

# Mineral of the Month Club January 2016

## HALITE

This month our featured mineral is halite, or common salt, from Searles Lake, California. Our write-up explains halite's mineralogy and many uses, and how its high solubility accounts for its occurrence as an evaporite mineral and its distinctive taste. In the special section of our write-up we visit a European salt mine that is a world-class cultural and heritage site.

### OVERVIEW

### PHYSICAL PROPERTIES

Chemistry: NaCl Sodium Chloride, often containing some potassium

Class: Halides

Group: Halite

Crystal System: Isometric (Cubic)

Crystal Habits: Cubic, rarely octahedral; usually occurs as masses of interlocking cubic crystals with corners sometimes truncated into small, octahedral faces; skeletal forms and recessed hopper-type faces are common. Also occurs in massive, fibrous, granular, compact, stalactitic, and incrustation forms.

Color: Most often light gray, colorless or white; also pale shades of yellow, red, pink, blue, and purple; blue and purple hues are sometimes intense.

Luster: Vitreous

Transparency: Transparent to translucent

Streak: White

Cleavage: Perfect in three directions

Fracture/Tenacity: Conchoidal; brittle.

Hardness: 2.0

Specific Gravity: 2.17

Luminescence: Often fluorescent

Refractive Index: 1.544

Distinctive Features and Tests: Best field indicators are distinctive "table-salt" taste, cubic crystal form, perfect three-dimensional cleavage, and occurrence in evaporite-type deposits. Halite can be confused with sylvite [potassium chloride, KCl], which is similar in crystal form, but has a more astringent taste.

Dana Classification Number: 9.1.1.1

**NAME:** The word "halite," pronounced HAY-lite (rhymes with "daylight"), is derived from the Greek *hals*, meaning "salt," and *lithos*, or stone. Halite is synonymous with the word "salt," which stems from *sal*, the Latin word for salt. Halite is also known as "common salt," "rock salt," "mineral salt," "salt stone," "alit," "salgemma," "salz," "Knistersalz," and "Steinsalz." In European mineralogical literature, halite appears as *halit*, *halita*, and *haliet*.

**COMPOSITION & STRUCTURE:** The molecular weight of halite is made up of 39.34 percent sodium and 60.66 percent chlorine. Halite is the most abundant of the halide-group

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minerals, in which various metals are bonded to halogen elements. The halite molecule and lattice are held together exclusively by ionic bonding, the attractive force that joins the positive ions of distinctly metallic elements with the negative ions of distinctly nonmetallic elements. In the halite crystal lattice, six sodium ions surround each chlorine ion to create a cubic structure. Because ionic bonding is relatively weak, halite has perfect three-directional cleavage and is quite soft at Mohs 2.0. Halite is very soluble in water, which explains its distinctive, tangy, “table-salt” taste that is the most diagnostic and familiar of all mineral tastes. Halite’s high solubility also accounts for its occurrence mainly as an evaporite mineral. Halite is present in all marine and continental evaporite deposits in association with such other evaporite minerals as gypsum [hydrous calcium sulfate,  $\text{CaSO}_4 \cdot 2\text{H}_2\text{O}$ ], thenardite [sodium sulfate,  $\text{Na}_2\text{SO}_4$ ], borax [basic hydrous sodium borate,  $\text{Na}_2\text{B}_4\text{O}_5(\text{OH})_4 \cdot 8\text{H}_2\text{O}$ ], and sylvite [potassium chloride,  $\text{KCl}$ ]. Evaporite minerals form in enclosed basins from the evaporation of saline lake water or seawater that is rich in dissolved halides, sulfates, chlorides, and carbonates of sodium, potassium, and calcium. Pure halite is colorless, but traces of such impurities as iron, particulate clay, or organic compounds can impart pale red, pink, yellow, white, gray, blue, and purple hues. Natural geophysical radiation can create intense shades of blue and purple.

**COLLECTING LOCALITIES:** In the United States, halite specimens are collected in California, Louisiana, Texas, Michigan, New York, Utah, and New Mexico. Foreign halite localities are in Austria, Italy, Poland, Russia, Germany, France, Greece, England, Argentina, Bahamas, Bolivia, Brazil, Dominican Republic, Chile, Canada, and Australia.

**HISTORY & LORE:** Known since prehistory, halite, which is common salt, has been used to enhance food flavors and to preserve food, hides, and other organic materials. Salt is an excellent preservative because it is hygroscopic, drawing water from the cells of microorganisms to disrupt their metabolism. Salt was a major trading commodity as early as 8000 B.C. As a chemical reducing agent, halite played a major role in the emergence of metallurgy; its high chemical reactivity made it vital to the advancement of modern chemistry; and its ability to preserve food greatly aided long-distance, maritime exploration and trade. Halite’s chemical composition was determined in 1810 after sodium and chlorine had been identified as elements. The mineralogical name “halite” was assigned in 1847. Halite had many early medicinal uses and is a common component of modern pharmaceuticals. Numerous folk remedies employ salt as a diuretic and to treat intestinal-tract disorders. In Europe, patients with respiratory ailments traditionally inhaled air in underground salt mines as therapy. The benefits of this ongoing practice, now called “speleotherapy,” are attributed to salt microparticles and the related absence of pathogens and allergens in salt-mine air. Halite deposits and natural brines are the only commercial sources of salt. Salt has more than 14,000 direct or indirect uses and is an indispensable feedstock for the global chemical industry. Salt is obtained by mechanized mining of halite deposits; solar evaporation of seawater and lake brines; solution mining, in which hot water is pumped into underground halite deposits and recovered as brine; and mechanical evaporation, which uses generated heat and vacuum systems to evaporate brines. Salt mining is currently a \$6-billion-per-year global industry that recovers 260 million metric tons of salt annually. According to modern metaphysical beliefs, halite corrects mood swings, enhances perception, and diminishes negativity. Halite’s metaphysical uses are color specific; pink crystals are believed to dispel depression, while blue crystals stimulating psychic powers and intuition.

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**ABOUT OUR SPECIMENS:** Our halite specimens are from Searles Lake near Trona in San Bernadino County, California. Located 25 miles west of the south end of Death Valley National Park and one of a chain of large sinks (intermittent lakes with no outlets), Searles Lake formed from glacial runoff during the Pleistocene Epoch some 2.5 million years ago. Seasonal evaporite deposition at Searles Lake has created a huge, 600-foot-thick, bedded deposit of halide, carbonate, sulfate, and borate minerals. The lake bed covers 50 square miles and contains more than 25 different evaporite minerals. Since the 1880s, Searles Lake has yielded evaporite minerals worth more than \$1.5 billion. Searles Valley Minerals, Inc. currently extracts 1.7 million tons of mixed evaporite minerals from the lake each year. An estimated four billion tons of evaporite-mineral reserves are sufficient to support mining for centuries to come. Searles Lake hosts the annual Searles Lake Gem-O-Rama, an October event sponsored by the Searles Lake Gem & Mineral Society that attracts thousands of mineral collectors and visitors. Our specimens include both gray and pink halite. The pink color is due to an organic, carotenoid pigment similar to those found in tomatoes, red peppers, shrimp, and many reddish flowers and autumn leaves. This carotenoid pigment is produced by huge numbers of halophyllic (salt-loving) microorganisms called halobacteria that thrive in saline environments. A single drop of Searles Lake brine contains millions of these rod-shaped bacteria that at times color the brine red. This reddish pigment is captured during the crystallization process and produces the pink color seen in some of our halite specimens. Our gray specimens crystallized when halobacteria concentrations in the lake brine were low.

### COMPREHENSIVE WRITE-UP

#### *COMPOSITION & STRUCTURE*

Halite [sodium chloride, NaCl] consists of the unlikely elements sodium (Na) and chlorine (Cl). Sodium is a highly reactive, silver-colored metal that oxidizes violently when contacted by water; chlorine is an extremely poisonous and corrosive greenish-colored gas. Yet these two elements combine to form halite, a stable mineral that has a multitude of uses and is vital to life itself.

Halite's molecular weight is made up of 39.34 percent sodium and 60.66 percent chlorine. Electrical stability in the halite molecule is achieved by the balance of the +1 charge of the sodium cation (positively charged ion) and the -1 charge of the chlorine anion (negatively charged ion). The halite molecule and lattice are joined together exclusively by ionic bonding, the attractive force that bonds the positive ions of distinctly metallic elements to the negative ions of distinctly nonmetallic elements.

The electronic configurations of the sodium and chlorine atoms account for halite's ionic bonding. Electronic configuration describes the distribution of electrons within atoms and explains why certain atoms react to form compounds, while others do not react at all. Electrons occupy space around the atomic nucleus in well-defined energy levels or "shells," with specific shells accommodating specific numbers of electrons. Elements are stable when their outer shells contain a "stable octet" of eight electrons. Atoms with incomplete outer shells react with other elements by gaining, losing, or sharing electrons to obtain the stable octet.

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Sodium and chlorine atoms both have three shells in their electronic configurations. Sodium has 11 electrons—2 in the inner shell, 8 in the middle shell, and 1 in the outer shell. The sodium atom achieves stability by losing its outer electron, thus enabling its middle shell, with eight electrons, to function as its outer shell. The loss of this electron creates the positively charged sodium ion  $\text{Na}^{1+}$  with its +1 charge. Meanwhile, the chlorine atom has 17 electrons in a 2-8-7 configuration. To achieve stability, the chlorine atom “borrows” a single electron to fill its outer shell, thus creating the negatively charged chlorine ion  $\text{Cl}^{1-}$  with its -1 charge. When sodium contacts chlorine, the chlorine “grabs” the sodium atom’s single outer electron, transforming both atoms into oppositely charged ions. Opposite charges attract, and the resulting attractive force is the ionic bond that joins sodium and chlorine ions in the stable halite molecule.

In the halite crystal lattice, six chlorine ions surround each sodium ion, while six sodium ions surround each chlorine ion. This creates alternating rows of positively charged sodium ions and negatively charged chlorine ions that are arranged in three axial directions, giving halite a cubic structure and perfect, three-directional cleavage. Because ionic bonding is inherently weak, halite is quite soft at Mohs 2.0 and cleaves easily along its three structural directions into cubes.

The dipolar action of water makes halite extremely soluble. Water’s dipolarity is due to the close positioning of the two hydrogen ions  $2\text{H}^{1+}$  within the water molecule ( $\text{H}_2\text{O}$ ). This creates a slight positive charge at the hydrogen end of the molecule and a negative charge at the opposite end, which is dominated by the large oxygen ion. Water’s dipolarity disrupts halite’s ionic bonds, disassociating the molecule into soluble sodium and chlorine ions in a saline solution. Water’s dipolarity accounts for halite’s hygroscopicity, or ability to absorb water from the air—a phenomenon that causes the familiar “caking” of table salt in humid climates. Solubility also produces halite’s distinctive taste. The sensation of mineral taste is created when soluble compounds disassociate into acidic and alkaline ions that are detectable by the tongue’s taste buds. Halite’s characteristic “table-salt” tang is the most diagnostic and familiar of all mineral tastes.

Because of its solubility, halite occurs mainly as an evaporite mineral. Halite occurs in all evaporite deposits with such other evaporite minerals as sylvite [potassium chloride,  $\text{KCl}$ ], gypsum [hydrous calcium sulfate,  $\text{CaSO}_4 \cdot 2\text{H}_2\text{O}$ ], thenardite [sodium sulfate,  $\text{Na}_2\text{SO}_4$ ], and borax [basic hydrous sodium borate,  $\text{Na}_2\text{B}_4\text{O}_5(\text{OH})_4 \cdot 8\text{H}_2\text{O}$ ]. Evaporite minerals form in enclosed basins from the evaporation of saline lake water or seawater that are rich in the dissolved halides, sulfates, chlorides, and carbonates of sodium, potassium, and calcium. Because of similar ionic size and electrical charge, potassium ions  $\text{K}^{1+}$  frequently substitute for sodium ions in halite. Solution concentration, which brings dissolved ions into closer proximity, triggers the evaporite-deposition sequence in brines. Those ions with the strongest attractions crystallize first, followed by those with progressively weaker ionic attractions. With their very weak ionic bonds, halite and sylvite crystallize last in the evaporite sequence.

Halite is the most abundant of the halide minerals, in which metals bond with one of the halogen elements (fluorine, chlorine, bromine, iodine, and astatine). All halides are soft, weak, and brittle. The Dana classification number 9.1.1.1 first identifies halite as a halide mineral (9). The subclassification (1) defines it as an anhydrous or hydrated halide with a 1:1 cationic-anionic

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ratio. Halite is then assigned to the halite group (1) as the first (1) of five members. The other halite-group members, which share similar physical properties and a 1:1 cationic-anionic ratio, include sylvite, villiaumite [sodium fluoride, NaF], carobbite [potassium fluoride, KF], and griceite [lithium fluoride, LiF].

Pure halite is colorless, but traces of iron, particulate clay, and even organic compounds impart pale hues of red, pink, yellow, white, blue, purple, and gray. Intense shades of blue and purple are caused by radiation emitted by ions of the radioactive isotope potassium-40 that substitute for sodium ions. This radiation disrupts the halite lattice structure by energizing and displacing electrons from their normal positions, some of which subsequently occupy vacant lattice sites called “traps.” Trapped electrons absorb only certain wavelengths of light, thus altering the absorption-reflection characteristics of the crystal. In halite, these trapped electrons absorb the wavelengths from the red end of the visible spectrum while reflecting those from the blue end, thus explaining the intense blue and purple colors of certain halite specimens.

As an evaporite mineral, halite occurs in deposits that range from shoreline incrustations to massive formations hundreds of feet thick. Salt “domes” are vertical diapirs (pipe-like masses) of halite that have been forced upward from deep beds by the weight of overlying rock. Halite crystals can grow very rapidly; under optimum conditions, one-inch crystals can develop in just a few months. Hopper crystals with pronounced, raised edges and “stair-step” depressions that descend into concave faces form when face edges crystallize more rapidly than face centers. Halite also occurs as stalactites in certain limestone caves and even as small crystals in stone-chondrite meteorites.

### *COLLECTING LOCALITIES*

Our halite specimens were collected at Searles Lake near Trona in San Bernadino County, California. California specimens also come from lacustrine evaporite deposits in Kern, Inyo, and Mono counties. Other localities in the United States include the salt domes of Calcasieu, Iberia, Iberville, La Foursche, Plaquemines, St. Mary, Winn, and Terrebonne parishes in southern Louisiana; the salt deposits of Harris, Matagorda, Liberty, Swisher, and Wharton counties in southeastern Texas; the salt mines of Michigan’s Alpena, Houghton, Newaygo, and Wayne counties; and the salt mines of western New York’s LeRoy, Livingston, and Tompkins counties. In Utah, halite forms shoreline incrustations along the Great Salt Lake in Box Elder, Tooele, Davis, and Cache counties; halite also occurs as large clusters in the potash mines of Grand County. Transparent halite crystals are found in the Carlsbad potash beds near Carlsbad, New Mexico.

Foreign sources of halite include the Austrian salt mines of the Tyrol, Salzburg, and Styria regions; the Sambuco salt mines at Calascibetta, Enna Province, Sicily, Italy; the mines at Wieliczka (see “A World-Class Salt Mine”) and Klodawa, Poland; the Stassburg salt mine in Saxony-Anhalt, Germany; the Timouns Quarry at Luzenac, Ariège, France; the Christiana Mine, Laurion District, Attikí Prefecture, Greece; and the Billingham anhydrite mine in County Durham, England, United Kingdom. The so-called “Siberian salt mines” of the Urals, Northern-Siberian, and Eastern-Siberian regions of Russia also provide halite specimens.

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Other localities are Salina Chico and Salinas Grandes, Península Valdés, Biedma Department, Chubut, Argentina; San Salvador Caves, San Salvador Island, San Salvador District, Bahamas; the Araco Mine, Looyzo Province, Oruru Department, Bolivia; the Nova Fátima salt deposit, Rio Fortuna, Santa Catarina, Brazil; and Las Salinas Mine, Baharona Province, Dominican Republic. Chilean localities include the Mantos Blanco Mine, Canchas, Antofagosto Province, Antofagosto Region; and the Rio de Sal quarry, Caballo Muerto District, Chañaral, Atacama Province. Canadian specimens come from Salt Springs and the Penobsquis potash deposit in King County, New Brunswick; and the Sifto Salt Mine at Unity, Saskatchewan. In Australia, halite stalactites are found in caves of the Nullarbor Plain in Western Australia.

### *JEWELRY & DECORATIVE USES*

Halite's hygroscopicity, softness, and brittleness preclude any gemstone uses. Well-developed, transparent halite crystals, especially when colorless or in hues of red, pink, yellow, blue, or purple are valued by collectors for display purposes. Because of their perfect cubic form, solubility, and excellent cleavability, halite crystals are often used for teaching purposes in high-school and college earth-science classes.

### *HISTORY & LORE*

Known since prehistory, halite has long been valued as a food-flavor enhancer and as a preservative for food, hides, and other organic materials. Halite is an effective preservative because it is hygroscopic, drawing water from the cells of microorganisms to disrupt their metabolism. Salt was a major trading commodity as early as 8000 B.C. and has since had an enormous impact on society and technology. Its function as a chemical reducing agent has advanced metallurgical science, its chemical reactivity was vital to the emergence of modern chemistry, and its role as a food preservative greatly aided long-distance maritime exploration and trade.

The chemical composition of halite became known only after English chemist Sir Humphry Davy (1778-1829) identified sodium and chlorine as elements in 1807 and 1810 respectively. English mineralogist E. F. Glocker (vita unknown) formally assigned the name "halite" to the mineral form of sodium chloride in 1847. Halite was the first mineral to be analyzed by X-ray diffraction. Its precise atomic structure was revealed in 1912 in a landmark mineralogical experiment in which 22-year-old, Australian-born physicist William Lawrence Bragg, working in England, pioneered the use of X-ray diffraction patterns to calculate atomic positions within a crystal lattice. Bragg's work with X-ray diffraction techniques earned him the 1915 Nobel Prize for physics and laid the groundwork for modern crystallography.

Halite has appeared on the 35-pfennig postage stamp of former Germany DDR (East Germany) in 1972 and on the 80-centime postage stamp of Algeria in 1983. In 1977, the X-ray diffraction pattern of halite as recorded by William Lawrence Bragg appeared on a United Kingdom 10-



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shilling stamp honoring the physicist's contributions to mineralogy. Many stamps have featured various aspects of salt mining.

Halite had many early medicinal uses and remains a standard component of modern pharmaceuticals. Numerous folk remedies employ salt as a diuretic and to treat lower intestinal-tract disorders. In Europe, patients afflicted with respiratory ailments traditionally inhaled the air of underground salt mines as therapy. Today, the beneficial effects of the on-going practice of inhaling salt-mine air, called "speleotherapy," are attributed to the presence of salt microparticles and the related near-absence of pathogens and allergens in salt-mine air.

According to modern metaphysical practitioners, halite corrects mood swings, enhances perception, and diminishes negativity. In such uses, halite is thought to be color specific; pink crystals dispel depression, while blue crystals stimulate psychic powers and intuition.

### *TECHNOLOGICAL USES*

Halite and brines, the latter consisting largely of dissolved halite, are the commercial sources of salt, which has more than 14,000 direct or indirect uses and is an indispensable feedstock for the chemical industry. In the United States, 40 percent of the salt supply is used as a source of sodium to manufacture sodium hydroxide (caustic soda, NaOH) and as a source of chlorine; 40 percent goes into highway de-icing mixtures; and 20 percent is used in industrial, food-processing, agricultural, and water-treatment applications.

Salt is obtained by four general methods: mechanized open-pit and underground mining of halite deposits; solar evaporation of marine and underground brines; solution mining, in which hot water is pumped into underground halite deposits and recovered as brine; and mechanical evaporation, which uses vacuum systems and generated heat to evaporate brines. The respective products are rock salt, solar salt, brine, and vacuum-pan salt.

Salt mining is a now \$6-billion-per-year industry that recovers 260 million tonnes (metric tons) of salt annually. China recently surpassed the United States as the world's leading source, producing 70 million tonnes annually. The United States ranks second with 40 million tonnes, an annual production that equates roughly to 280 pounds of salt for every person in the nation. The top domestic producers are Louisiana, Texas, New York, Kansas, and Utah. Other important salt sources are Germany, India, Canada, and Australia. Salt prices vary widely depending upon purity and form: Table salt retails for about \$1 per pound; crude halite sells for \$12 per ton.

### *A WORLD-CLASS SALT MINE*

In terms of collective history, culture, art, cumulative production, and now tourism, Wieliczka (vee-LEECH-ka) is the world's best-known salt mine. Located near Kraków, Poland, the Wieliczka Salt Mine has 125 miles of underground passages that connect some 2,000 excavated chambers as deep as 1,100 feet below the surface, along with a spectacular collection of halite

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carvings and sculptures. Wieliczka is now a United Nations World Cultural Heritage Site of “outstanding universal value to mankind.”

Late Stone Age nomads gathered halite crystals from brine ponds at what is now Wieliczka more than 5,000 years ago. After the salt ponds were depleted in medieval times, salt-gatherers dug deep wells to reach subterranean brines and, in 1280, discovered thick beds of solid halite. The Polish Crown monopolized salt mining and trading, while leasing the underground halite deposit to miners who sank shafts, then drove lateral workings to extract salt with hammers and chisels. Mining large, underground chambers, they left behind carefully positioned pillars of salt to support the workings—the first known example of the “room-and-pillar” underground-mining method. After 1400, Wieliczka supplied most of northern Europe’s salt and accounted for a third of the Polish Crown’s revenues.

By 1600, Wieliczka was one of Europe’s largest mines, exploiting a three-mile-long, 1,000-foot-thick, bedded halite deposit. To maximize production, miners replaced the original salt pillars with timber ground support. They also devised many mechanical innovations and organized labor systems that were far ahead of their time. Nevertheless, salt mining at Wieliczka remained hazardous. Besides the usual dangers of underground work, the mine accumulated explosive methane gas which open-flame light sources sometimes ignited. More than 10 percent of Wieliczka’s workforce was killed or seriously injured each year.

To help cope with these dangers, miners turned to prayer. While priests celebrated underground masses, miners fashioned altars, chapels, and religious icons, all from wood. But after a disastrous 1697 fire, superintendents banned all underground chapels and accouterments made of wood. The miners then began fashioning chapels, murals, carvings, and altars from rock salt. For the next 300 years, generations of miners and invited sculptors carved freestanding blocks and in situ walls of gray rock salt into freestanding miniature, life-size, and larger-than-life statues; bas-relief murals; architectural arches and columns; and even elaborate chandeliers. Most remarkable is a 120-foot-long chapel in which the walls are adorned with life-size, bas-relief murals of biblical scenes and a replication of Leonardo da Vinci’s *The Last Supper*, all carved from solid, massive halite.

By 1900, Wieliczka had been modernized to further increase production. Operations halted during World War II when the Nazis occupied Poland and converted the mine into an underground, aircraft-component plant that was safe from Allied air attacks. By the time mining finally ceased in the early 1970s, Wieliczka had produced a phenomenal 7.5 million cubic meters of rock salt—enough to fill a train of standard rail hopper cars more than 1,000 miles long. Although the mine had obvious potential as a tourist attraction, time, humidity, and air pollution had taken a toll on its hundreds of salt carvings. In 1978, the United Nations Educational, Scientific, and Cultural Organization (UNESCO) recognized Wieliczka as one of the world’s foremost, threatened cultural sites. The threat was deterioration of the salt carvings caused by changing environmental conditions.

In 1989, the United States helped to fund an international study and remediation effort at Wieliczka. Scientists concluded that the salt sculptures had begun deteriorating about 1900, when new ventilation systems drew large volumes of warm, surface air through the cool,



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underground workings. The hygroscopic rock salt then began accumulating water as the relative humidity increased. In Wieliczka's upper mine levels this was an especially serious problem during the humid summer months. Scientists also learned that sulfur dioxide and dust pollution from nearby industrial towns drawn into the mine through the ventilation system had darkened some sculptures that were originally white.

After installation of dehumidification and air-filtration systems in 1999, UNESCO removed Wieliczka from its list of threatened cultural sites. Restoration experts, using special mixtures of crushed salt and epoxy resins, then began restoring and preserving many sculptures. Today, the Wieliczka Salt Mine, administered by the Polish Ministry of Art and Culture, hosts one million visitors annually. For further information, visit the Wieliczka Salt Mine's web site at [www.museum.wieliczka.pl](http://www.museum.wieliczka.pl).

### *ABOUT OUR SPECIMENS*

Our halite specimens, some of which are pink and others gray in color, were collected at Searles Lake near Trona in San Bernadino County in southeastern California. Searles Lake, a leading source of both commercial evaporite minerals and evaporite-mineral specimens, is located 25 miles east of Ridgecrest and 25 miles west of the southern end of Death Valley National Park. It is one of several large, Pleistocene Epoch sinks (intermittent lakes with no outlets) that include Owens, China, Panamint, and Manly lakes, all of which formed some 2.5 million years ago with glacial runoff from the eastern slopes of the Sierra Nevada.

Lacustrine deposits of evaporite minerals form when surface water from rain or snowmelt drains into sinks. Sinks are created in arid climates where incoming water flows only seasonally. When this incoming water leaches mineral salts from surrounding soil and rock, it becomes highly saline. With no outlets, sinks lose their saline water only through evaporation, which concentrates the dissolved salts. When the resulting brines become saturated, the dissolved minerals precipitate out of solution to crystallize on the lake bed. Sink water often evaporates entirely during seasonal cycles, causing complete precipitation and deposition of all dissolved minerals. Sinks range in size from small ponds to large lakes many miles across. The underlying evaporite deposits also vary greatly in size; some are only a few feet thick, but others, given optimum conditions of sink size, incoming water volume, climatic aridity, and water salinity, can be hundreds of feet thick.

Evaporite precipitation is a complex process that depends upon a combination of temperature, pH, and qualitative and quantitative water salinity. Because each evaporite mineral has its own solubility level, precipitation occurs in specific sequences beginning with carbonates and followed by borates, sulfates, and halides. During this cyclical deposition, crystallized evaporite minerals sometimes redissolve to precipitate again later. Layers of evaporite minerals are usually interspersed with beds of mud and silt from particulate and organic matter that the original saline water carried into the sink. Today, Searles Lake is a huge, bedded deposit of sodium, potassium, and calcium carbonates, sulfates, borates, and halides that is at least 600 feet thick. The lake itself covers 50 square miles; its beds contain more than 25 different evaporite minerals.

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Searles Lake was initially named Slate Range Playa after a nearby mountain range. At this site in 1862, gold prospector John Wemple Searles (1828-1897) collected surface encrustations of a white salt which chemists identified as borax [basic hydrous sodium borate,  $\text{Na}_2\text{B}_4\text{O}_5(\text{OH})_4 \cdot 8\text{H}_2\text{O}$ ]. Searles finally acted on his discovery in 1872, after learning that a Nevada dry lake was being profitably mined for borax. He returned to his discovery to stake a section (640 acres) of land and establish the San Bernadino Borax Mining Company that shipped borax by mule-drawn wagons 175 miles west to the harbor at San Pedro, California. Although Searles limited his production to surface digging, he also drilled exploratory wells that revealed continuous beds of evaporite minerals more than 600 feet deep.

After John Searles died in 1897, Slate Range Playa was renamed Searles Lake in his honor. Although Searles' company then ceased operations, other mining companies arrived to employ solution-mining methods, drilling wells and pumping subterranean brines to the surface to recover the evaporite minerals. Today, solution mining at Searles Lake is controlled by Searles Valley Minerals, Inc., which extracts 1.7 million tons of mixed evaporite minerals each year. Over the past 140 years, Searles Lake has yielded evaporite minerals worth \$1.5 billion. The lake's evaporite-mineral reserves, estimated at four billion tons, can support mining at the current rate of production for centuries to come. In recognition of its rich history, Searles Lake was declared a California Registered Historic Landmark in 1962.

More than 1,000 mineral collectors and visitors attend the Searles Lake Gem-O-Rama, an annual event held each October that is sponsored by the Searles Lake Gem & Mineral Society. Searles Valley Minerals, Inc., provides equipment and personnel to trench the lake bed and pump up subterranean brines and crystals to make evaporite minerals, including halite, accessible to collectors.

Some of our halite specimens are gray; others are pink. The pink color is caused by organic pigments produced by microorganisms. Despite its very high salinity, Searles Lake brine is home to a surprising amount of aquatic life that includes huge numbers of microscopic, halophyllic (salt-loving) bacteria called halobacteria. Halobacteria thrive in aqueous environments that contain four or more times the salinity of seawater. A single drop of Searles Lake brine contain millions of these rod-shaped bacteria, each of which produces carotenoid pigments similar to those in tomatoes, red peppers, shrimp, and reddish flowers and autumn leaves. Carotenoid pigments are precursors of vitamin A and the source of the anti-oxidant Beta-carotene. In Searles Lake halobacteria, carotenoid pigments are believed to protect the organisms' sensitive cells from the intense desert sunlight. At Searles Lake and other regional sinks, large "blooms" of halobacteria periodically color the brine red. When this brine crystallizes along the lake shore, the resulting halite crystals "capture" the reddish color of the carotenoid pigments.

Our specimens were gathered by commercial specimen collectors from natural lakeshore encrustations that form periodically in conditions of warm temperatures and decreasing brine levels. The color in our pale-pink specimens is zoned, reflecting varying concentrations of halobacteria in the brine when crystallization occurred. These pink crystals developed atop a matrix of massive halite which has a more saturated pink color. Our gray halite crystals

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developed when concentrations of halobacteria were very low. The crystals in some specimens are skeletal or “hollow” in form with only partial development of faces and edges; others exhibit the “hopper” form with pronounced, raised edges and “stair-step” depressions that descend into concave faces.

Be sure to handle your specimen of Searles Lake halite carefully. Because of its softness of only Mohs 2.0, halite is easily scratched. Due to their weak ionic bonding, the crystal clusters are fragile. These specimens also have a high level of solubility, so never place them in contact with water. Also, because the color of the pink crystals may fade with prolonged exposure to sunlight, be sure to store them away from strong light sources.

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