Northwest Micro Mineral Study Group

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FALL MEETINGVANCOUVER, WASHINGTON

November 3, 2007

9:00 am to 5:00 pm

Clark County P. U. D. Building 1200 Fort Vancouver Way Vancouver, Washington

Come find out what everyone has been up to this summer. Bring your microscopes and something for the free table to share with others. There will be samples of fluoro-edenite from Summit Rock available. We will have our usual brief business meeting in the afternoon, to be followed by our update

session to find out what localities are actively producing material and are good bets for collecting trips.

No guest speaker has been planned, so if you have slides of mineral specimens or collecting localities that you would like to share, bring them along; we will have a projector and screen waiting. There should be ample time to enjoy looking at each other's special pieces, and swapping stories and information about collecting.

The kitchen area is again available and we will plan on sharing lunch together. We will provide meat, cheese, bread, lettuce, tomatoes, mayo and mustard for sandwiches as well as coffee, tea, cider, cocoa. Members need to bring some sides, *ie*, salads, chips, desserts and anything else that they would like to have to munch on.

In the evening, many of us plan to go to a local buffet restaurant, so please join us if you can.



ARSENIC IN AGATE

by Don Howard and Rudy Tschernich

Unusual red, yellow, and black inclusions described as sagenite in agate were first found in the late 1940's by Ceil Stickney of Eugene, Oregon near the town of Trent in Lane County, Oregon, just southeast of Springfield/Eugene (Staples, 1950). The history of the area is rather interesting. The Rattlesnake post office was established near Rattlesnake Creek in 1868. Later the name was changed to Trent in 1875. The post office was finally closed in 1963. The town's name still appears on most maps, as does Rattlesnake Creek.

Much speculation has been made about the agate locality, with erroneous information published. The material was found in a railroad cut and adjacent land southeast of Trent in the extreme northwest part of T19S R1W in the north part of section 7, although the township and range designations are poorly defined in that area. A better location is 122° 51.376 W and 43° 56.127 N at the 682 foot elevation.



According to Gary Buss (pers. comm.), the Trent sagenite was first found loose in the Willamette River near Trent and later in loose rock along the Southern Pacific railway, southeast of Trent, when construction for the foundation for 3 to 4 section-houses were built on the south side of the tracks. The collecting site was found by proceeding from Trent south along the Rattlesnake Creek road, crossing Highway 58 to the Southern/Union Pacific tracks where you park and walk ¹/₄ mile east along the tracks to a small hill. According to Gary Buss (pers.



Fig 3 Realgar needles in chalcedony, Trent, Lane County, Oregon



Fig. 4 Hollow realgar needles, Royal Reward mine, Green River, King County, Washington



Fig. 5 Yellow orpiment needles in chalcedony, Trent, Lane County, Oregon



Fig. 6 Yellow orpiment coating red realgar needles in chalcedony Trent, Oregon



Fig. 7 Hollow needles, formerly realgar or orpiment, coated with black or gray arsenic covered with colorless to red chalcedony Trent, Oregon



Fig. 8 Gray and black arsenic coated hollow realgar straws, realgar naturally dissolved away, covered with colorless chalcedony. Trent, Lane County, Oregon.



Fig. 9 Hollow realgar shell coated inside and out with gray to black arsenic and covered with colorless chalcedony. Trent, Lane County, Oregon



Fig. 11 Hollow red realgar needles with silver colored hexagonal-appearing arsenic plates and black round arsenic aggregates in colorless chalcedony. Trent, Lane County, Oregon.



Fig. 10 Red realgar straws with hollow gray shells cover with gray and black arsenic. Trent, Lane County, Oregon



Fig. 12 Silver colored hexagonal-appearing plates of arsenic and black arsenic dust on hollow realgar shells covered with colorless to white chalcedony. Trent, Lane County, Oregon.



Fig. 13 Black to silver colored hexagonalappearing plates of arsenic in chalcedony. Trent, Oregon.



Fig. 14 Silver to black arsenic coating on realgar shells covered with chalcedony. Trent, Oregon.

comm.), in the 1950-60's, a metal tank and buildings were present along the tracks marking the collecting site. Pits were dug along the railway cut and further up the hill beyond the fence line onto the Snyder Farm. An agreement was made with the landowner that the holes dug would be filled in. The hill, only 15 feet high, is now covered with trees and brush with no trace of collecting activity. Several hundred veins were found during the collecting period at this site. The agate veins were vertical and averaged from a few inches to 14 inches thick. The smaller ones were of the best quality for cutting since they were solid agate. The larger veins usually contained rotten or broken up quartz in the center with only a few inches of good material on both sides. The chalcedony in the veins varied greatly from colorless to highly prized red carnelian, black, gray, and the rarest cobalt blue (really blue-gray). Pits were dug long the veins were embedded in a clay that when wet would stick to the shovel and had to be scraped off, but when dry was like concrete. The pits were dug down and sideways until the veins tapered out and no more material was found. Nothing was found east of a small draw in the collecting area. More material is not expected to be found.

The massive agate is rather ugly, being coated with black and red staining. When thin slices are made, the unusual inclusions are revealed. Red realgar needles (Fig. 3) are covered with chalcedony in many of the veins. The realgar usually forms hollow rectangular straws similar to those found at the Royal Reward mine, in Washington (Fig. 4). Much rarer are bright yellow orpiment needles (Fig. 5) and yellow orpiment coatings on red realgar (Fig. 6). Small octahedrons of brassy-colored pyrite occur along the base of some veins. Several different-looking black and silver colored minerals are commonly present on the realgar and orpiment. Small ball-like aggregates (Fig. 7, 8, 9) are present that are composed of black or silver colored mineral. Some of the black material forms tiny aggregates composed of minute pointed crystals (Fig. 2a) on the outside and inside of the realgar straws (Fig.10, 11). Other black to silver material forms tiny hexagonal plates (Fig. 2d, 12) on the realgar or suspended in the chalcedony (Fig 13) that appear silver colored when cut and polished (Fig. 14). A black sooty material also covers the hollow shells of realgar (Fig 14). All of the black to silver material that covers colorless to red realgar elongated shells resembles long needles of stibnite and thus temporarily gave its name to this rare sagenite.

The first written report on this material was a paper by Lloyd Staples, a member of the Department of Geology, University of Oregon. Clearly, x-ray equipment was not available at the time to confirm the identity of the minerals present. Dr. Staples (1950) conducted two other kinds of tests. In the first, the silica was dissolved away rapidly using hydrofluoric acid. This freed the red needles, and angle measurement on their faces proved them to be realgar, As_4S_4 , an unusual inclusion in quartz. Subsequent exposure to sunlight (after remove from the ground) altered the crystals to an orange dimorph of realgar, pararealgar, AsS. Although much rarer at the site, bright yellow orpiment, As_2S_3 , forms long needles similar to the realgar. Orpiment is often found covering the surface of realgar (Fig. 6).

The second type of test used to identify these minerals was the use of the heated microscope stage. Thin slices were heated to 250, 300, 350, 400, 500, and 650 degrees Celsius. For the first two lower temperatures, no changes were observed. At 350°, alteration occurred within 30 minutes, and at 400° the realgar melted and formed blisters on the specimens. This was exactly the expected behavior.

The dark minerals did not show alteration until the temperature reached 500° , and by the time the specimens had been held at 600° for 30 minutes, all the dark mineral had disappeared

and only the cavities where it had been could be seen. Based on this, Dr. Staples postulated that the dark mineral was stibnite, Sb_2S_3 , which has a melting point at 550°, assuming that it then sublimed. This was a very clever surmise, and a reasonable material to expect to be in the same environment as arsenic sulfides. From that time on, agate from Trent with darker inclusions has been referred to as having stibnite inclusions.

However, that dark material usually coats the outside of realgar crystals or their casts rather being slender needles that is the usual form of stibnite. There are inclusions in the agate with roughly a hexagonal form, whereas stibnite is an orthorhombic mineral. So the question recently arose: what other minerals could be present in this agate?



Clearly we are dealing with tiny amounts of material. The ideal instrument to identify the composition of small amounts of material is the scanning electron microscope operating in x-ray fluorescent mode (Howard, D., 2005). However, this technique is limited to looking at surfaces, and is not practical for inclusions unless they are partially exposed at a surface. We contemplated having to remove the silica as Dr. Staples had done with hydrofluoric acid, a nasty dangerous material to handle.

First, we started with a simpler experiment. We found a cut surface showing many exposed realgar crystals also containing a few of the larger of the black aggregates cut in cross-section. We thought we might have stibnite (antimony) and possibly iron (if the aggregates and six-side flakes were hematite). The result was that the x-rays found silicon, oxygen, sulfur, arsenic, *and nothing else!* Very simple chemisty, indeed. The only element present that could be the black aggregate was arsenic! This explained the whole thing. Native arsenic crystallizes as a rhombohedral mineral. It can have a silver metallic luster when fresh, but usually looks black due to surface alteration. One of the forms that it can take is that of a flattened rhombohedral flake (form *d* in Fig.2) resembling the usual crystal form of hematite.

The two tests done by Dr. Staples also now make sense. The native arsenic is going to dissolve in the hydrofluoric acid quite readily, so it is not going to be found in the residue, as stibnite would have been. Arsenic is known to sublime at 615° . In the heat treatment at 600° , the vapor pressure would be so high that the material would have evaporated easily in the 30 minutes. No wonder there was no residue left, only cavities where material had been remained.

So we are left with a positive identification: native arsenic. We have a very simple system: arsenic in abundance with only a little sulfur to form realgar As_4S_4 , and orpiment, As_2S_3 with arsenic left over to crystallize on its own. We are also left with a mystery. In solution, arsenic is normally readily oxidized. Only in the most extreme reducing environments could elemental arsenic crystallize in a silica-gel, yet we see the individual crystallites embedded in the agate. What kind of an environment could possibly be so reducing as to make that happen?

To the best of our knowledge, this is the first occurrence of native arsenic in Oregon. It is known to occur in other places, usually associated with metallic sulfides in hydrothermal deposits. This is certainly the first report of arsenic inclusions in agate.

The collecting site at Trent is completely overgrown and shows no signs of previous work. More collecting is not recommended. Specimens are still available at several dealers. Water in the area around Trent is known to contain large amounts of arsenic and should not be drunk. Care must be taken when cutting or sanding quantities of this material, for it is poisonous. Arsenic builds up in your system until it kills you. It takes two ounces to kill the average person.

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Some Zeolite Occurrences in Montana Part II Central Montana

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Central Montana has an extremely diverse geology. Precambrian metamorphic rocks occur in the Beartooth/Absaroka Mountains of Park County and the Little Belt Mountains of Cascade/Meagher counties. Precambrian metasedimentary rocks of the Belt Supergroup are exposed in the Big Belt Mountains in Lewis and Clark County. Paleozoic and Mesozoic sedimentary rocks occur in many locations. Cretaceous-Tertiary igneous rocks are also found in many scattered and isolated locations.

In this, the second, part of zeolite occurrences in Montana, the focus is in on the central portion of the state. The counties covered are: Broadwater, Cascade, Gallatin, Lewis and Clark, Meagher, and Park.

Analcime

Cascade County: Igneous rocks, Adel Mountains (Schmidt, 1978; Irving & Hearn, 2003) questionable identification (Whiting, 1977) - northern (Larsen, 1940; McBride, 1979), Adel Mountains and associated dikes and laccoliths (Lyons, 1944), Square Butte laccolith (Beall, 1972); Sedimentary rocks, 6 miles northeast of Vaughn - in bentonitic shale (Berg & Cox, 2001), near Vaughn - in members of Blackleaf Formation (Sheppard, 1976).

Lewis and Clark County: Igneous rocks, Adel Mountain volcanics (Schmidt, 1978).

Meagher County: Igneous rocks, Castle Mountains (Larsen, 1940), Crazy Mountains - Gordon Butte (Emmart, 1985) - Loco Mountain (Twyman, 1979) - northwest corner (Simms, 1965) - northern and Target Peak area (Simms, 1966) - Comb Creek area - questionable identification (Fink, 1975), Sedimentary rocks, various locations - Livingston Group - minor amounts (Roberts, 1963).

Park County: Igneous rocks, Crazy Mountains (Wolff, 1938; Dudas, 1989, 1991); Sedimentary rocks, various locations - Frontier and Mowry formations - minor amounts locally as cement (Lizak, 1977), various locations - Livingston Group - minor amounts (Roberts, 1963).

Chabazite

Broadwater County: Igneous rocks, northeast Elkhorn Mountains - alteration product - some potassium-rich (Smedes, 1966).

Cascade County: Igneous rocks, Adel Mountains - northern - questionable identification (Whiting, 1977).

Chabazite-Gmelinite

Meagher County: Crazy Mountains - northern - pink in malignite (Simms, 1966).

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Clinoptilolite

Broadwater County: Beaver Creek area - west side of Canyon Ferry Reservoir - in tuffaceous sediments (Berg & Cox, 2001).

Cascade County: Sedimentary rocks, road to the top of Belt Butte - in bentonitic shale (Berg & Cox, 2001), near Vaughn - in members of Blackleaf Formation (Sheppard, 1976).

Gallatin County: Sedmentary rocks, southern Madison Range - Albino Formation (Rose, 1967), near Maudlow - in volcanoclastic sedimentary rocks (Sheppard, 1976) - Maudlow Formation (Skipp & McGrew, 1977).

Lewis and Clark County: Sedimentary rocks, Wolf Creek area - Two Medicine Formation (Ogden, 1974).

Meagher County: Sedimentary rocks, various locations - Livingston Group - trace (Roberts, 1963).

Park County: Sedimentary rocks, south of Livingston, Hepburn's Mesa - in tuffaceous claystone, siltstone and sandstone (Berg & Cox, 2001), Cottonwood Creek area - Middle Sandstone and Mudstone members of Sedan Formation (Skipp & McGrew, 1977), Livingston area - Fort Union Formation (Piombino, 1979), near Point of Rocks - in tuffaceous rocks (Sheppard, 1976), near Wilsall - in volcanoclastic sedimentary rocks (Sheppard, 1976), various locations - Livingston Group - trace (Roberts, 1963).

Faujasite

Cascade County: Igneous rocks, Adel Mountains and associated dikes and laccoliths (Lyons, 1944).

Meagher County: Igneous rocks, Crazy Mountains - Gordon Butte (Emmart, 1985).

Heulandite

Cascade County: Igneous rocks, Adel Mountains and associated dikes and laccoliths (Lyons, 1944); Sedimentary rocks, north of Vaugh - Colorado Shale (Cobbin, 1955).

Gallatin County: Bozeman Pass (Walsh, 1986) - blocky crystals up to 1 cm (Tschernich, 1992); Cedar Knoll Quarry - south of Gallatin Gateway (Tschernich, 1992) - in brecciated zone, crystals up to 7 mm (Toland, 1973), near Maudlow (Montana Tech Mineral Museum #5219, #5300 with laumontite).

Lewis and Clark County: Sedimentary rocks, Wolf Creek area - Two Medicine Formation - volcanogenic sediment (Schmidt, 1978).

Meagher County: Sedimentary rocks, northern Crazy Mountains - Livingston Group (Roberts, 1963; Sims, 1969a) - Calcium-rich heulandite (Sims, 1969b) - Hamen Formation (Sims, 1967).

Park County: Igneous rocks, Hammond School dike - east of Bozeman Pass (Montana Tech Mineral Museum #17197, #17196 with stilbnite and laumontite); Sedimentary Rocks, Gardiner area - Landslide Creek Formation - individual grains and veinlets common near the top of the formation (Frazer and others, 1969), near Livingston - Livingston Formation (Sheppard, 1976), various locations - Livingston Group (Roberts, 1963).

10 Laumontite

Gallatin County: Bozeman Pass - up to 3 cm long (Tschernich, 1992), near Madlow (Montana Tech Mineral Museum #5219, #5300 with heulandite); Sedimentary rocks, near Maudlow - in volcanoclastic sedimentary rocks (Sheppard, 1976).

Lewis and Clark County: Helena district, Spring Hill mine (Jones, 1933, 1934); near Wolf Creek ["...veins up to 5 meters..."] (Shannon, 1921), roadcuts along Interstate 15 between Craig and Hardy - in cavities in igneous rocks (Walsh, 1986); Sedimentary rocks, Wolf Creek area - Two Medicine Formation (Ogden, 1974).

Meagher County: Sedimentary rocks, various locations - Livingston Group - trace amounts (Roberts, 1963).

Park County: Igneous rocks, Railroad cut east of Bozeman Pass (Walsh, 1986), Hammond School dike - east of Bozeman Pass (Montana Tech Mineral Museum #17197, #17196 with stilbite and heulandite); Sedimentary rocks, near Wilsall - Cottonwood Creek area - Middle Sandstone and Mudstone members of Sedan Formation and Lennep Sandstone Member of the Bear Paw Shale (Skipp & McGrew, 1977), near Wilsall - in volcanoclastic sedimentary rocks (Sheppard, 1976), various locations - Livingston Group - trace amounts (Roberts, 1963).

Variety Leonhardite

Cascade County: Igneous rocks, Adel Mountains and associated dikes and laccoliths (Lyons, 1944).

Mesolite

Lewis and Clark County: roadcuts along Interstate 15 between Craig and Hardy - in cavities in igneous rocks (Walsh, 1986).

Mordenite

Cascade County: Sedimentary rocks, near Vaughn - in members of Blackleaf Formation (Sheppard, 1976).

Gallatin County: Sedimentary rocks, near Maudlow - in volcanoclastic sedimentary rocks (Sheppard, 1976).

Park County: Igneous rocks, near Silver Gate (Tom Tucker specimen); Sedimentary rocks, near Wilsall - Cottonwood Creek area - Middle Sandstone and Mudstone members of Sedan Formation (Skipp & McGrew, 1977), near Wilsall - in volcanoclastic sedimentary rocks (Sheppard, 1976).

Natrolite

Cascade County: Igneous rocks, Square Butte laccolith (Beall, 1972), Adel Mountains and associated dikes and laccoliths (Lyons, 1944).

Meagher County: Igneous rocks, Crazy Mountains - Gordon Butte (Wolff, 1938; Emmart, 1985; Chakhmouradian & Mitchell, 2002) - Comb Creek area (Wolff, 1938) - northern (Simms, 1966), Dry Range area - questionable identification from vesicles in basalt (Hruska, 1967), Deadman Canyon-Copperopolis area - questionable identification from vesicles in basalt (Blumer, 1971).

Park County: north of Livingston - prisms up to 7 cm long and 2 mm wide (Tschernich, 1992). **Phillipsite**

Cascade County: Igneous rocks, Adel Mountains - northern - questionable identification (Whiting, 1977).

Scolecite

Cascade County: Igneous rocks, Adel Mountains - northern (Whiting, 1977), Adel Mountains and associated dikes and laccoliths (Lyons, 1944).

Stilbite

Cascade County: Igneous rocks, Adel Mountains and associated dikes and laccoliths (Lyons, 1944).

Gallatin County: Bozeman Pass - single crystals and "bow ties" up to 3 cm (Tschernich, 1992); Cedar Knoll Quarry, south of Gallatin Gateway (Toland, 1973) - lustrous brown, flat-topped crystals up to 15 mm (Tschernich, 1992), southeast of Sedan - crystals up to 13 mm (Toland, 1973); Sedimentary rocks, near Maudlow - Maudlow Formation (Skipp & McGrew, 1977).

Lewis and Clark County: Dry Gulch - in contact metamorphic zones - radial aggregates of crystals several millimeters across (Knopf, 1953; Ream, 2004); Wolf Creek near Craig - light pink blades up to 4 mm (Tschernich, 1992), roadcuts along Interstate 15 between Craig and Hardy - in cavities in igneous rocks (Walsh, 1986), roadcut along Rt. 434 near the South Fork of the Dearborn River crossing (Walsh, 1986), locations along the Middle Fork of the Dearborn River (Walsh, 1986).

Park County: Igneous rocks, Hammond School dike - east of Bozeman Pass (Montana Tech Mineral Museum #17197, #17196 with heulandite and laumontite), near Clyde Park (Feldman, 1985); Sedimentary rocks, near Wilsall - Cottonwood Creek area - Middle Sandstone and Mudstone members of Sedan Formation - common in veins (Skipp & McGrew, 1977), near Wilsall - in volcanogenic sedimentary rocks (Sheppard, 1976).

Thomsonite

Broadwater County: Igneous rocks, northeast Elkhorn Mountains (Smedes, 1966).

Cascade County: Little Belt Mountains - ten miles south of Neihart - in contact metamorphic zone (Taylor, 1935); Igneous rocks, Adel Mountains - northern - alteration product (Whiting, 1977), Adel Mountains and associated dikes and laccoliths (Lyons, 1944), Square Butte laccolith (Beall, 1972).

Meagher County: Igneous rocks, Crazy Mountains - Gordon Butte (Chakhmouradian & Mitchell, 2002) - northern - questionable identification (Simms, 1966); Sedimentary rocks, northern Crazy Mountains - Hamen Formation - questionable identification (Sims, 1967).

Unknown Zeolites

Broadwater County: Igneous rocks, Park district, Marietta mine area - possibly several (Schell, 1961, 1963).

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Cascade County: Igneous rocks, Adel Mountains - northern - many unknown zeolites ["...occur as cavity fillings, mineral replacements and as interstitial fills between groundmass minerals."] (Whiting, 1977; McBride, 1979), Adel Mountains and associated dikes and laccoliths (Lyons, 1944), Square Butte laccolith (Beall, 1972).

Gallatin County: Sedimentary rocks, near Maudlow - Maudlow Formation (Skipp & McGrew, 1977).

Lewis and Clark County: Sedimentary rocks, Wolf Creek area - Two Medicine Formation - volcanogenic sediment (Schmidt, 1978).

Meagher County: Igneous rocks, Castle Mountains - Volcano Butte area (Weed & Pirsson, 1896), Crazy Mountains - Comb Creek area (Fink, 1975) - northern (Simms, 1966) - Loco Mountain (Twyman, 1979); Sedimentary rocks, north of Lennup - Amsden, Kootenai, and Lennup formations (Glasheen, 1969).

Park County: near Clyde Park (Feldman, 1985); Igneous rocks, Crazy Mountains (Dudas, 1989, 1991).

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Update – Research on Northwest Minerals

Don Howard

Some recent research has lead to the identification and reclassification of some of the minerals at places we have been collecting. Most of this work has been done by Etienne Medard, who has been post-docing at MIT and acting as the newsletter editor for the Micromounters of New England.

Summit Rock

Etienne Medard has used the microprobe equipment at MIT to look at the needles that we have been calling magnesiohornblende. He informs me that they should be classified as

Fluoro-edeniteNa Ca2 Mg5 (Si7 Al) $O_{22} F_2$ This is a hard mineral to identify without special equipment, since the fluorine does not record well in the
SEM. He looked at this because he recognized the similarity of the occurrence to certain French locations
where he has been studying fluoro-edenite. Also, he finds that the green mineral analyzes as diopside,
though it is close to augite and may vary from sample to sample.

Lemolo Lake

The fine needles, colorless to light brown, found in the rims of the flow along the spillway are also **fluoro-edenite**. Etienne has also identified the bright yellow, stubby crystals that are occasionally found in the rims as **diopside**.

Obsidian Cliffs

Examination of the flat, metallic-appearing blades that occur in the cristobalite along with the osumilite and phlogopite have clarified their composition. Bill Henderson, using optical methods, has found that the centers of the blades are fayalite. Etienne Medard says he sees "One dominant phase making maybe 80 % of the crystals, with a thick (about 60 microns) rim and inclusions of a second phase (about 20 %). And there is a thin coating of oxides (maybe hematite) on the outside of the crystal. Microprobe says Mg, Mn-bearing fayalite (Fa83) for the bulk of the crystal, in agreement with Bill's optics. Thick rim and inclusions are of an Fe silicate with a stoichiometry close to Fe₄Si₃. This could be a pure Fe³⁺ olivine end-member. He agrees that the thick rim and inclusions should probably be classified as laihunite. So that would make our specimens **laihunite** coating **fayalite**.

Update on Zeolite Species

Don Howard

With the three following species, we complete with this issue the minerals that have been moved into the zeolite family. These three were not included originally because they contained no water molecules in their structure. However, it makes good sense to include leucite and ammonioleucite, since the lattice structure is essentially identical to pollucite, analcime and wairakite. The larger potassium and ammonium ions occupy the sites that are occupied by water in analcime, leaving no room for water in the lattice. The cesium ions in pollucite are similarly too large and pollucite would not have qualified had it been the pure cesium end-member, but in pollucite, sodium ions replace some of the cesium ions, and for each of those, a water molecule can enter. Thus, structurally, we see that these minerals belonged in the zeolite family all along.

Leucite is a common, widespread mineral, and it is not practical to list all places that it occurs. We have tried to summarize the more important occurrences of specimen-quality material. In so far as we may have left out important localities, please pass the information along and we will update our data summary.

Leucite

K Al Si₂ O₆ , Z = 16

Named by Werner in 1791 after the Greek leukos, white, its usual color.

Type locality: Mt. Vesuvius, Campania, Italy.

Structure

Below 630° C Crystal System: Tetragonal (pseudocubic) Space Group: I4₁/a Crystal axes: a=13.09 A c=13.75 A Above 630° C Crystal System: Isometric Space Group: Ia3d Crystal axes: a=13.4 A

Type of Structure: The aluminosilicate framework is identical with that of analcime: 4-ring chains wrapped around square prisms and interconnected to form cages. The aluminum and silicon are not ordered. The larger potassium ions replace the water molecules in the larger cages, and the smaller interstices, partially occupied by sodium ions in analcime, are empty in leucite. In the tetragonal structure, the shape of the cavities occupied by the potassium ions are distorted slightly.

Physical Properties

Optical Properties

Color : colorless to white or gray	Refractive Index :
Streak:white	$n_0 = 1.508$
Luster: vitreous	$n_e = 1.509$
Hardness: 5.5-6	
Density : $2.45-2.50 \text{ g/cm}^3$	uniaxial positive
Fracture: brittle	2V very small
Cleavage : {110} very poor	
Twinning: When cooled below 630° C, the tran	sition to the tetragonal phase is acc

Twinning: When cooled below 630° C, the transition to the tetragonal phase is accomplished by repeated fine-scale twinning on {110}. The sample reverts to the untwinned cubic phase if reheated above 630° C, but retains a "memory" so that it forms the same proportion of twin domains and the same twin planes when cooled.

Morphology

Euhedral trapezohedral crystals to 9 cm in diameter. Also as disseminated grains, granular and massive. **Forms**: [112] dominant. {110} also sometimes present.

Chemical Composition

Usually nearly pure K Al Si₂ O₆. TiO₂ is usually low, but can reach 1.4 wt%. Na₂O may reach 2 wt%. Minor amounts of CaO, FeO and MgO may also be present.

Alteration

In some rocks, called pseudoleucite, the leucite has been replaced by an intergrowth of potassium-rich feldspar and nephiline.

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Occurrence

Leucite is a higher temperature mineral than most other zeolites. It forms above 630° C and therefore retains an overall cubic form after it cools. Found as phenocrysts, in the matrix, and in the cavities of K-rich mafic and ultramafic volcanics and hypabyssal rocks. Often associated with K-feldspar, analcime, nepheline, kasilite, natrolite, etc. Leucite is a common, widespread mineral of K-rich igneous rocks, and only some of the many occurrences can be singled out below.

Australia

Leucite occurs in the kimberlites and lamproites at several locations near Noonkanbah, Western Australia.

Austria

Leucite occurs at Stradner Kogel Mt., Wilhelmsdorf, Styria.

Brazil

Leucite has been reported from the Pântano intrusion, Pântano, Patos de Minas, Minas Gerais.

Czech Republic

Clear grains to several centimeters are found in the volcanics at Radesin Hill, Usti Region, Bohemia.

France

Small, clear, sharply-faceted crystals occur with esseneite at Lapanouse-de-Severac, Aveyron, and at Saint-Maime, Alpes de Haute Provence..

In veins in the analcite basanite of Causses, Auvergne.

French Polynesia

Present along the Faataua River, near Papeete, Tahiti.

Germany

Occurs in a number of locations in the Eifel Mountains, such as in pneumatolytic fissures with pyroxene, perovskite, magnetite, nepheline, melilite and apatite at Graulai Quarry, Bolsdorf and at Loley Quarry, Udersdorf, Eifel, Rhineland-Palatinate.

Indonesia

A series of leucite-bearing basic lavas are found at the Muriah volcano, central Java.

Italy

As xenoliths in the lavas from Mt. Somma-Vesuvius complex, Naples Province. Opaque, white trapezohedral crystals over a centimeter in diameter occur in the Roccamonfina Volcanic complex, Caserta Province, Campania. As clear trapezohedral crystals in early quaternary volcanic rocks classified as basaltic leucitite, with pyroxenes,

melilite, nepheline and magnetite at Vallerano Quarry, Vallerano, Roma, Latium.

Large crystals of leucite, phlogopite, hauyne and clinopyroxene make up large blocks of fresh lava that fill up some sections of a karst cave at Grotta del Cervo, Abruzzi, about 60km NE of Rome.

Leucite is a component of the lavas of Mt. Etna, Catania Province, Sicily.

Japan

Found with dolomite, analcime and ammonioleucite in veinlets and cavities in hydrothermally altered schist at Fujioka, Tatarazawa, Sanbagawa, Gumma Prefecture.

Russia

Leucite is a component of the Lovozero and Khibiny Massifs, Kola Peninsula. It is also found in the Murunskyi Massif, Torgo River Basin, Eastern Siberia.

Spain

Small crystals of leucite occur in olivine and clinopyroxene near Cancarix, Castile-La Mancha and Jumilla, Murcia.

Tanzania

Leucite is a component of the volcanics of Mt. Kilimanjaro.

Uganda

Leucite occurs in a variety of volcanics in the lava fields E and SE of Ruwenzori, and in other potassium-rich ultrabasic rocks throughout the country.

United States

Arizona: Leucite is present in certain olivine-rich dikes on the Navajo Indian Reservation, Apache Co.

Arkansas: At Magnet Cove, Hot Springs Co.

Montana: Reported from the Bearpaw Mts., Hill Co.

Wyoming: As white to gray phenocrysts in volcanics from the Leucite Hills, Sweetwater Co.

Zaire

Giant leucite blocks are present in the talus slopes of Mt. Nyiragongo, Kivu, Congo.

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Ammonioleucite

 $(NH_4,K)\;Al\;Si_2\;O_6\;,\;\;Z=16$

Named by Hori *et al* in 1986 from the composition and relationship to leucite. **Type locality**: Tatarazawa, Fujioka, Gunma Prefecture, Japan.

Structure

Crystal System: Tetragonal (pseudocubic) **Space Group**: I4₁ /a **Crystal axes**: a=13.214 A c=13.713 A

Type of Structure: Isostructural with leucite and very similar to analcime. 4-ring chains wrapped around square prisms and interconnected to form cages. The ammonium ions take the place of the potassium ions.

Physical Properties

Optical Properties

Color: white, translucent	Refractive Index :
Streak:	$n_0 = 1.518$
Luster: vitreous to resinous	$n_e = 1.518$
Hardness:	
Density : 2.29 g/cm ³	uniaxial positive
Fracture:	
Cleavage:	
Twinning:	

Morphology

Powdery. **Forms**:

Chemical Composition

 $[(NH_4)_{0.68} K_{0.19}] Al_{0.89} Si_{2.12} O_6$

Occurrence

The mineral occurs as a powdery surface replacement of analcime. It appears to have formed when ground water containing ammonium ions ion-exchanged with the water molecules in the analcime, replacing them and driving out the sodium.

Japan

Found with dolomite and analcime in veinlets and cavities in hydrothermally altered schist at Tatarazawa, Fujioka, Gunma Prefecture.

References:

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Kalborsite

 $K_6 Al_4 Si_6 O_{20} B (OH)_4 Cl ; Z = 2$

Named in 1980 by Khomyakov after the composition.

Type locality: The Apatitovyy Cirque, Mount Rasyumchorr, Khibiny alkalic pluton, Kola Peninsula, Russia.

Structure

Crystal System: Tetragonal Space Group:P42₁c Crystal axes: a=9.851 A c=13.06 A

Type of Structure: Consists of a three-dimensional backbone of SiO_4 and AlO_4 tetrahedra, with broad channels along the c-axis in which the potassium ions are separated from each other by chlorine ions and isolated $B(OH)_4$ tetrahedral.

Physical Properties

Optical Properties

 $n_e = 1.525$

 $n_0 = 1.525$

Refractive Index:

Color: transparent, pale pinkish brown **Streak**: **Luster**: vitreous to nacreous **Hardness**: 6 **Density**: 2.5 g/cm³ **Fracture**: **Cleavage**: (110) perfect **Twinning**:

uniaxial positive

Morphology

Equidimensional grains 1-2 mm in diameter **Forms**:

Chemical Composition

 $K_{6.04} \ B_{1.35} \ Al_{3.93} \ Si_{6.07} \ O_{22.58} \ Cl_{0.99} \qquad \mbox{The hydroxyl was determined by infrared absorption and crystal structure analysis.}$

Occurrence

The mineral occurs as grains in a pectolite rim surrounding segregations of lomonosovite.

Russia

Found as disseminated grains in pectolite in a lovozerite-rich pegmatite containing potassic feldspar, nepheline, thin-acicular aegirine, eudialyte, lomonosovite, lamprophyllite, shcherbakovite and magnesium astrophyllite in the Apatitovyy Cirque, Mount Rasyumchorr, Khibiny alkalic pluton, Kola Peninsula.

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