

January 2006 Mineral of the Month: Hanksite

“One of the wonderful things about Searles Lake is that several of the minerals which occur here are so abundant that you can actually take home as much as you could ever want.”—Jon Gladwell,
Mineral Collecting at Searles Lake

PHYSICAL PROPERTIES

Chemistry: $\text{Na}_{22}\text{K}(\text{SO}_4)_9(\text{CO}_3)_2\text{Cl}$ Sodium Potassium Sulfate Carbonate Chloride

Class: Sulfates Subclass: Anhydrous Compound Sulfates

Crystal System: Hexagonal

Crystal Habits: Usually in well-formed, hexagonal prisms with dipyramidal terminations with pyramidal faces precisely aligned with corresponding prismatic faces. Tabular and twinned crystals common.

Color: Usually colorless, white, or gray; less commonly green, yellow, black.

Luster: Vitreous

Transparency: Transparent to translucent

Streak: White

Cleavage: Perfect in one direction

Fracture: Uneven to conchoidal

Hardness: 3.0-3.2

Specific Gravity: 2.5

Luminescence: Usually none; impurities in some specimens may cause yellow-white fluorescence under long-wave ultraviolet light.

Refractive Index: 1.46-1.48

Distinctive Features and Tests: Best field indicators are crystal habit and symmetry of hexagonal crystal form; sweet, alkaline taste; evaporite mineralogical environment and association with other evaporite minerals such as halite, gypsum, borax, and calcite.

Dana Classification Number: 32.3.1.1



Figure 1. Hanksite crystal.

NAME

This month's mineral is pronounced just as it is spelled—HANKS-ite (the first syllable rhymes with 'banks'). Hanksite is named in honor of American geologist Henry Garber Hanks (1826-1907), as explained in *History and Lore*. European mineralogists have previously referred to hanksite as "hanksit" and "hanksita."

COMPOSITION

Hanksite's chemical formula $\text{Na}_{22}\text{K}(\text{SO}_4)_9(\text{CO}_3)_2\text{Cl}$ identifies its elemental components as sodium (Na), potassium (K), sulfur (S), oxygen (O), carbon (C), and chlorine (Cl). The molecular weight of hanksite consists of 32.32 percent sodium, 2.50 percent potassium, 18.44 percent sulfur, 42.94 percent oxygen, 1.54 percent carbon, and 2.26 percent chlorine.

As in all molecules, the molecular stability of hanksite depends upon an electrical balance between its cations (positively charged ions) and anions (negatively charged ions). The hanksite molecule consists of two cations and three anions. The two cations are sodium and potassium, both with a -1 electrical charge. These elements are present quantitatively as 22 sodium ions and 1 potassium ion that together account for a total cationic charge of +23. Hanksite's three anions consist of two radicals and an elemental ion. (A "radical" is a group of atoms of different elements that are bound together and act as a single chemical entity.) In hanksite, the anionic radicals are sulfate $[(\text{SO}_4)^{2-}]$ and carbonate $[(\text{CO}_3)^{2-}]$, both with a -2 charge.

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Hanksite's elemental anion is chlorine (Cl⁻), which has a -1 charge. In hanksite's compound anion, the 9 sulfate radicals, 2 carbonate radicals, and one chloride ion amount to a cumulative -23 charge. Thus, the hanksite molecule is balanced by a cumulative +23 cationic charge and a -23 anionic charge.

Hanksite is one of the very few minerals that contain both sulfate and carbonate anions. And because anions are usually the basis for mineralogical classification, hanksite's complex composition initially created some confusion. All mineralogical classification systems now include hanksite as a sulfate (or compound sulfate), because its sulfate radicals outnumber its carbonate radicals.

Sulfate and carbonate radicals are the building blocks of the hanksite molecule. Sulfates are compounds of sulfur and oxygen with one or more metals. In the sulfate radical, a single sulfate atom is surrounded by four oxygen atoms positioned at the corners of a tetrahedron. The sulfur and oxygen atoms share electrons to form strong covalent bonds. The sulfate radical's two excess negative charges are distributed evenly over the oxygen atoms. Carbonates are compounds of carbon and oxygen with one or more metals. The carbonate radical is a flat, triangular structure that is joined together, like the sulfate radical, by strong covalent bonds with shared electrons.

The hanksite molecule consists mainly of negatively charged sulfate and carbonate radicals ionically bound to positively charged sodium ions. In this complex molecular arrangement, 9 sulfate and 2 carbonate radicals accommodate 22 sodium ions—an arrangement that may be difficult to picture. But to envision the hanksite molecule and lattice, think of hanksite as three separate minerals that are ionically bound together. These minerals are thenardite (sodium sulfate, Na₂SO₄, our August 1999 featured mineral), natrite (sodium carbonate, Na₂CO₃), and sylvite (potassium chloride, KCl). To reflect this structure, hanksite's chemical formula Na₂₂K(SO₄)₉(CO₃)₂Cl can be rewritten as 9(Na₂SO₄)·2(Na₂CO₃)·KCl. (The chemical period [·] represents a chemical bond linking the separate components of a compound and is most often used to separate the bonded water-of-hydration molecules from the parent minerals in the formulas of hydrous minerals.) In the hanksite lattice, hanksite molecules are joined together into a repeating, three-dimensional structure mainly by ionic bonding and a lesser degree of covalent bonding. Of the three bonding planes within this lattice, two are joined by a combination of covalent and ionic bonding. The third plane, however, is held together entirely by ionic bonding and is much weaker, which explain hanksite's perfect, one-directional cleavage. Weak ionic bonding also accounts for hanksite's relatively low hardness (Mohs 3.0-3.2).

Another of hanksite's most important properties—its high solubility in water—is also due to the predominance of ionic bonding, a type of bonding that is vulnerable to the dipolar action of water. Because of the close positioning of its two hydrogen atoms, the water molecule (H₂O) is essentially a dipolar particle, exerting a positive charge at the hydrogen end and a negative charge at the opposite end. This dipolarity easily breaks ionic bonds, reducing certain compounds into soluble ions. Solubility is the key to hanksite's primary occurrence in evaporite mineral deposits, as explained in *About Our Specimens*.

Because of its high solubility in water, hanksite is inherently unstable. Hanksite is hygroscopic, meaning it can absorb water from the air, usually when atmospheric relative humidity exceeds 65 percent. In a process that is not completely understood, the accumulation of free water on the surface of hanksite breaks its ionic bonds, causing it to disassociate into simpler compounds which form a white crust followed in time by a more difficult-to-remove, yellowish crust. With prolonged periods of exposure to very humid atmospheres, hanksite specimens can completely deteriorate. Some collectors work around this potential problem by gently drying hanksite crystals with hair dryers, then storing the specimens in sealed plastic bags. Others coat the hanksite specimens with clear mineral oil or a non-yellowing acrylic spray. Our specimens have been dipped in clear mineral oil to prevent deterioration, and it is recommended that this immersion be repeated every year or so to preserve yours. Common mineral oil from the drug store

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will work fine. Remember, never attempt to wash a surface film from hanksite crystals with water; use only a brine with a chemical composition roughly similar to that of hanksite itself.

Hanksite's solubility gives it a distinct and even diagnostic taste. The sensation of mineral taste is created when soluble compounds disassociate into acidic and alkaline ions which are detected by the tongue's taste buds. The most familiar mineral taste is the salty taste of halite (rock salt, sodium chloride, NaCl). Other minerals with distinct tastes are the halides, sulfates, and borates of the alkali and alkaline-earth minerals lithium, sodium, potassium, calcium, and magnesium—all minerals with predominant ionic bonding. The hanksite taste falls between "salty" and "sweet alkaline." Other minerals with distinct tastes are borax [hydrous sodium borate, $(\text{Na}_2\text{B}_4\text{O}_5(\text{OH})_4 \cdot 8\text{H}_2\text{O})$], sweet alkaline; epsomite (magnesium sulfate, MgSO_4), bitter; glauberite [sodium calcium sulfate, $\text{Na}_2\text{Ca}(\text{SO}_4)_2$], bitter-salty; sylvanite (potassium chloride, KCl), bitter; and ulexite [hydrous sodium calcium borate, $\text{NaCaB}_5\text{O}_6(\text{OH})_6 \cdot 5\text{H}_2\text{O}$], alkaline. To "taste" a mineral, place a moistened fingertip on the mineral, then touch the fingertip briefly to the tongue, so as to experience the taste while minimizing ingestion. Remember that although most evaporite minerals such as hanksite are harmless in trace amounts, other minerals, notably those of heavy metals, can be quite toxic.

The Dana classification number 32.3.1.1 identifies hanksite as a compound sulfate (32), that is, a poly-anionic mineral in which the sulfate radical is one of the anions (and usually the most predominant). The subclassification (3) next defines it as an anhydrous compound sulfate, meaning one without attached water molecules. Finally, it is a member of the hanksite group (1), of which it is the first (1) and only member.

COLLECTING LOCALITIES

As a rare mineral, hanksite has few collecting localities. Most of the hanksite in existence occurs at the type locality at Searles Lake, San Bernardino County, California, which has provided the best specimens. Occasional specimens have also been collected at evaporite deposits at Mono Lake, Mono County, California; the Soda Lake District in Churchill County, Nevada; and at Alnö, Sundsvall, Medelpad, Sweden.

JEWELRY & DECORATIVE USES

Because of its relative softness (Mohs 3.0-3.2), hygroscopicity, and chemical instability, hanksite has no gemstone uses. Well-developed hanksite crystals from California's Searles Lake are highly valued by mineral collectors for mineralogical and display purposes. The largest crystals known from Searles Lake reach just three inches, although crystal groups can reach twelve inches and more.

HISTORY & LORE

After study and analysis of specimens obtained from the type locality at Searles Lake, California, American mineralogist and mineral collector William Earl Hidden (1853-1918) and English-born, American chemist Dr. James Buckton Mackintosh (1856-1891) identified hanksite in 1885. After publication of their findings in the *American Journal of Science*, mineralogists accepted hanksite as a distinct mineral species the next year. Hidden then formally named the new mineral in honor of Harvard-educated geologist Henry Garber Hanks (1826-1907), who had served as California's first state mineralogist from 1881 to 1886.

Hanksite is one of the main attractions at the world's most popular annual mineral-collecting field trip—the Searles Lake Gem-O-Rama, held each October by the Searles Lake Gem & Mineral Society. Searles Valley Minerals, which manages the mining operation there, generously provides equipment and

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personnel to trench the lake bed and also to pump up a slurry of subterranean brines and crystals to make such minerals as hanksite and pink halite available to collectors. Nearly 1,000 visitors now attend this annual event. For further information about the Searles Lake Gem-O-Rama, contact the Searles Lake Gem & Mineral Society, P.O. Box 966, Trona, California 93592-5356, or visit their web site at <http://www1.iwvisp.com/tronagemclub/Index.html>. This annual event takes place every year on the Columbus Day weekend, which is bad timing for us, as we participate in the Big Sure Jade Festival every year on that same weekend.

According to modern metaphysical belief, hanksite provides insight to combat trickery and delusion, dispels introversion, and facilitates meditation and the development of spirituality. When placed under a pillow before bedtime, hanksite crystals are thought to assist in the recollection of dreams.

TECHNOLOGICAL USES

Hanksite has no technological or industrial uses. Searles Valley Minerals extracts brine from Searles Lake and pipes it to its three local plants, where boric acid, anhydrous borax, pentahydrate borax, and other boron products along with soda ash (sodium carbonate) are produced for a myriad of industrial uses.

ABOUT OUR SPECIMENS

Evaporite minerals are formed by the evaporation of saline water in enclosed basins. As an evaporite mineral, hanksite occurs exclusively in lacustrine (lake bed) deposits. Lacustrine deposits form when surface water from rain or snowmelt drains into sinks (intermittent lakes with no outlets). Sinks form in arid climates where the incoming water flows only on a seasonal basis. This feed water, which can originate nearby or hundreds of miles away, leaches mineral salts from soil and rock and can be highly saline. These dissolved minerals usually include the halides, sulfates, carbonates, bicarbonates, and borates of such alkali and alkaline-earth elements as lithium, sodium, potassium, calcium, and magnesium.

Because sinks have no outlets, their saline water is lost only through evaporation, which concentrates dissolved salts. When the resulting brines reach their saturation point, the dissolved minerals precipitate out of solution to crystallize on the lake bed. Sinks often evaporate completely during their annual seasonal cycles of replenishment and evaporation, causing complete precipitation and deposition of all dissolved mineral salts. Sinks can range in size from small ponds to lakes many miles across. Accordingly, evaporite deposits vary greatly in size; some are only a few feet thick, but given optimum conditions of sink size, incoming water volume, climatic aridity, and water salinity, others can be hundreds of feet thick and of extraordinary mineral richness.

In the latter category, Searles Lake, the type locality for hanksite, is a textbook example of a world-class evaporite deposit that has been developed into a major mining complex. Searles Lake is located in southeastern California's San Bernardino County, roughly 25 miles east of the city of Ridgecrest and 25 miles west of the southern limit of Death Valley National Park. It is one of a chain of large Pleistocene (Quaternary Period) sinks that includes Owens, China, Panamint, and Manly lakes, all of which originated some 2.5 million years ago with glacial runoff from the eastern slopes of the southern Sierra Nevada Range. The high salinity of the Searles Lake feed water is attributed to large numbers of hot springs and to Pleistocene mountain glaciers that ground rock into fine powder, both increasing mineral solubility.

The stratigraphic record indicates that Searles Lake once contained brackish (a mixture of seawater and fresh water) H₂O deeper than 600 feet. Lake levels fluctuated in rhythm with the advances and retreats of the distant Sierra Nevada glaciers. During the last 150 years alone, geologists have identified a sequence

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of salt and mud beds that represent more than 30 major lake levels. Precipitation of evaporites is a very complex process that depends upon a combination of temperature, pH, both qualitative and quantitative water salinity, and even water pressure. Because each specific evaporite mineral has its own solubility level, precipitation usually occurs in a specific sequence with carbonates first, followed by borates, sulfates, and halides. During the cyclical precipitation process, crystallized evaporite minerals can sometimes redissolve to be precipitated later. Evaporite beds are usually interspersed with beds of mud and silt formed from particulate and organic matter carried into the sink along with the saline water. Today, after 2.5 million years of evaporite deposition, Searles Lake is a huge resource of sodium and potassium carbonates, sulfates, borates, and halides deposited in beds some 700 feet deep. The lake itself covers 50 square miles and contains more than 25 different evaporite minerals.

Native Americans used Searles Lake and other regional playas as a source of salt. This lake, first named the Slate Range Playa after the mountain range to the east, was probably known to Spanish, Mexican, and Anglo prospectors and explorers by the early 1800s. In 1862, a frustrated American gold prospector named John Wemple Searles (1828-1897) collected surface encrustations of a white salt which chemists later identified as borax (hydrous basic sodium borate, $\text{Na}_2\text{B}_4\text{O}_5(\text{OH})_4 \cdot 8\text{H}_2\text{O}$). Searles did nothing about his discovery until 1872, when he learned that a newly established mining venture on a dry lake in southern Nevada was recovering borax. Realizing the potential value of his earlier discovery, John Searles, together with his brother Dennis, returned to the Slate Range Playa to stake an entire section (640 acres) of land. The following year, the Searles Brothers formed the San Bernadino Borax Mining Company and began mining borax from the surface and shipping it by mule-drawn wagons 175 miles to the harbor at San Pedro, California. Although Searles' limited his mining to surface digging, he also drilled a series of exploratory wells. The deepest reached 627 feet and encountered evaporite minerals all the way.



Figure 2 John W. Searles. He grew a beard to hide the scars received in a losing fight with a grizzly bear.



Figure 3 Hauling borax via mule-drawn wagons. All photos courtesy Searles Valley Minerals, used by permission.

When Searles died in 1897, Slate Range Playa was renamed Searles Lake in his honor. Although Searles' company ceased operations after his death, other companies arrived to employ solution-mining methods, drilling wells and pumping subterranean brines to the surface for evaporation recovery of mineral salts. Today, solution mining remains a major industry at Searles Lake under control of Searles Valley Minerals, which extracts some two million tons of evaporite minerals each year. To date, Searles Lake miners have recovered evaporite minerals worth more than \$1.5 billion. Despite such large production, the lake's reserves of

evaporite minerals are pegged in excess of 4 billion tons—enough to last for many centuries of mining. In recognition of its rich mining history, Searles Lake was declared a California Registered Historic Landmark in 1962.

More than thirty different minerals have been identified so far from Searles Lake. Eleven of these were first discovered here, making Searles Lake their type locality: burkeite [$\text{Na}_4\text{SO}_4(\text{CO}_3, \text{SO}_3)$], galeite [$\text{Na}_{15}(\text{SO}_4)_5\text{F}_4\text{Cl}$], northupite [$\text{Na}_3\text{Mg}(\text{CO}_3)_2\text{Cl}$], pirssonite [$\text{Na}_2\text{Ca}(\text{CO}_3)_2 \cdot 2\text{H}_2\text{O}$], schaiierite [$\text{Na}_{21}(\text{SO}_4)_7\text{F}_6\text{Cl}$], searlesite [$\text{NaBSi}_2\text{O}_5(\text{OH})_2$], sulphohalite [$\text{Na}_6(\text{SO}_4)_2\text{FCl}$], teepleite [$\text{Na}_2\text{B}(\text{OH})_4\text{Cl}$], tinalconite [$\text{Na}_2\text{B}_4\text{O}_5(\text{OH})_4 \cdot 3\text{H}_2\text{O}$], tychite [$\text{Na}_6\text{Mg}_2(\text{CO}_3)_4(\text{SO}_4)$] and, of course, hanksite. Other minerals commonly found in evaporative environments that are likewise found at Searles Lake are borax, gypsum variety selenite, halite, thenardite, trona, and ulexite, while rare evaporite minerals found here include

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apthitalite $[(K,Na)_3Na(SO_4)_2]$, gaylussite $[Na_2Ca(CO_3)_2 \cdot 5H_2O]$, merlinoite $[K_5Ca_2[Al_9Si_{23}O_{64}] \cdot 22H_2O]$, mirabilite $[Na_2SO_4 \cdot 10H_2O]$, nahcolite $[NaHCO_3]$, and phillipsite, which has been divided into a series with complex formulas including phillipsite-Ca, phillipsite-K, and phillipsite-Na. If you take a moment to examine these formulas, you will notice that almost all contain sodium (Na), many have potassium (K), and are either carbonates or sulfates or both, with some other elements thrown in: magnesium (Mg), fluorine (F), boron (B), silicon (Si), calcium (Ca), aluminum (Al), hydroxyl (OH), and water (H_2O).

At the annual Searles Lake Gem-O-Rama you can hope to collect hanksite, halite, borax, tinalconite (which forms by the alteration of borax), trona, sulphohalite, gaylussite, nahcolite, and burkeite, which occur in the areas where collectors are allowed, although due to the changeable nature of the environment, it is always possible to find others. You will also need to bring lots of large containers to fill with brine, to use in cleaning your minerals once you get them home. Since most of the minerals found at Searles Lake dissolve in water, the Searles Lake brine is the best way of cleaning them. And if you go, be sure to bring throwaway clothes, as the brine will saturate and ruin them, particular shoes and socks. Part of the after show ritual is the tossing away of ruined clothing!

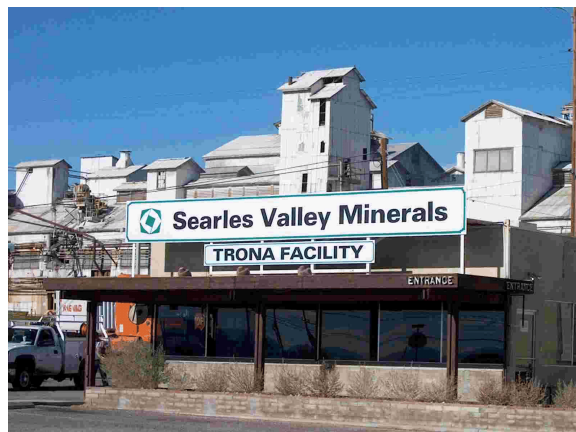


Figure 4 Mining facility in Trona.

It is the excellence of the crystal forms that draws us to hanksite. Doesn't your specimen look like a doubly terminated quartz crystal, like a Herkimer "Diamond"? This six-sided hexagonal crystal form with such perfect terminations is highly appealing! Hanksite is also found at Searles Lake in a pinacoidal habit, with the crystals truncated into a flat surface perpendicular to the length of the crystal. Alas, hanksite falls far short of quartz in the color and luster department, as most specimens are colored an unappealing shade of yellow, green, or gray-black by inclusions trapped inside by the growing crystal. As a result, the crystals are unfortunately not lustrous like quartz. Still, these are amazingly well-crystallized examples of a very rare mineral, which would be extremely difficult to obtain were it not for Searles Lake. As always, we put specimens under our fluorescent lamp, noticing a pale yellowish green color under shortwave and more so under longwave UV light. The color is probably caused by the inclusions.

Some collectors shy away from collecting hanksite, halite, and other minerals that can alter when removed from their natural environment, while others tend to be more philosophical about it—accepting that the beauty of some minerals may be fleeting. And should alteration occur, if you're fortunate, you can always make another trip to the Searles Lake Gem-O-Rama to collect more!

References: *Dana's New Mineralogy*, Eighth Edition; *2004 Fleischer's Glossary of Mineral Species*, J. A. Mandarino and M. E. Back, The Mineralogical Record, Inc.; *Encyclopedia of Minerals*, Second Edition, Roberts, et al, Van Nostrand Reinhold Company; *Manual of Mineralogy*, 21st Edition, Cornelius Klein and Cornelius S. Hurlburt, Jr., John Wiley & Sons; *Mineral Collecting at Searles Lake*, Jon Gladwell; "The Crystal Structure of Hanksite," Takahara Araki and Tibor Zoltai, *American Mineralogist*, July-August 1973; "The Crystal Habits and Forms of the Minerals of Searles Lake, San Bernardino County, California," H. Earl Pemberton, *The Mineralogical Record*, March-April 1975; "The Crystal Structure of Hanksite and Its Relation to the K_2SO_4 Structure," K. Kato and H. Saalfeld, *Structural Crystallography and Crystal Chemistry*, December 1972; *Borax: From the Desert, Through the Press, To the Home*, Pacific Coast Borax Company, 1895; *Searles Lake Borax: The Centennial of the John W. Searles Borax Discovery: 1862-1962*, L. Burr Belden and Ardis Manly Walker, Death Valley '49ers, Inc., 1962; "Geology, Mineralogy, and Mining History of Searles Lake," Stephen P. Mulqueen, geologist, transcript of talk given March 11, 2005, Pasadena City College, Pasadena, California. Special thanks to Jim Fairchild and to Searles Lake Minerals for photos.