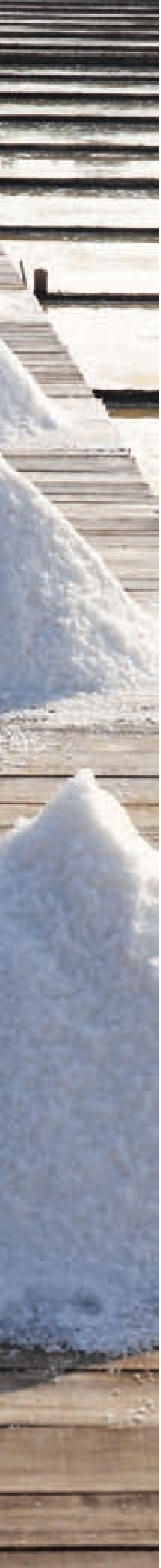


Salt *of the Earth*

Whether dried by the sun or harvested from underground, the salt in your shaker has been a simple but ubiquitous staple for thousands of years

BY VIRGINIA HUGHES

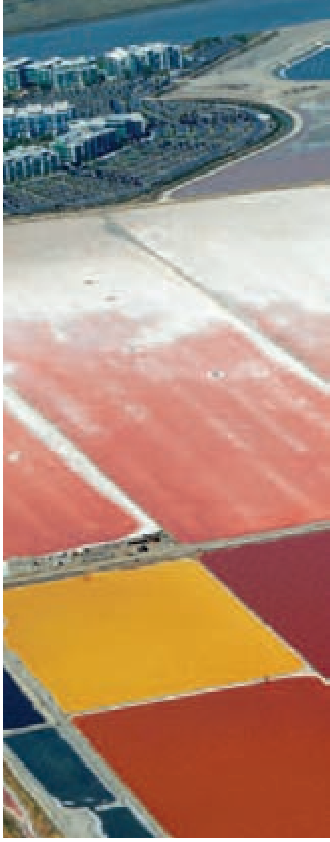
Despite the heat, blue skies and steady winds, the village of Ada looks something like the surface of the moon. Its eerie reflective coastline on the south Atlantic Ocean, extending about 10 miles across the southeastern corner of Ghana, is painted with sharp gray pebbles and crumbling mounds of gleaming white ore.

The rocks are made of salt, the remote village's only major commodity. The women of Ada have harvested it, by hand, every February for 300 years.

Starting around 4 a.m. on each day of the dry season, when the slush below their ankles is still cool, hundreds of women use their bare hands or shards of plastic to scrape up the wet, crusty clumps. Then they crush the salt into smaller pieces, rub off any remaining dirt, and drop them in a large wicker basket. They carry the load on their heads, 50 pounds at a time, back to shore, where it is bagged, sold and carried away by truck.

This technology, called "salt winning," is an example of solar salt evaporation—one of two industrial methods of transforming salt from its origin in the ground to the tasty crystals inside the shaker on your kitchen table. The second method mines the salt not from slushy beaches, but from huge domed deposits sitting thousands of feet below the Earth's surface. (See "Types of Salt," page 11.)

Salt buffs like to say that the mineral we know today as sodium chloride has in fact driven the economic and political development of just about every major human civilization.



"It's always been there," says Richard Hanneman, president of the Salt Institute. "In the prehistory, we have evidence that cavemen were settling in areas where there were salt springs, so they could get salt. Even they understood how important it was."

Before 2,000 B.C., the ancient Egyptians discovered that fish would stay fresh—and could thus be traded—if covered in salt. Two thousand years later, overtaking towns with known salt deposits was a major strategy of the ever-aggressive Roman Empire, which often paid its soldiers in salt. In the Middle Ages, salt mines spurred development in dozens of villages in the English countryside; that's why their names often include the Anglo-Saxon word for a saltworks, *wich.*

In the late 19th century, salt mines sprang up all over the United States and Canada. In 1930, Mahatma Gandhi led more than 100,000 people to the Arabian Sea to gather salt, thus undermining the British salt tax and pushing India one step closer to independence.

It's not surprising, then, that in many cultures salt has come to symbolize purity and power. Jesus called his people the "salt of the Earth." Medieval Germans believed that spilling salt attracted evil spirits (and ever since, superstitious cooks have countered a spill by throwing a pinch of salt over their left shoulder—hoping to keep the devil at bay). In modern English vernacular, a hardworking man is said to be "worth his salt."

Technological progress over the past century in both evaporation and deep mining methods has made salt cheap and easy to acquire in most developed countries. The total global production in 2008 was 260 million metric tons. The world's largest salt producer is China, which produced 60 million metric tons in 2008—and then the United States, at 46 million metric tons. (See "By the Numbers," page 15.)

UNDER THE SUN

The earliest record of salt extraction, dating to 6,000 B.C., belongs to the people who lived near salty Lake Yucheng, in the northern part of China. They harvested salt much as the women of Ada do today. Over thousands of years, the Chinese evolved the method to boiling saltwater in clay vessels and, later, in shallow iron pans.

Industry has since streamlined this basic pan evaporation process, making it much more efficient. "You can take that same land area, and instead of waiting for Mother Nature, you get pumps and dikes and you control the flow of that water," says Lowry Redd, CEO of REDD Engineering & Construction in Salt Lake City, Utah, which provides industrial consulting for budding salt evaporators in Utah, India and West Africa. "By managing your brine ponds, you can increase your yield by many-fold."

Some of the world's largest solar operations are located in the San Francisco Bay, in Western Australia and in Baja California, Mexico. For these, like any successful solar venture, geography and climate are key: the facility must be near a saltwater coast, and evaporation is faster in places with steady wind and little rain. The best sun exposure is near the equator. "You want direct sunlight beating down on your ponds, and it's better straight overhead than if it's coming in at an angle," Redd says. Hard clay soil helps, too. "You don't want the water to seep into the soil and run away from you."

Mounds containing tons of salt are ready to be bagged and shipped, far left. The aerial view of salt ponds showcases the colorful algae, which expedite evaporation, left. Gozo, an island of the Maltese archipelago, offers an environment for salt evaporation ponds to thrive, above.

TYPES OF SALT

Sodium chloride comes in many forms, each of which is suited for a variety of commercial and industrial purposes.

SEA SALT is any salt that arises from evaporated seawater. Its mineral content can vary widely, depending on what's in the water, and different combinations lead to slightly different tastes and textures.

ROCK SALT is mined from horizontal salt deposits thousands of feet underground. It's kept in fairly large chunks, and contains 5 to 10 percent mud impurities so it won't dissolve too quickly when thrown on icy roads.

BASIC TABLE SALT is usually mined from underground salt domes. After it's purified to at least 97 percent sodium chloride, it may be sprayed with iodine. Iodized salt came about in the 1920s as a public health initiative to prevent iodine deficiency, a disease that can lead to large goiters and mental retardation.

Companies that extract salt from horizontal salt deposits and salt domes sometimes make specialty salt products, too.

KOSHER SALT is just like basic table salt, except it isn't crushed into very small particles. It's so-named because of its use in making meats kosher: meat is covered in the salt to draw out all of the blood. If the particles were any smaller, they would simply dissolve into the meat.

SALT PELLETS, the jelly bean-sized capsules used for water softening machines, are formed at a manufacturing plant when salt is put under high pressures. This makes it become flexible, like plastic, and harder to dissolve.

SALT LICKS are blocks of salt—as big as 50 pounds—used for feeding animals. They, too, are made from high-pressure manufacturing systems, so they won't dissolve in rainwater.

The salt from the Dead Sea is often used to make cosmetics and bath salts, above. Salt mounds dry near salt ponds located close to Sicily, Italy, right. Salt crystals are gathered near Senegal's coastline, far right.

A solar salt facility includes a series of shallow rectangular ponds, often covering tens of thousands of acres and pumping hundreds of millions of gallons of saltwater.

First, saltwater—which naturally holds about 3.5 percent sodium chloride—is pumped into a pond and left to evaporate. The water, now much saltier, moves into an adjacent pond to dry out further. Meanwhile, a fresh load of saltwater flows into the first pond. This pumping-drying pattern continues across about a dozen ponds, so that each successive reservoir holds water with a higher concentration of salt. The purpose of connecting so many ponds is to maximize output. "The amount of salt you can put out at the end is determined by how much water you pull in the front," Redd explains. "The more land area you have, the more ponds you can have, and the more efficient you can be in getting that salt out of the water."

The last pond in the series holds brine made up of about 26 percent sodium chloride. That's a "saturated solution" in chemical terms, meaning that no more salt can dissolve in the water.

The concentrated brine is then drawn into a series of secondary reservoirs, where it crystallizes into an almost-pure sodium chloride.

Interestingly, each pond's specific chemical makeup attracts different species of halophilic—Greek for 'salt-loving'—algae, bacteria and small sea life. The bugs are different colors: green algae crop up in ponds with low salt; tiny orange shrimp in slightly saltier waters; and red bacteria in the saturated pools. The spectrum is not only visually stunning, but useful: the color absorbs sunlight, making the water warmer and speeding up the evaporation process.

From start to finish, it takes a given quantity of saltwater up to five years of repeated evaporations until it becomes salt. Once the salt layer is about 5 inches thick, large trucks haul it to a nearby "wash plant" for dirt and sand removal. The final product, usually called sea salt, has a variety of uses, from cooking to cosmetics. The precise chemical makeup—and the taste and texture—of sea salt varies depending on the minerals in the water it came from. The Dead Sea and Mediterranean Sea, for example, produce popular bath salts, often marketed for their health benefits.

LAVA LAMPS

Purified dietary salt can also come from deep below the ground. Saltwater lakes from eons ago gradually dried up over time, leaving a horizontal layer of salt behind. Some of the salt beds would be exposed to more water, and more drying, adding to the salt layer. Over hundreds of millions of years, those thick salt slabs were covered, layer after layer, by rock and sediment. They're now buried as much as 2,500 feet underground.

As part of its natural chemical properties, salt becomes extremely flexible under pressure. When underground salt layers are pushed by particular kinds of geological stress—such as the movement of tectonic plates—the salt can seep up

ON THE ROADS

In the United States, the greatest use of salt is in its rock form, 5 to 10 percent of which consists of mud particles. This doesn't meet the international standard for food-grade salt of 97 percent sodium chloride, but it's great for keeping highways ice-free.

Rock salt is mined from horizontal salt deposits (the geological predecessors of salt domes). And just as for iron, gold and coal, we can reach the horizontal slabs of salt by digging a mine.

Elevators, called "skips," take workers down the mine at about 600 feet per minute. Once they reach the salt vein, they use dynamite—which can dislodge 900 tons of salt in three seconds—to blast out a horizontal tunnel, about 60 feet wide, 25 feet tall, and up to a mile long.

With the first tunnel hollowed out, the miners will cut out a second one perpendicular to the first, creating an L shape. Then they'll blast another chamber, 100 feet from and parallel to the first one, and another one, 100 feet from and perpendicular to that. "As this thing grows, you start getting something like a crossword puzzle being cut out of this huge chunk of salt," says Morton Satin, director of technical and regulatory affairs at the Salt Institute.

This "room and pillar" method is aptly named: the 100-foot-square salt pillars left between the corridors become the walls of dozens of large rooms and support the roof of the mine. "Essentially, they make a warren," he says, referring to the interconnected underground areas where rabbits abound. "And it's a really neat thing to see because they're such large, spacious areas," Satin says. (Once abandoned, these sprawling underground sites have been used for industrial offices, waste storage—even for "salt therapy" spas, especially popular in Eastern Europe.)

One of the world's largest salt deposits stretches out under the Great Lakes and across southern Canada. It supports about 15 salt mines, including one at the Goderich Harbour, in Ontario—which, with 45-foot-tall rooms that span 1.5 by 2 miles, is the world's largest.

Inside the warren, front-end loaders move 12-ton shipments of blasted rock salt from the ceiling and walls into a crushing machine, which breaks them into 7-inch pieces. This is the optimal particle size for de-icing roads; smaller pieces dissolve too quickly. The rocks are then rolled onto long conveyor belts that take them to the skips and up to the surface for packaging and shipping. De-icing is the largest commercial market for salt in North America. In 2008, the United States put about 20 million tons of rock salt on the roads.

During the harvesting process, salt becomes white only after it's cleaned, above. Heavy harvesting machinery is required to manufacture salt at mines across the world, including the Camargue mine located in France, right.

through the layers in a mushroom shape, called a salt dome. "You end up with this thin tail, as the salt moves upward into a spherical formation, just like a lava lamp," explains Morton Satin, director of technical and regulatory affairs at the Salt Institute.

To extract salt from these buried mushrooms, engineers use a micro-fracturing technique called "solution mining."

First, echolocation or sonic detectors point to the center of the dome. Miners drill one well directly into the center, and a second parallel well about 250 feet away. Then they propel water under extremely high pressure down the first well, driving a hole into the center of the dome. Some of the salt dissolves in the water, and the massive, continuous pressure drives it out the only possible exit: the second hole.

Because the mud impurities in salt are heavier than the sodium chloride, gravity peels them away as the brine goes up the second well. The crystals that surface are usually about 99 percent sodium chloride. "I know some plants where it's not even filtered because it's just so pure coming out the pipe," Satin says.

Once the brine has been lifted to the surface from a salt dome, the water is dried out of it using heat and vacuum pressures. The entire drying process takes 20 to 40 minutes, says Satin. Once dried into uniform crystals, the salt is packaged and shipped to store shelves across the world.

Taking out too much salt from a given salt deposit can make the earth above sink, an event called "subsidence." Unfortunately, that concept wasn't fully understood by the small-scale salt miners of 18th- and 19th-century England. By 1880, more than 400 buildings had been destroyed in Northwich, where salt deposits were as much as 180 feet thick. Nearby railroad lines, sewage systems and bridges also were affected.

Sinkholes still happen today, but rarely. Modern mining practice calls for abandoning a mine when the walls are still thick. Moreover, salt's chemistry makes it extremely sturdy. "Because salt is so plastic under pressure," Satin says, "if it gets any cracks it kind of self seals them like a rubber tire."

This property makes salt an ideal place for oil storage. In fact, the United States Strategic Petroleum Reserve—the 700 million-barrel emergency oil supply maintained by the Department of Energy—is stored at four large salt domes on the Gulf of Mexico.

Although the precise breakdown varies widely in individual countries, about 60 percent of the world's salt is used for chemical purposes—such as making chlorine-based products for detergents and PVC pipes—30 percent for food and 10 percent for everything else—including feeding livestock, softening water, leather tanning and developing pharmaceutical drugs.

People in the salt industry like to say that there are more than 14,000 uses for the substance. That's obviously a difficult number to verify. "We don't have such a list," Hanneman says with a chuckle. But, as his Salt Institute's Web site proudly attests: "sodium chloride touches our lives more than any other chemical compound."

By the Numbers: Salt Production Across the World

WORLD'S BIGGEST SALT PRODUCERS

	Country	2008 Salt Production, Reserves, and Reserve Base (in thousand metric tons)	Billions of Pounds
1.	CHINA	60,000	132.3
2.	UNITED STATES	46,000	101.4
3.	GERMANY	19,000	41.9
4.	INDIA	15,800	34.8
5.	AUSTRALIA	12,000	26.5
6.	CANADA	12,000	26.5
7.	MEXICO	8,400	18.5
8.	BRAZIL	7,000	15.4
9.	FRANCE	6,000	13.2
10.	UNITED KINGDOM	5,800	12.8
	WORLD TOTAL	**260,000**	**573.2**

Source: *U.S. Geological Survey, Mineral Commodities Summaries, January 2009*