleys of the state, knowing that sooner or later many of these trails would lead to salt licks. Earlier, they knew, Indian hunting parties had tracked wild animals over

some of these same trails and probably collected salt at the licks to preserve the meat of the animals they had killed. Although the geologists found many salt licks, Owen in his final report recommended that wells should be drilled to obtain adequate quantities of brine for salting.

Although scarce and difficult to procure, salt was a must for early settlers. They knew they had to keep a supply of salt on hand. They not only found unsalted food unappetizing day after day but also needed to keep food for use when a fresh supply could not be had. To keep meat even for a few days during warm weather, they had to salt it down. Because salt was scarce, the settlers used it sparingly. When curing meat, for example, they placed the meat in a trough—generally made from a poplar log—and covered it with brine. When they removed the meat, they usually smoked it for further preserving, and they collected the brine from the trough and saved it to be used again. According to reports, some salt sources were guarded much as were the waterholes in the early days of the western plains. Groups of settlers sometimes camped at a site and worked together long enough to obtain a supply that would last for several months. So, we can conclude that in those early days salt was worthy not only of cooperative effort but also perhaps of combat.

Salt licks and mineral springs were much more common in southern Indiana than in northern Indiana. Streams in nearly every southern county are named Salt Creek, Lick Creek, etc., which probably indicates the importance of sources of salt to the pioneer. Many of these salt licks and mineral springs had little or no sodium chloride in their chemical makeup, although wild animals used them. Despite this lack, the mineral-impregnated soil or mineral water seemed to help satisfy an animal's craving for salt.

EARLY HOOSIER SALT PRODUCTION

Nearly all the larger saltworks of Indiana's early history were operated by migrant pioneers who had operated saltworks in the eastern states. These men drilled wells with primitive equipment and used the brine obtained from the wells to produce the salt (fig. 5). During the middle and latter parts of the 19th century, many wells were drilled in Indiana in search of oil. Salt producers later used many of these same wells as sources of brine. The deeper wells were



Figure 5. "Stomping down a well" with a spring-pole drilling rig.

more highly valued, for their brines were generally stronger. The brine was collected and boiled down in large kettles until it thickened and crystallized. The brine from some of the best wells was reported to have made a bushel (80 pounds) of salt from 65 to 70 gallons of brine. Eighty or more gallons of most brines were needed to produce a bushel of salt. The daily output of a well depended largely on the number and size of the kettles that the operator had available. Some saltworks reportedly produced from 12

bushels of salt a day to as much as 25 to 30 bushels a day. Many smaller operations yielded only about a barrel (about 3½ bushels) of salt a day.

When salt could be purchased by the settlers, the price was usually high. But as with other commodities, the price varied with scarcity. In some places salt reportedly sold for 10 to 20 cents a pound. One early report stated that salt was sold for \$10 a barrel at Vincennes but for only \$3.50 a barrel at Vevay in Switzerland County, where it could be purchased from riverboats coming downriver from Cincinnati. Everywhere salt was a desirable item for barter, for "hard money" was scarce on the frontier. Salt was scarce and expensive in the western part of the United States until the middle of the 19th century. In fact, salt reportedly was so scarce in the Oregon Territory in 1852 that it literally was worth its weight in gold. But the canal era had changed the picture in the eastern part of the country. Shipping by water had drastically reduced freight rates.

IMPROVED TRANSPORTATION — CANALS AND RAILROADS

The Erie Canal, which was opened in 1825, has been called "the ditch that salt built." Salt-tax revenues paid for half of its cost. Flatboats of salt were floated from Troy on the Hudson River to Buffalo on Lake Erie. There the salt was reloaded into lake boats enroute to coastal settlements along the shores of the Great Lakes and on to the rapidly growing Chicago. The huge success of the Erie Canal resulted in the beginning of extensive canal construction throughout the eastern United States. But those canals that were completed soon became bankrupt, and many others were never finished. And by the mid-1850's, the need for canals had virtually ceased because of the growing competition of the railroads.

Canals were vital to the progress of the country, because they were an improved means of transportation to and from the frontier until something better could replace them. For the first time, salt, coal, all kinds of produce, and manufactured goods could be shipped long distances at low freight rates. Canals enabled westerners to ship produce to eastern and southern markets and also enabled easterners to ship coveted manufactured goods and badly needed staples to the settlers on the western frontier. Besides, canals transported thousands of immigrants into the western country.

INDUSTRIAL USES

Salt was a raw material desperately needed by many early Hoosier industries. Often there was a real problem of obtaining adequate supplies for their continued operation. As Hoosier industries developed and expanded, the availability of salt became increasingly critical. Besides its use in meat preservation, salt was needed for curing hides and tanning leather, glassmaking, pottery glazing, textile dying, soap manufacturing, and later for iron and steel manufacturing and other food processing. Today, the chemical industry—the major consumer of salt—uses more than 40 out of every 100 pounds produced.

SOME HOOSIER SALTMAKERS

In the early 1830's, several salt wells were drilled in western Indiana to furnish brines for saltworks. Some of these wells were drilled on Silver Island in southwestern Fountain County. One owner was Norman H. Thomas, who made salt for many years from these wells. Thomas, a "practical saltmaker," had migrated from the famous saltmaking area along the Kanawha River in Virginia (now West Virginia). One of his best wells was the famed Lodi Artesian Well (near present Waterman), a 1,118-foot-deep well that had originally been drilled in search of oil. Thomas continued to operate his business until cheaper salt from deposits in New York and Michigan was brought into Indiana at extremely low freight rates by the Wabash and Erie Canal. In 1838 David Dale Owen visited Thomas's Coal Creek operations in Fountain County during his geological survey of the state. He was particularly impressed by the size of the Thomas saltworks and by the quality of its salt. A Mr. Wallace, another Silver Island saltmaker whose 600-foot-deep well was a quarter of a mile up Coal Creek from the Thomas wells, produced good-quality salt from his well for several years.

In 1869 State Geologist E. T. Cox visited the Thomas saltworks in Fountain County. He reported that "the 'Thomas well' still produces a good flow of brine, which, at the time of my visit, was pumped by hand, and made into salt on a limited scale by a man who was permitted to use the company's kettles, nine in number, free of charge. He collected the fuel used under the kettles from the fallen forest trees, and carried it to the works upon his shoulders, pumped



Figure 6. Brine from an old oil-test well at Mifflin (Crawford County, Ind.) used by Otter Creek saltmakers.

the water, and in fact did all of the work about the establishment himself, and was making about one barrel of good white salt per day."

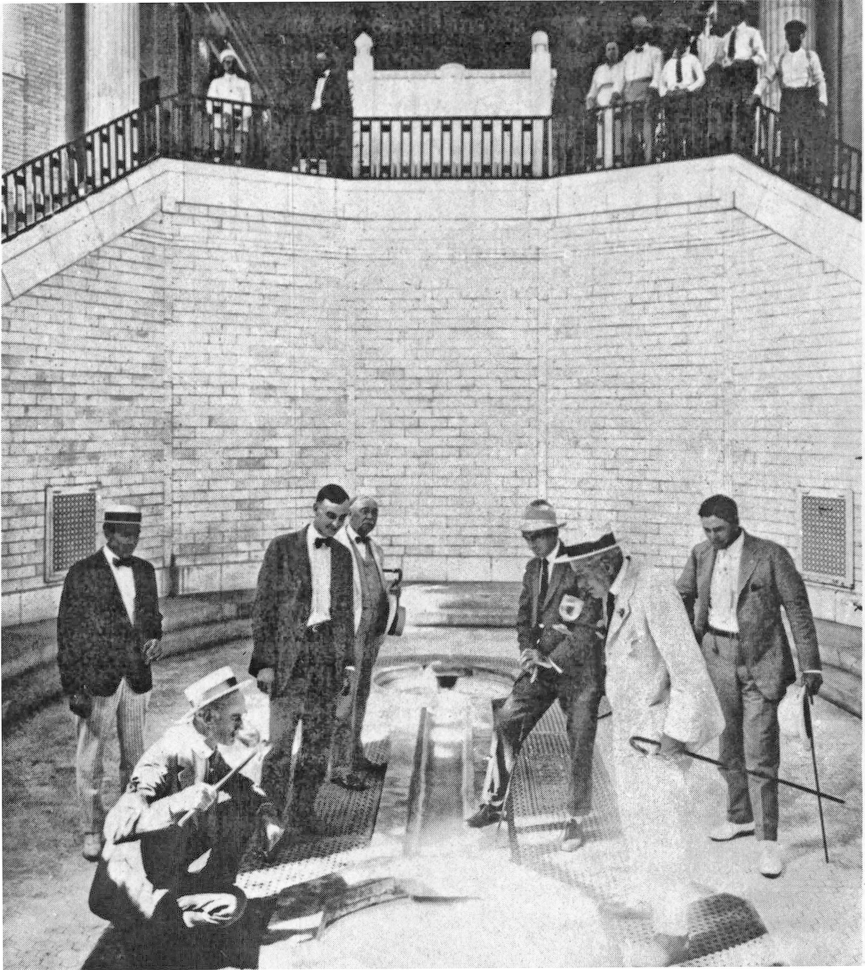


Figure 7. Guests drinking mineral water at the West Baden Springs Hotel, one of Indiana's popular mineral spas.

In 1870 Cox visited salt wells along Otter Creek in Crawford County operated by E. H. Golden and by a Mr. Benham, whose wells were about a mile south of Golden's wells. All were old oil-test wells drilled near Mifflin (fig. 6). The best was the 1,170-foot-deep well used by Mr. Golden. Brine reportedly flowed from this well at the

rate of 1,600 gallons in a 12-hour period. Sixteen kettles, each holding a hundred gallons, constituted the boiling capacity of the works, which yielded 25 barrels of salt in a 36-hour period. Wood was used as fuel under the kettles, and the cost of manufacturing was about 17½ cents a bushel. Cox also visited Benham's two wells and reported that while they yielded about the same quality of brine as Golden's best well, they made only about 12 barrels of salt a day.

END OF AN ERA

The lower freight rates made possible by the Wabash and Erie Canal marked the beginning of the end for Indiana saltmakers. With the construction and expansion of railroads resulting in even lower freight rates, Hoosiers could obtain large quantities of relatively inexpensive salt from out-of-state deposits. Therefore, a colorful pioneer industry came to an end. Indiana's mineral waters—both the natural springs and many of the old wells—went on to be exploited in a different way. They marked the sites for development of mineral-water spas, which were popular from the 1880's until about 1920 (fig. 7). Most of those that were still in operation after 1920 went out of business during the depression of the 1930's.

Improved Methods of Producing Salt

Although man had been making salt for thousands of years, he had never improved the basic methods of production: boiling brine in kettles, solar evaporation in ponds, and mining rock salt out of the earth. The first advances in salt production ever recorded were made in the 1880's by two American saltmakers—Joseph Duncan of Silver Springs, N.Y., and Crockett McElroy of St. Clair, Mich.

For years Duncan had operated his saltworks, making the same gray flaky salt produced by countless generations of saltmakers the world over. Seeking to improve the quality of his salt, this ingenious man began experimenting. Eventually, he found that by boiling the brine in a sealed kettle from which the air had been removed, the salt crystallized into clean white cubes like granulated sugar (fig. 8). This method required less heat and therefore less fuel than did the traditional open-kettle boiling. Duncan's method, with the use of many larger and improved "kettles" and special pumping systems, is used today by salt industries to produce table salt.

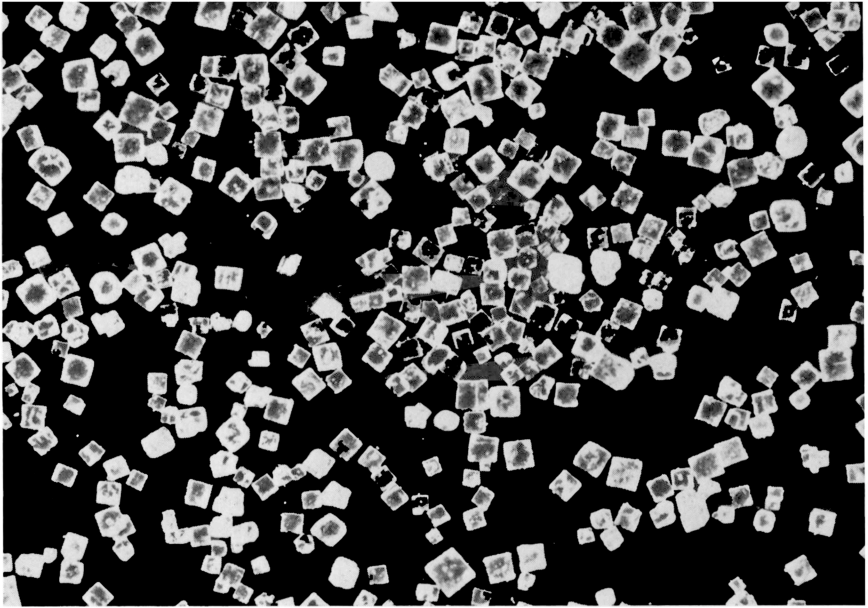


Figure 8. Magnified cube-shaped crystals of table salt.

Almost by accident, Crockett McElroy discovered a way to extract salt from deep underground deposits without digging an expensive mine shaft. After surface salt springs and streams near St. Clair began to dry up, McElroy decided to drill a deep well to obtain brine. After drilling for 3 months, he found salt at a depth of 1,633 feet. But to his bitter disappointment it was rock salt instead of brine. McElroy's hopes vanished, for he could see no way of extracting the salt without digging a mine shaft. After brooding for many days over his failure to obtain brine from the well, he was suddenly inspired. If he couldn't get brine from the well, he would pump water into the deposit. Suspending a smaller pipe inside the outer casing, he pumped fresh water down between the two pipes (fig. 9). To his great joy, the water dissolved the salt, and soon rich brine flowed back to the surface through the smaller pipe. Now he could obtain unlimited quantities of brine for his saltworks at low cost.

Modern hydraulic mining of salt deposits requires enormous quantities of fresh water and elaborate pumping systems, but it still

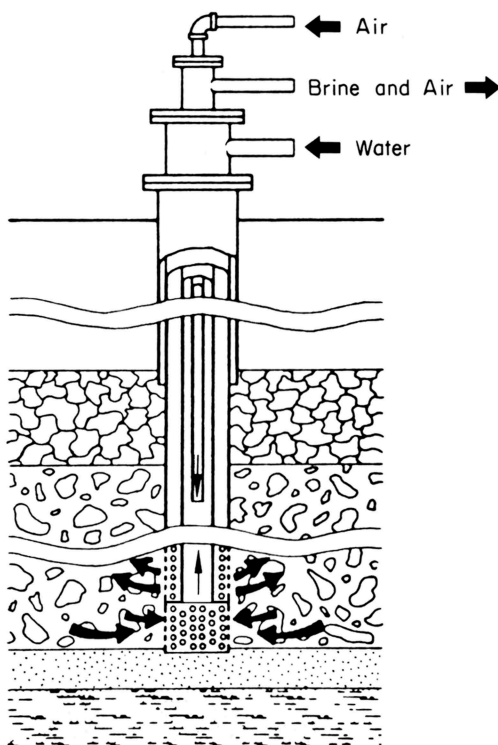


Figure 9. Diagram showing method of recovering brine from subsurface salt deposits by injecting water and air. Modified from "Industrial Minerals and Rocks," 4th ed., Am. Inst. Mining Metall. Petroleum Engineers, 1975.

is the cheapest way of obtaining salt from subterranean deposits. Today, McElroy's brine-pumping method accounts for more than half of the salt produced annually in the United States.

Salt Deposits in the United States

Salt deposits occur in many places in the United States (fig. 10). Known reserves are conservatively estimated to be 60 trillion tons, so salt can be considered one of our most abundant mineral resources.

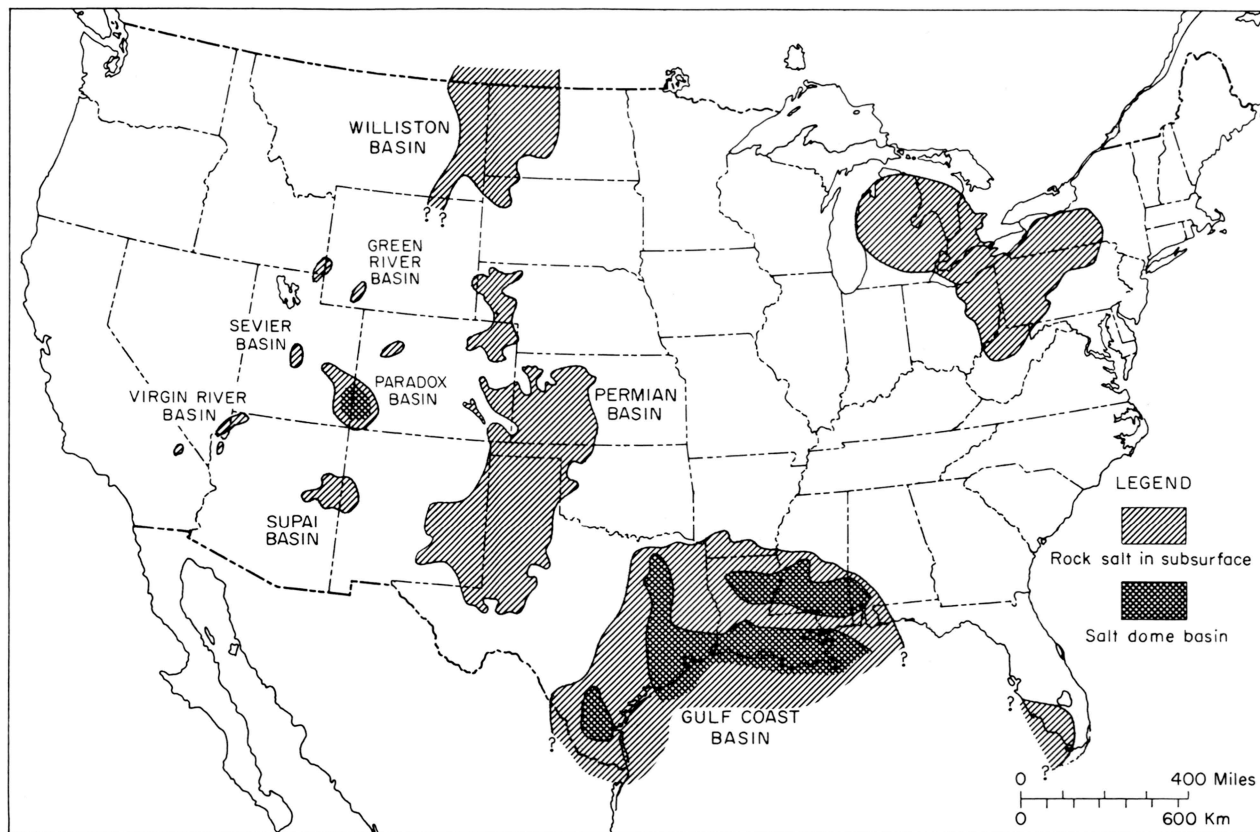


Figure 10. Subsurface salt deposits in the continental United States. Modified from "Industrial Minerals and Rocks," 4th ed., Am. Inst. Mining Metall. Petroleum Engineers, 1975.



Figure 11. Ceilings 140 feet high in a salt dome mine at Avery Island, La., making men and machines look like toys. Photograph courtesy of International Salt Co., a part of Akzona, Inc.

Numerous small deposits are found in basins of evaporated lakes, or playas, which occur in arid regions. But nearly all larger deposits are subsurface bedded deposits and salt domes.

During a long time, playas built up salt and other evaporite minerals as mineral-laden water evaporated following infrequent rains. The salt and other soluble minerals, if present, were leached from the rocks by these rains in the area surrounding the enclosed basin. Most subsurface bedded deposits are parts of ancient inland seas that covered areas of what is now the United States several different times throughout the geologic past. These deposits, later buried by thick beds of sediments that became sedimentary rocks, may be hundreds of feet thick and extensive laterally.

Salt is easily deformed, and when subjected to high pressure, it can flow. Salt domes are structures resulting from the upward movement of deeply buried salt masses; the pressure involved is partly caused by the weight of the overlying sediments and rock formations. In the Gulf Coast region of the United States, where salt domes are common, the salt is in the form of roughly circular plugs of relatively small diameter, but many of these plugs are several thousand feet deep. Some of the largest underground mines in America extract salt from salt domes in the Gulf Coast region (fig. 11).

Modern Methods of Mining Salt

Most playa deposits are surface-mined. The salt and any other evaporate minerals of value are segregated during the processing of the material at the mill. Subsurface deposits, both bedded salt and salt domes, are mined either by brine pumping or by conventional methods of underground mining. All presently operating underground rock-salt mines in the United States and Canada use the room-and-pillar method commonly used in mining coal, limestone, and gypsum.

Annual Production and General Uses of Salt

According to the latest statistics, more than 46 million tons of salt is produced in the United States annually. Louisiana, Texas, New York, Ohio, and Michigan are leading producers. The chemical industry uses more than 40 percent of the U.S. production; de-icing of highways, about 15 percent; food processing, 7 percent; paper manufacturing, 8 percent; ceramic industry, 6 percent; soap manufacturing, 5 percent; plastics industry, 5 percent; metallurgical industry, 4 percent; water treatment, 3 percent; and miscellaneous applications, as much as 14 percent. Hydrochloric acid, soda ash, caustic soda, sodium sulfate, and the elements sodium and chlorine are the major chemical products.

Salt is produced cheaply today, particularly in industrialized nations like America. The average cost of salt in the United States is about \$6 a ton. The average cost of salt from “mining” brines is a little more than \$3 a ton. Even the best quality salt can be sold for a fraction of a cent a pound. The cardboard container you purchase at the store costs two to three times as much as the salt that it holds.

Conclusion

No longer do we value salt and human life in the same terms. Today, salt is so cheap and plentiful that it is taken for granted by most Americans. But do you realize that nearly all the food you eat, every article of clothing you wear, the paper you are looking at, and the ink imprinted on it—in fact, almost every useful article you find in your home or use in your daily living—either is made partly from salt or requires the use of salt at some stage of its manufacture? It is said that salt has 14,000 everyday uses (fig. 12). Salt is truly one of the earth’s most useful and necessary minerals. It is fortunate that salt is available in such abundance.

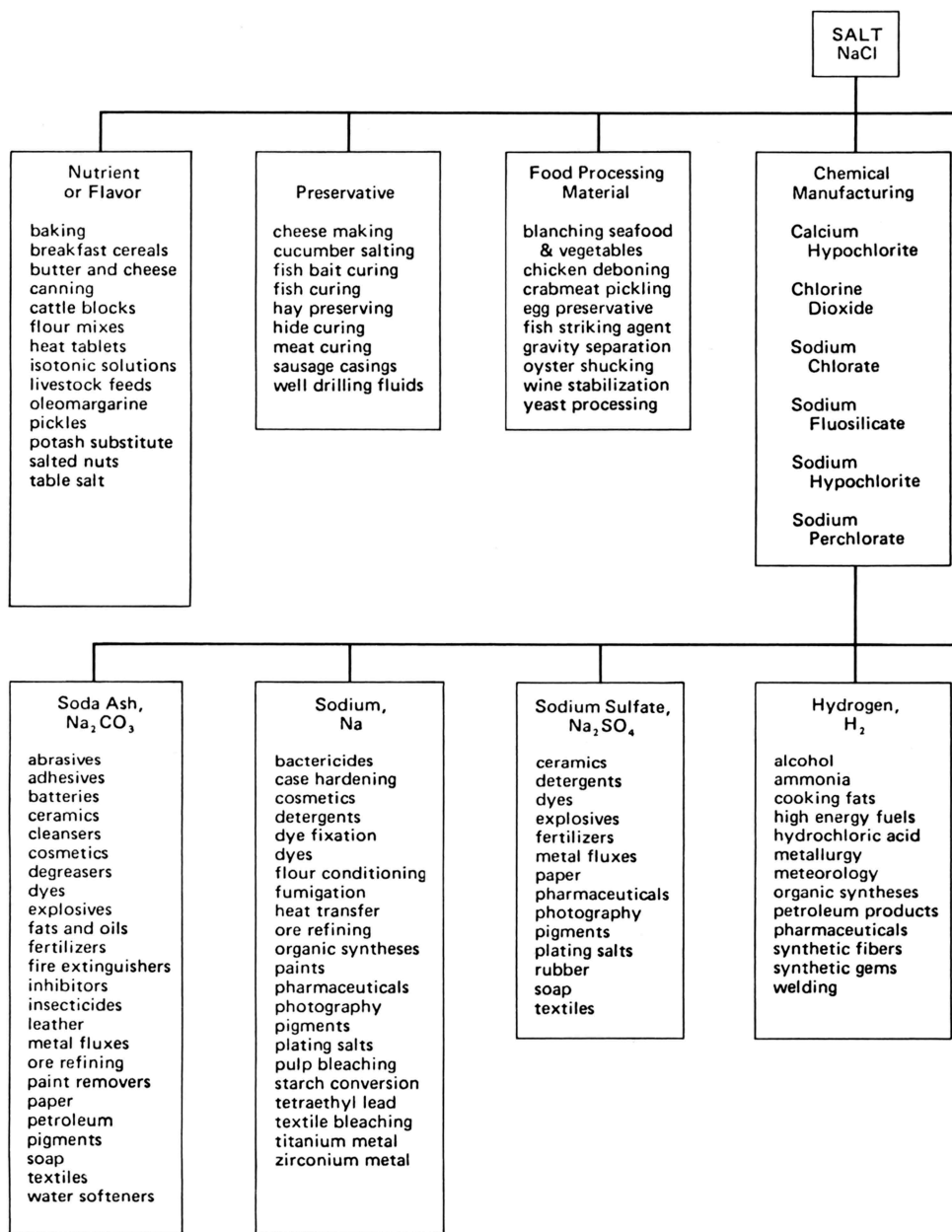


Figure 12. Uses of salt. From "Industrial Minerals and Rocks," 4th ed., Am. Inst. Mining Metall. Petroleum Engineers, 1975.

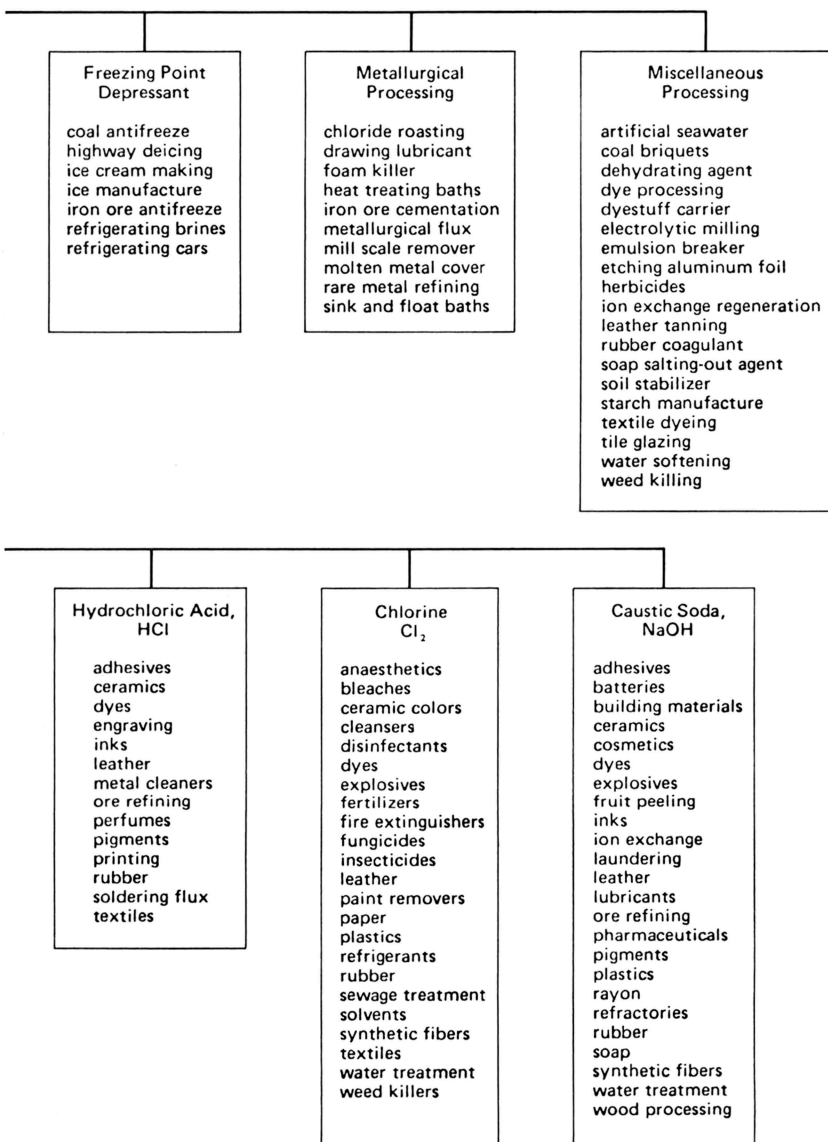


Figure 12—Continued

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