

The World Salt Industry: A Heritage of Progress for the 21st Century

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INTRODUCTION

The history of salt is synonymous with the history of mankind. From primitive man to modern man, every human being that has ever lived on this planet has been directly influenced by salt. It is impossible to discuss here, completely and properly, the role salt has played in the history of civilization. We can, however, take a short look at some of the more significant and interesting events and topics pertaining to this fascinating mineral. Whatever topics that are not covered here will probably be mentioned in some of the other presentations in this volume. The salt industry dates back to many hundreds of years; very few mineral industries have such a long legacy as salt. To appreciate the present status of the world salt industry, we need to reflect on where it began and where it is going. As we embark on the beginning of a new millennia, let us look back and reflect on the origin, history, production, uses, and trade of salt in the world.

THE RESOURCE

We begin with the ultimate salt resource — the Earth and its saline oceans, seas, rivers, and lakes. These bodies of water comprise more than 70% of the Earth's surface. When observing this beautiful blue planet from space, salt is not what is readily noticeable by the observer. We do not see the world's largest solar salt facility in Baja California owned by Exportadora de Sal. Nor do we see the solar ponds of the salt producers in Utah or those of Leslie Salt in California. It is very appropriate that this 7th International Symposium dedicated to salt is being held during the year of the 500th anniversary of Christopher Columbus's discovery of the New World. His

voyage proved that the Earth is spherical, rather than two-dimensional. If Columbus had had this 20th-century perspective of the world in 1492, he may never have had to set sail from Italy.

The world's oceans contain approximately 530 million km³ of water, in which is dissolved about 42 quadrillion metric tons of sodium chloride (as shown in Fig. 1). At the present annual rate of world salt consumption, which is about 183 million tons, there is enough salt in the oceans to last more than 20×10^{11} years. On average, one km³ of ocean water weighs 2.6 billion tons, and contains 4.2 billion liters of seawater. This one-cubic kilometer contains 93 million tons of dissolved matter, of which 78 million tons is sodium chloride. This is equal to about one-half of the total annual world output of all forms of salt production. To visualize and comprehend what 78 million tons of salt looks like, it would take about 18 Vertical Assembly Buildings like the one at the

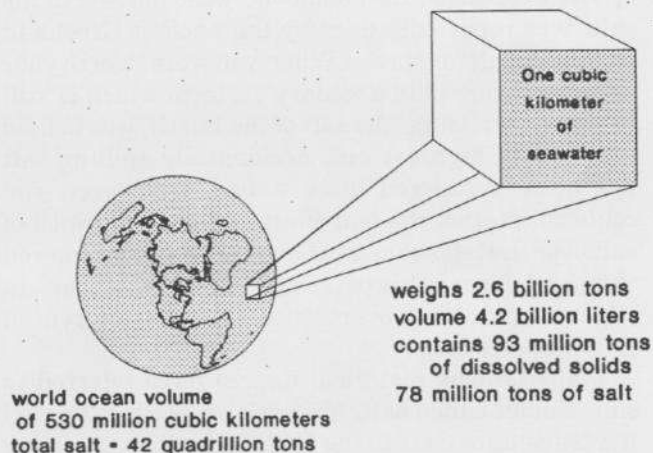


Fig. 1. Abundance of salt in the oceans.

Kennedy Space Center at Cape Canaveral, Florida, which is the world's largest building in terms of volume, to hold all the salt contained in one cubic kilometer of seawater. This building, which has been used to assemble the stages of the Saturn 5 Apollo lunar rockets and the space shuttle, is so gigantic that the United Nations building in New York City could be rolled through one of its 139-meter-high doors. In summary, salt is one commodity that is not in short supply.

THE LEGEND OF SALT

Salt is perhaps the only mineral commodity in the world that is used by virtually every human being in every country. Although there is no written record of the first use of salt, its history is as old as history itself. Many settlements worldwide grew up around sources of salt, and as a result, many cities, rivers, lakes, and islands have been named after salt. Towns such as Lavanapura, India; Salzburg, Austria; Salzgitter, Germany; Saltcoats, Scotland; Saltpond, Ghana; Salt Lake City, Utah, and Saltville, Virginia, owe their origin to this important mineral commodity.

Superstitions, covenants, and traditions pertaining to salt surrounded the religious, social, economic and political aspects of civilization. Every culture in the world has some recorded tale pertaining to salt's symbolism. Some symbolisms have evolved into phrases that are still in use today. Being "the salt of the earth" refers to a person's worthiness, as referenced in Matthew 5:13 of the Bible. Taking something "with a grain of salt" dates back to Roman times when Triumvir Pompey was known to add a grain of salt to his drinks as a supposed antidote to poison. Therefore, to take something "cum grano salis" is to regard it with suspicion.

The expression that someone was "not worth his salt" was reportedly used by the ancient Greeks in bartering salt for slaves. When you were "worth your salt", you were paid a "salary", a term which is still in use today. Being "the salt of the Earth" was to hold someone in high esteem. Accidentally spilling salt has been considered to be unlucky; however, you could counteract the bad effect by tossing a pinch of salt over the left shoulder. Leonardo da Vinci showed this symbolism in his painting "The Last Supper", in which he placed an overturned saltcellar in front of the ill-fated Judas.

Many famous historical figures have referred to salt. Homer called salt, "divine", while Plato termed it a "substance dear to the Gods". The Roman statesman Cassiodorus, proclaimed "Some seek not gold, but there lives not a man who does not need salt".

The famous world traveller Marco Polo told of the high value of salt coins bearing the seal of the Great Khan of Cathay that he observed in use in the Himalayas. The English bard, Shakespeare used the word 37 times in many of his famous plays.

Countries from all over the world have customs in which salt plays an important part. For example, it is still the custom in several countries for the host to offer guests bread and salt upon entering the home. Newly-weds are offered wine, bread, and salt, in which the salt is offered as a life-giving and sustaining substance. In Japan, Sumo wrestlers sprinkle salt around the wrestling arena in a symbolic gesture before they engage one another.

EARLY SALT PRODUCTION PROCESSES

In the era of manned space-flight, personal laptop computers, fax machines, and high-technology consumer products, salt production techniques throughout the world have varied very little since the dawn of civilization. Only the refinements in the different scientific techniques to improve salt quality and quantity at the lowest possible costs have changed in most of the developed nations of the world. Many countries today continue to produce salt as their forefathers did generations ago. Let us examine the evolution of some of the different salt production processes. Rather than attempt to cover the entire world, I will limit the discussion to include only the more important historical aspects with an emphasis on those of the United States.

Brine

Other than archaeological evidence which indicated that cavemen in Western Europe used salt more than 5,000 years ago, the earliest known record of salt production occurred in China more than 2,200 years ago. Salt wells were drilled during the Han period (circa 200 B.C. to circa 1 A.D.) in Szechuan province. Bored holes were drilled 600 meters deep to recover the natural subterranean brines. The principles used were still practised even into the 20th century. Depths of 1,200 meters were reported in the 1930s, and in 1944, one hole reportedly reached 1,440 meters.

Father Imbert, a missionary in China, visited the Szechuan salt works in 1825 and published his observations in the periodical of The Association for the Propagation of the Faith. He reported that one thousand wells, ranging in depth from 490 to 585 meters, were in operation. The holes were drilled with a 15-cm diameter bit which weighed 135-160 kilograms and had a crown face. The bit was suspended from a 'rope cord'. It took about three years to drill

one well, advancing as much as 0.6 meters in twenty-four hours. Delays of five or six months were occasionally encountered because of lost drills. Rather than attempting to recover them, Chinese workers pulverized them.

The 'rope' drilling was actually a drill attached to a line made of bundles of split bamboo strips fastened together with ropes from a derrick. The device appeared more like a belt cable, rather than a rope or a rod. It apparently possessed the rigidity of a rod but was flexible enough like a rope to be able to be wound on large drums. This flexibility freed the driller from the difficult task of disassembling and reassembling the drill line when the drill bit had to be changed. Bamboo, the native plant in China, also was not affected by the corrosion of the salt brine. The brine was raised in 'bailing tubes' suspended by rope. Bamboo pipes carried the brine to evaporation pans, which were inexpensively fuelled by local natural gas supplies. In 1847, a French driller used the 'Chinese method' and successfully drilled 89 wells but the technique was distrusted by those who advocated using the traditional method of drill rods. By 1850, the Europeans had reached the level of achievement obtained in China nearly 2,000 years previously.

Although Levi Disbrow is credited with receiving the first U.S. patent on drilling equipment in 1825, he attributed the beginning of earth boring in the United States to early salt drilling activities in Kanawha, Virginia, which is now known as West Virginia. David and Joseph Ruffner inherited a salt spring in 1797, and in 1806 decided to improve the quality of the brine by establishing a well. A worker inside a hollow sycamore log, which had an internal diameter of slightly more than one meter, worked the log down into the spring using a pick and shovel. At four meters down, rock was encountered but was easily broken through only to find an even weaker brine source. Going to another site with the same technique, the Ruffners dug a hole 14 meters deep, beyond which they used an iron-tipped oak log that was driven down deeper with a pile driver. Again, they hit weak brine. They returned to their first hole, determined not to give up.

At five meters, they hit bed rock; however, they noticed that the cracks and joints between the sycamore logs they were using were being sealed with minerals from a stronger brine which was obviously seeping up through the rocks. The Ruffners used a chisel bit on welded sections of drill rod to drill another 8.5 meters into the rock. After eighteen months, and a total depth of 17.5 meters, they encountered the strong salt brine. They set up a boiling house to process the brine, and developed a prosper-

ous salt business. Although the Ruffners were not the first to make salt in West Virginia, they are credited with pioneering the use of drilling wells to obtain salt brine.

Solar salt

The concept of solar salt production has not changed throughout history, only the refinements in the technique. Some countries continue to produce solar salt in the same manner as their ancestors once did, such as in India, Thailand, Sri Lanka, Jordan, and Colombia. Other countries have modernized the process, and incorporated the latest state-of-the-art harvesting and washing equipment, such as in Australia, Mexico, and the United States. This energy-efficient process utilizes two of nature's free gifts — the sun and the wind. Solar salt harvesting is also one of the most colorful mineral operations to observe in the world, as seen with those of the Great Salt Lake in Utah and of the Netherlands Antilles.

The first solar salt was probably obtained as dried white crusts along saline lakes or coastal margins in the summertime. Many salt pans throughout the world have provided a livelihood for many cultures. In the Danakil Depression of Ethiopia, slabs of salt are crudely pried apart and fashioned into small blocks of salt ready for transport to market by caravan. In Chang Tang, in the western section of Tibet, tribesmen pound large chunks of evaporated salt with old yak horns into pieces of salt that are packed into woven saddle bags that have been sewn shut. The bags are loaded onto sheep and goats and the 80 km, one month-long trip back to camp begins. In Niger, in central Africa, man-made salt pans are used to collect and concentrate saline water, leaving behind thick deposits of salt.

Many cultures around the world also began producing salt from the ocean about the same time. One of the earliest recorded solar salt activities in the Western Hemisphere was by the Mayan civilization in Mesoamerica along the Yucatan peninsula.

Salt-making was an important economic activity for at least 2,000 years in northern Yucatan. Between about 50 B.C. to A.D. 300, the Mayans inhabited a lot of the coastal areas around the peninsula adjacent to salt production sites. Evidence suggests that the sites represented hamlets or the seasonal camps of fishermen and salt-makers. Obsidian blades have been found at only a few sites along the northern coast; however, because obsidian artifacts are relatively scarce to find at coastal sites, this would indicate that salt may have been traded with nearby inland communities. Indirect evidence suggests that Yucatan salt was also being traded to the southern lowlands far away.

Although the Yucatan had been the largest producer of 'sal solar', or 'sun salt' in Mesoamerica, the Pacific coastline that includes Guatemala and El Salvador also was an important source of salt but was produced differently. The process, which also had been used for more than 2,000 years, involved filtering estuary water through large wooden canoes that were filled with salty marsh soil, through which a saline brine percolated. The brine was collected and boiled in large ceramic vessels, yielding the final product, 'sal cocida', or 'cooked salt'. In the late 19th and early 20th centuries, iron kettles replaced the older, crude vessels.

In the highlands, the salinas of Chiapas and the salt springs of San Mateo Ixatan, (which means 'the place of the salt') Guatemala were important sources of inland salt during prehispanic, colonial, and modern times. The process of making salt has remained virtually the same since prehistoric times. The task was usually given to the women of the village, who fill and carry large water jars filled with brine weighing 25 kg up steep mountain slopes. The brine is cooked in 'apastes', or ceramic vessels for 12–14 hours. After the water evaporates and the salt cools and hardens, the vessel is broken and the 22 kg mass of salt known as a 'pilon', is removed. At Chiapas, the brine was cooked in large rectangular iron vats on top of wood-burning adobe ovens. As the salt began to crystallize, it was packed into cylindrically-formed matted straw, which was removed after the salt hardened. The loaves of salt weighed about 600 g. Salt continued to be an important economic industry during the Colonial period, 1525–1821.

During the same time period but many thousand of kilometers away, the Chinese were using two methods to obtain salt along coastal areas. In the first technique, workers would dry clumps of seaweed in the sun. The dry seaweed was then boiled and the brine evaporated to recover the salt. The second technique was a winter–summer process. In winter, salt workers dug pits about six meters deep, over which bamboo poles were placed. The poles were covered with two mats and spread with sand on the top. Every morning and evening with the incoming and outgoing tides, concentrated salt solutions filtered through the sand and mats and settled in the pits. In the summertime, workers entered the pits with torches to test the brine. Reportedly, if the vapor from the brine extinguished the torches, the brine was concentrated enough for the following step. The brine was removed with buckets from the pits and poured into clay-lined evaporating ponds. After evaporation, the salt was raked into one corner of the pond, where it drained until it was ready for use.

In Europe, salt-making had become a major industry by the 1st century B.C. Many evaporation ponds covered the shores of Europe from the North Sea around to the Mediterranean Sea. In 55 B.C., Julius Caesar landed in Britain with his troops and found salt-makers making salt by a crude process. Seawater was splashed on red-hot embers in a fire, and the black crust that was formed was scraped off and used for salt. Caesar, who carried his salt makers with him, showed the people how to make salt by boiling the seawater in open lead pans, the joints of which were sealed with a paste made of ox blood mixed with ashes.

Over the next few hundred years, the English improved the quality of their salt. They discovered that the grain size varied in relation to the amount of heat generated by the fire over which the brine was boiled. Slowly simmering the brine produced larger crystals; rapid boiling produced finer grains. The first documented evidence of salt production in Essex, England was in the Domesday survey of 1085. The list showed that no less than 45 salt pans operated in the Maldon area, four of which allegedly belonged to Edward the Confessor. During this time, about 1,200 salt works operated along the southern English coastline, where seawater was introduced through shallow trenches into clay ponds. After most of the water evaporated, the brine was heated in clay pots after which the pots were broken to retrieve the salt. Today, the red hills of Essex are believed to owe their reddish color to the broken remains of the earthenware containers.

Various Dutch, Flemish, and German salt-making operations were constructed on the shores of the English Channel and the North Sea. These salt works used the same pan and kettle boiling and seawater evaporation methods used in England. By the Middle Ages, these two processes were used throughout Europe. A lot of what we know about European salt-making processes is due to the efforts of Vannoccio Biringuccio, who wrote *The Pirotechnia* in 1540, and Georgium Agricola who wrote *De Re Metallica* in 1556. These treatises on 16th century mining and metallurgy provide insight on the salt industry of the times. Many of the same principles used long ago are still used today by small, family-owned businesses, like those along the west coast of France.

Rock salt

Many countries that are landlocked and not located near the ocean sought other forms of salt. The mining of near-surface rock salt deposits has been conducted since prehistoric times. One example are the rock salt mines of the eastern Alps at Salzburg,

Hallstatt, and Durrenberg, were have been important sources of salt in Europe. Tools excavated from the mines indicated that they were mined during the late Bronze Age (since 1,400 B.C.). The salt mines of Poland and Germany also date back to around this time period. In the High Atlas Mountains of Morocco or the desert of South Yemen, men today still chisel out chunks of rock salt like their ancestors did many years ago.

Underground rock salt mining, like many other types of underground mining, has undergone changes in technology in order to improve productivity and reduce costs. Whether salt was carried out in large blocks, like it used to be at the mine at Marosujvar, Hungary or as blasted, crushed and screened fragments, like it is today at Avery Island, Louisiana, rock salt mining has many common elements associated with it throughout the world.

EARLY USES OF SALT

Today, all of us are aware that there are reportedly about 14,000 different direct or indirect uses of salt. The first use was probably when prehistoric man noticed animals congregating around salt springs or salt licks to satisfy their salt cravings. Although early man was not aware of his physiological need for salt, he obtained his salt mainly from the meat he ate of the animals he hunted. With the beginnings of an agricultural society, man found the need to supplement his vegetable and cereal diets with additional quantities of salt. Aside from the biological need for salt, salt was discovered to have other uses. The Sumerians ate salted meat and used salt to preserve food approximately 3,500 B.C. About

3,000 years ago, the Trojans learned to use salt for preserving fish. The seafaring Phoenicians engaged in an extensive salt trade among the ancient ports of the Mediterranean. Egyptians used salt to flavor their food, and to embalm their dead. Finally, one Mesopotamian legend tells of a wounded pig that ran into the ocean and drowned. After being recovered from the ocean where it was saturated in the salt brine, the pork was found to taste better than unsalted meat.

Rather than discuss the evolution of the remaining 14,000 end uses of salt since Mesopotamian times, let us now jump into the 20th century to see the global relationship between supply and demand. The measurement of this relationship is data, and one of the yardsticks has been the U.S. Bureau of Mines.

THE ROLE OF THE U.S. BUREAU OF MINES IN INTERNATIONAL DATA COLLECTION

The U.S. Bureau of Mines has collected and published international salt production statistics since 1890. Over the years, we have expanded our coverage of international data collection. Although there are more than 170 nations in the world today, the Bureau presently collects or estimates salt data from 98 different nations, which probably represents the majority of the actual quantity of salt produced in the world. Some nations may produce some salt but do not collect or publish information on a formal or routine basis, and therefore are not included in our world statistics. Because collecting mineral production data usually is the responsibility of a country's governmental geology or mining agency, some information often is not available. For example, several nations do not report captive brine production for chloralkali manufacture because the chemical companies do not regard themselves as mining companies that should respond to a mineral survey. The omission of this type of data usually understates the actual quantity of salt being produced in the world.

To appreciate the magnitude of the U.S. salt industry, salt was compared with 32 other industrial minerals that the Bureau of Mines surveys. Table 1 lists the top 10 industrial minerals produced in the United States during 1950 to 1990. In 1950, for example, production of the top ten industrial minerals amounted to 652 million tons, with salt ranking in fourth place. The trend continued until 1980, when salt moved to fifth place as the domestic phosphate industry moved up in rank. It is clear that minerals for the construction industry are the leaders in terms of tonnage; however, salt is the leader of the industrial minerals used by the chemical industry.

TABLE 1

The top ten U.S. industrial minerals, 1950-1990

	1950	1960	1970	1980	1990
1	Sand	Sand	Stone (C)	Stone (C)	Stone (C)
2	Stone (C)	Stone (C)	Sand	Sand	Sand
3	Clay	Clay	Clay	Phosphate	Phosphate
4	Salt	Salt	Salt	Clay	Clay
5	Gypsum	Phosphate	Phosphate	Salt	Salt
6	Phosphate	Gypsum	Lime	Gypsum	Gypsum
7	Lime	Lime	Gypsum	Lime	Lime
8	Sulfur	Sulfur	Sulfur	Sulfur	Sulfur
9	Soda ash	Soda ash	Soda ash	Soda ash	Soda ash
10	Stone (D)	Potash	Potash	Potash	Potash
Total	652 M	1.34 B	1.75 B	1.80 B	4.1 B
tons					

(C) Crush; (D) Dimension.

WORLD SALT PRODUCTION TRENDS

By the turn of the 20th century, the United States had become a major salt-producing nation in the world, along with England, France, Germany, India, and Russia. The world population had reached 1.6 billion people, and world salt production totalled 12.2 million tons. Per capita consumption was 7.6 kg per person. The growth of the world chemical industry and the use of salt for highway de-icing during the next several decades contributed to world per capita consumption rising to 36.4 kg per person by 1990. Figures 2A through 2D illustrate the growth in world salt production, by region and country, from 1890 to 1990. In almost every case, we notice a gentle, positive growth in world salt production until 1950, when the trend began to rise dramatically. For the next twenty years, salt production throughout the world continued to grow.

SALT IN THE LAST HALF OF THE 20TH CENTURY

To estimate production and consumption trends for the remainder of the decade and to forecast them for the next century, we need to study the world salt industry between 1950 and 1990, for which we have reliable data. Despite the many global events that have occurred since 1950, such as the Korean conflict in the early 1950s, the 'Cold War' years, the world energy crises, the Vietnam war, world recessions, environmental problems, and the political and social changes in Eastern Europe, the international salt industry has been relatively stable.

Between 1950 and 1990, world salt production grew from 48.1 million tons to 193.5 million tons, an increase of 282% as seen in Fig. 3. During these years, many countries developed thriving synthetic soda ash, chlorine, and caustic soda industries that

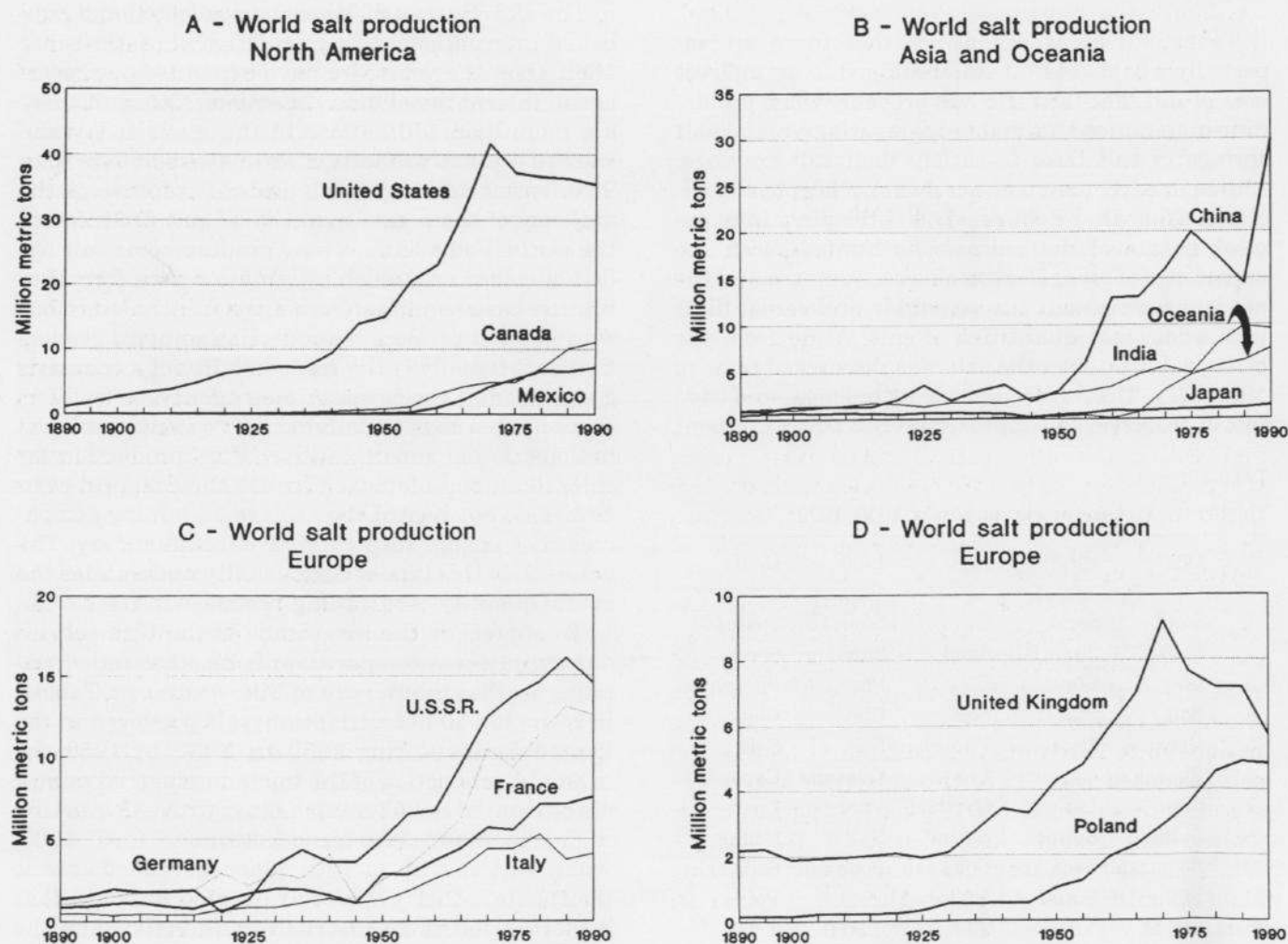


Fig. 2. World salt production

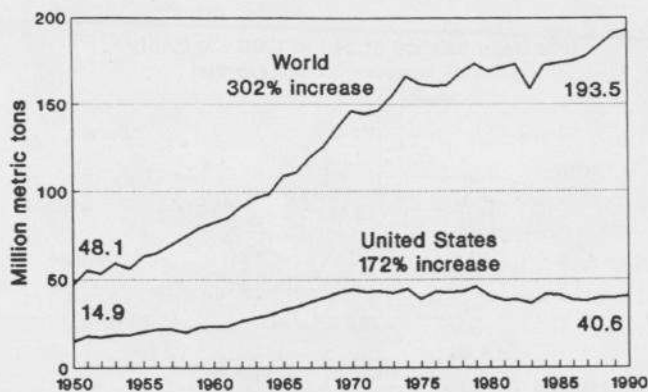


Fig. 3. U.S. and world salt consumption, 1950-1990.

in turn manufactured many glass, plastic, and other chemical household consumer products. Assuming that world salt consumption is equal to world salt production, and that worldwide inventories are kept at minimum levels, most of the growth in world salt consumption took place between 1950 and 1970. Since 1970, the trend has flattened a little; however, Fig. 3 clearly shows that the trend in world salt consumption continues to grow. In the United States, salt consumption has been relatively flat for the past several years.

It is probably no surprise that on a regional basis, North America, Europe, and Asia dominated the world in terms of salt production. What is interesting to note, however, is that despite the tremendous growth in world salt output between 1950 and 1990, production ratios for each region remained fairly constant. For example, North America's share in 1950 was 34%, followed by 32%, 37%, 30%, and finally 30% in 1990. Asia was 27%, 31%, 28%, 27%, and 28%. In the other regions of the world during this time period, we notice a decrease in salt production from Africa and the Middle East but increases in South America, the Caribbean, and Oceania as new salt operations began production.

The same countries that dominated world salt production at the beginning of the 20th century — the U.S.A., England, France, Germany, India, and Russia — would continue to be major producers throughout the century. The top ten salt-producing nations since 1970 and their cumulative tonnages of salt produced from 1970 through 1990 are, in descending order, the United States (783 million tons), China (401 million tons), Germany (305 million tons), the Soviet Union (303 million tons), Canada (160 million tons), U.K. (157 million tons), India (155 million tons), France (140 million tons), Mexico (121 million tons), and Australia (113 million tons).

U.S. salt production has increased substantially since production statistics were first recorded in

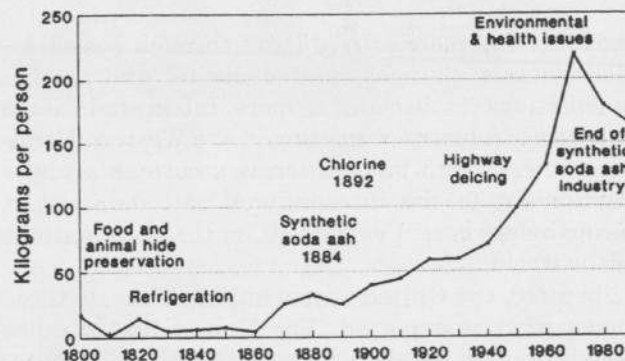


Fig. 4. Factors that influenced per capita consumption of salt in the United States, 1950-1990.

1797. The historical trend of salt production, which includes brine, rock salt, and evaporated salt (which includes solar evaporated and vacuum pan salt), has been fairly regular, except beginning in the 1970s when rapid fluctuations began to occur. The most radical changes were in salt brine production for use by the domestic synthetic soda ash industry. The energy crisis that began in 1973, the passage of environmental legislation to reduce byproduct emissions, and competition from less expensive natural soda ash producers, contributed to the closures by 1979 of seven of the eight synthetic soda ash plants that operated in the 1970s. The last U.S. Solvay plant closed in 1986.

The historical trend in U.S. per capita consumption of salt resembles that of the U.S. salt production. Figure 4 shows some of the important factors that influenced salt consumption during this time period. The non-chemical uses of salt dominated most of the nineteenth century; however, with the development of synthetic soda ash and chlorine facilities after 1880, salt for chemical applications became more important.

Between 1950 and 1990, the U.S. population increased 64% while domestic salt consumption increased 172%. Despite the downturn in U.S. salt production beginning in the 1970s, imports of salt increased for chlorine manufacture, water treatment, and highway deicing. This contributed to the rise in U.S. salt consumption. U.S. per capita consumption ranged from 98.6 kg in 1950 to 163.3 kg by 1990. World per capita consumption rose 86% throughout this forty-year period; from 18.6 kg per person in 1950 to 36.4 kg in 1990.

THE PRESENT AND THE FUTURE OF THE U.S. AND WORLD SALT INDUSTRY

The U.S. salt industry today is comprised of 34 companies that operate 69 plants in 14 States. The

industry has restructured itself through consolidations, name changes, and domestic and foreign acquisitions to become a more integrated North American industry competing in the Western Hemisphere. Although its position is secure as a major participant in the international salt industry, it nevertheless is still dependent on the other nations of the world.

In 1990, the United States imported nearly three times what it exported. The United States relies heavily on its neighbors to the North and South, Canada and Mexico, for salt. These two countries supplied 55% of the United States' imports and accounted for 96% of the U.S. export market, as noted in Fig. 5. In terms of revenue, salt exports generated only \$33 million of sales while imports exceeded \$88 million, as shown in Fig. 6.

The rest of the world will continue to mine, harvest, process, transport, and sell salt to neighboring countries. New deposits will be developed in the future that will probably compete with existing facilities operating today. Competition will be strong. The operations that have low production costs, that offer a high-quality product, and that have low shipping costs, will be the leaders of the industry. But what about the future of the consumers of salt? Will world salt consumption be as strong in the next century? The worldwide awareness and concern regarding several environmental issues and their consequences will continue to be discussed. Some groups have advocated the ban of chlorine-based compounds for use in pulp and paper bleaching, chlorofluorocarbons, and water treatment. This would have an adverse effect on salt. Although the topic will continue to be debated, we are certain that salt will continue to be the most important mineral commodity consumed by the world chemical industry for many years to come.

In this era of high-speed aircraft, bullet trains, and global telecommunications, the world seems to have become a little smaller. Just as Christopher Columbus brought Europe and the New World closer together, this symposium has brought together hundreds of representatives of the world salt industry. As we reach the end of this decade and enter the next century, all of us gathered here today should take pride in the heritage left to us by our predecessors. Without their accomplishments, and failures, we would not be here today. Many people today have taken salt for granted. We have long forgotten that wars were fought over it; that it once was considered as precious as gold. Salt will continue to play a vital role in the future history of mankind long after we are gone. Future generations will reflect on our achievements, and will continue to be intrigued by

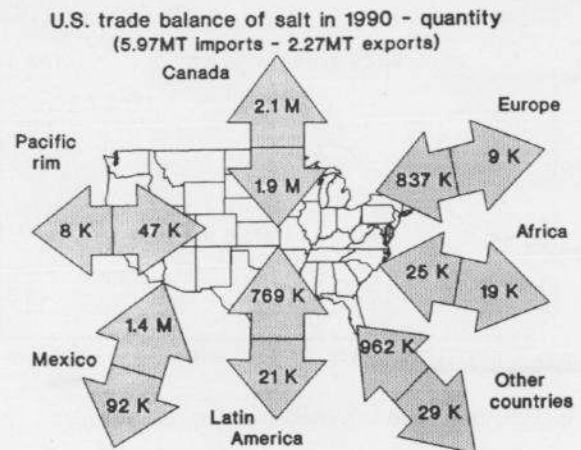


Fig. 5. U.S. trade balance of salt in 1990 — quantity.

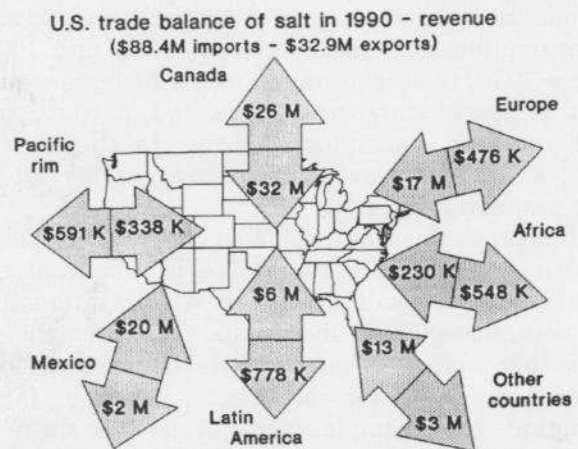


Fig. 6. U.S. trade balance of salt in 1990 — revenue.

this fascinating commodity.

I will end this presentation as I began it. As we take a final glimpse of this wonderful planet, we are reminded of an old custom pertaining to salt that has taken on universal significance. The ancient custom of the host offering bread and salt to visitors continues today, but only from a much higher perspective. It has been a tradition on all Soviet manned spaceflights to carry bread and salt aloft and leave them behind on the orbiting space station Mir, as welcoming presents for the next visiting crew. Perhaps the famed Japanese television correspondent, Toyohiro Akiyama, who went into space in December 1990 was greeted with this symbolic offering as he entered the space station for the first time. Perhaps future voyagers of the 21st century will travel to the other planets, like Mars, and will carry with them some precious supplies of something we call 'sel', 'sal', 'salz', 'zout', 'soy', 'salt', and 'shio'.