

**Northwest
Micro Mineral
Study Group**



MICRO PROBE

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May 6, 2006

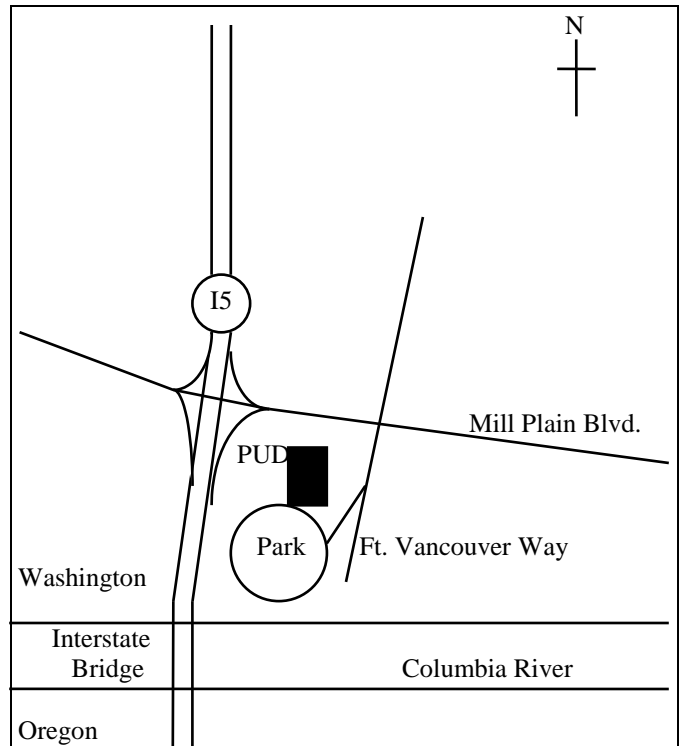
9:30 am to 5:00 pm

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

Once again we are able to get together in the Fort Vancouver facility. Bring your microscopes and something for the free table to share with others, as well as your special new finds and your unknowns to be identified. 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 special speaker has been planned, but 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. Doug Merson will have more examples of multi-level photography, and Don Howard will have pictures of the various minerals that are to be found in the cavities at Summit Rock and Lemolo Dam. There should be ample time to enjoy looking at each other's special pieces, and swapping information about collecting.

The kitchen area is again available and we will plan on sharing lunch together.

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



Hexagonal Filiform Minerals in Nature and in the Laboratory

Donald G. Howard

Recent research has turned up with a new form for filiform minerals to take. Until recently, the only filiforms were minerals that crystallize as isometric minerals. The cubic symmetry would indicate that all such minerals in their “normal” perfect form should be equant, with each class of faces present equally developed. The filamentary form present in filiforms of cubic minerals, such as pyrite and cuprite (chalcotrichite) are therefore obviously unique.

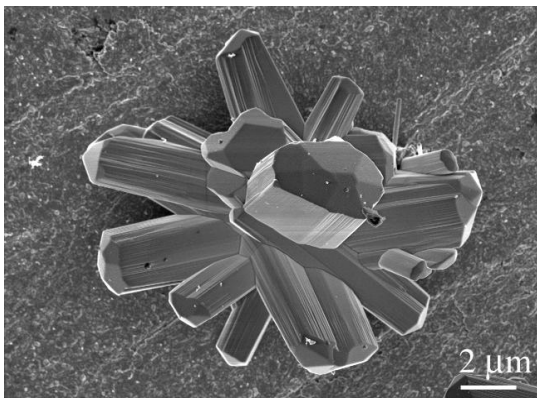
To extend the concept of a filiform mineral to other systems requires us to define more explicitly what we mean by the term *filiform*. Crystal systems with lower symmetry all provide at least one unique direction, and elongation along that direction is common in many minerals. For instance, natrolite, a tetragonal mineral, and millerite, a hexagonal mineral, are commonly elongated along their *c*-axis. Since the structure along that direction is unique, the elongation can be explained in terms of the growth mechanisms favoring adding material preferentially in those directions. We have no reason to think, therefore, based on filamentary structure along their *c*-axis, that there is anything odd about finding them in needle-like form. Many chemical compounds grow needles because that is the easy direction to add new material.

So I propose limiting the term “filiform” to crystals that are elongated along a direction that is not crystallographically unique. This would technically allow us to have filiform minerals in all but the triclinic system. But except in extraordinary cases, this definition probably limits the likelihood of finding filiforms to the tetragonal and hexagonal systems, where several *a*-axes are crystallographically equivalent.

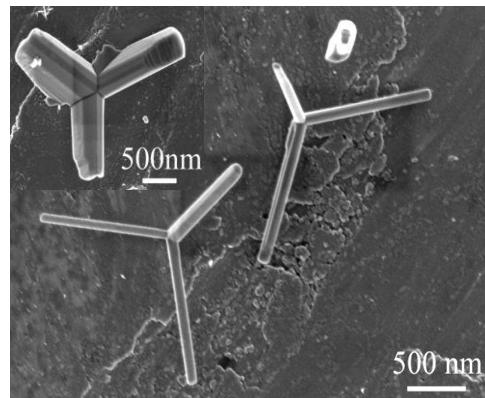
In the laboratory, a phenomenon called “whisker growth” has been known for many years. Under certain conditions, surfaces exposed to a metal vapor would grow fine hair-like growths rather than a uniform even coating. If the goal was to obtain a mirror finish or a layer of uniform thickness, this could be a real nuisance. The conventional explanation for such growths involved screw dislocations, since these were structures known on theoretical grounds to be able to add atoms more rapidly to a crystal by avoiding the necessity of nucleating new layers.

At first, the *intentional* growth of these whiskers was done more through the developing of recipes than by any understood procedure. Sometimes they grew and sometimes they did not. But over time, as vacuum techniques improved and the cleaning of surfaces got better, whiskers became less and less of a problem. This suggested to researchers that maybe the effect was rooted in impurities. So the logical thing to do was to clean a surface really well and then intentionally introduce an impurity in a controlled way to see the effect.

A case in point involves the work of Professor Jun Jiao and her students at Portland State University, where they studied the growth of CdS on a tungsten surface. CdS crystallizes in the wurtzite structure, which is hexagonal. The crystals that were formed at 800° C on a very clean surface (shown below) are elongated along the *c*-axis, as we would expect.



Crystals of CdS grown from vapor at 800° C



on a clean tungsten surface.

The tiny clusters resemble many of the natural minerals that we collect.

Very different results are obtained when a very small amount of gold is evaporated onto the clean tungsten surface before it is exposed to the CdS vapor. Though gold in bulk would be a solid at these temperatures, on such a surface it is very mobile and tends to form tiny clusters that act much more like a liquid. When exposed to CdS vapor at 800° C, thin crystals form very rapidly. Moreover, these crystals are elongated along an a-axis instead.

To explain this very different growth habit, we first notice, as in the picture at right, that there is a dark glob at the top, growing end of the needle. Analysis by x-ray fluorescence shows that the glob is a particle of gold. What is thought to happen is that the CdS vapor dissolves in the liquid-like gold preferentially, and then crystallizes out of the gold at the point it contacts the surface. The added material raises the gold particle as the process continues, so it stays at the growing tip of the crystal. This whole process is referred to as *catalyzed growth* and the detailed mechanism is called a VLS (vapor-liquid-solid) process.

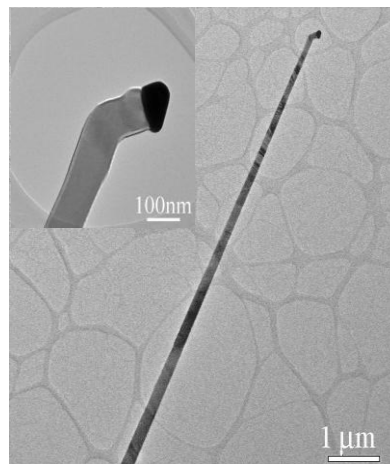
This is the process now thought to be responsible for most whisker growth. The use of gold is not unique – several other metals, such as iron and nickel, have been used in a similar way to catalyze growth in a number of different materials, including tungsten nitride and carbon nanorods. What seems to be more important than the material of the catalyst is the size of the particles present.

One thing to notice particularly in the picture above is that for some reason, the gold particle shifted off-center, and this resulted in a bend. Since the a-axes are at 120° to each other, the bend is at that angle rather than the 90° that we commonly see in filiform pyrite. In a cubic or tetragonal system, the equivalent axes are at 90°.

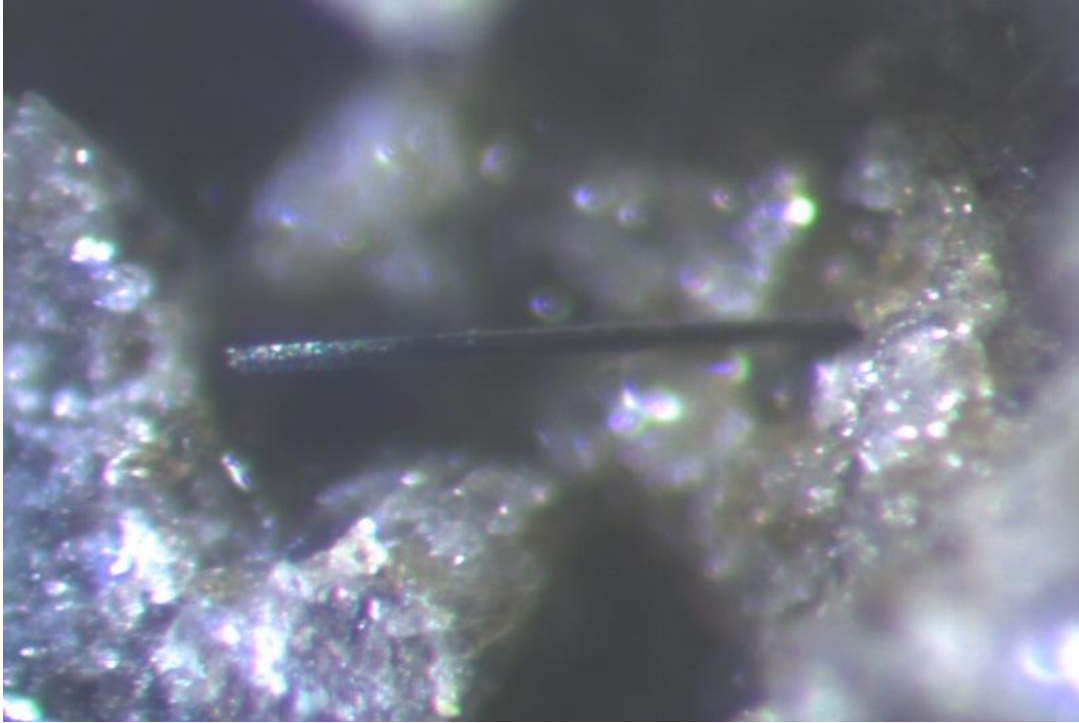
Cadmium sulfide is not a material that we are likely to find occurring naturally, but we have a natural analog to this laboratory accomplishment in the filiform ilmenite crystals recently found at Lemolo Lake. The situation seems to be very similar. The other minerals present – enstatite, pseudobrookite, and especially tridymite – indicate that the formation occurred at a relatively high temperature where ilmenite was formed from vapor as the hot lava flowed out over the scoria layer beneath. The presence of both normal and filiform crystals of ilmenite means that only occasionally was the proper catalyst present.

But what was the catalyst? That may be a nearly impossible question to answer. The tiny particle responsible has undoubtedly long since dissolved or otherwise been lost. The only way we might find a clue is if a fragment of the catalyst would become embedded in the crystal and we could locate it using an electron microscope. Embedded bits of gold are sometimes seen in the laboratory grown crystals. But the natural ones may grow far slower and are usually thicker, so even that may not prove to give a clue.

Other natural filiforms are not such a similar match of processes. The filiform pyrite and copper were formed at much lower temperature. We know that from the associated clay and zeolite minerals that are all low temperature. They probably formed in the presence of water. I think there is a very good chance that they also represent catalyzed growth. But to my knowledge, no one has accomplished the growth of whiskers from a solution. There is some evidence that fine needle-like growths can be accomplished from solution through electrolysis in certain materials, but that would most likely yield growth along a unique direction instead. As the usual closing statement usually says, more research is needed to duplicate what nature seems to do rather easily.



CdS filiform crystal grown at 800° C using gold as catalyst.



Filiform Ilmenite from Lemolo Lake, Douglas Co., Oregon. The crystal is approximately 0.6mm long.



Filiform Ilmenite from Lemolo Lake, Douglas Co., Oregon. The crystal is approximately 0.5mm long. Notice that it has a normal flat hexagonal ilmenite blade growing at the end of the filament like a flag.

Update on Zeolite Species

Donald G. Howard

This time we continue adding to the data sheets for zeolites that was begun last issue. The four minerals included – gaultite, maricopaite, partheite and tschortnerite – were included in the zeolite group when IMA redefined the criteria in 1998. It is not clear to me why partheite was originally excluded from the group, since its structure and composition are similar to other zeolites of long standing. The other three are unusual in that they contain atoms of heavy metals not in the alkali or alkali earths part of the periodic chart. In the cases of maricopaite and tschortnerite, the lead and copper are present as cations much the same way calcium would be present inside the spatial network. Gaultite is rather unique in that the zinc is a part of the framework, filling the role that aluminum usually plays.

All four of these minerals are quite rare. In fact, two of them – gaultite and tschortnerite – have been found only in a single piece of rock (and with gaultite in a single cavity). Of the four, only maricopaite has been found in sufficient quantity that you are likely to come across it in a collection or a dealer's catalogue. Nevertheless, for the sake of trying to be as complete as possible, I have included all the data I could find out about them in the format of Rudy's "Zeolites of the World". I hope you find the information useful and interesting.

THE MICROPROBE

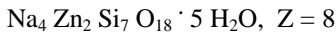
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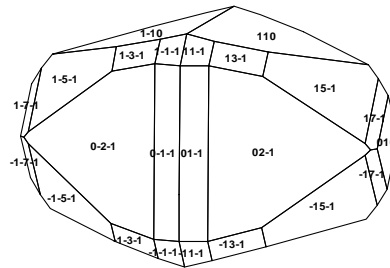
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Gaultite



Named in 1994 for Robert Allen Gault of the Canadian Museum of Nature.

Type locality: Poudrette Quarry, Mont Saint-Hilaire, Rouville County, Quebec.



Structure

Crystal System: Orthorhombic
Space Group: F2dd (pseudo mmm)
Crystal axes: a=10.21 Å
 b=39.88 Å
 c=10.304 Å

Type of Structure: All Si and Zn atoms are tetrahedrally coordinated, with the tetrahedra in an all-corners-linked arrangement to form a framework. This results in 4-membered rings and a 5-membered spiral structure. The Zn and Si are fully ordered. Water molecules provide considerable hydrogen bonding.

Physical Properties

Color: colorless to pale mauve
Streak: white
Luster: vitreous
Fluorescence: bright apple green under SWUV
Hardness: 6
Density: 2.52 g/cm³
Fracture: conchoidal
Cleavage: {101} and {010} perfect
Twinning: none

Optical Properties

Refractive Index:
 $\alpha = 1.520$
 $\beta = 1.521$
 $\gamma = 1.524$
 biaxial positive
 $2V = 61.3^\circ$
 XYZ parallel to acb

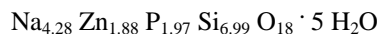
Morphology

Euhedral, equant multifaceted crystals up to 0.5mm in diameter.

Forms: Dominant forms are {010}, {110}, {-110}, {021}, {151} and {1-51}.

Subordinant forms include {111}, {-111}, {131}, {-131}, {171}, {-171} and {011}.

Chemical Composition



Occurrence

Gaultite occurs in a cavity in a single specimen from the center of a 12m inclusion of sodalite syenite near a contact of hornfels and nepheline syenite. Associated minerals include aegirine, analcime, cancrinite, catapleiite, chabazite, eudialyte, galena, graphite, lovozerite-group minerals, makatite, microcline, nepheline, natrolite, phillipsite, polyolithionite, pyrite, serandite, sodalite, steenstrupine, ussingite, villiamite, vitusite, vuonnemite. Gaultite was the last to form.

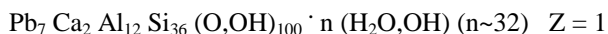
Canada

Poudrette Quarry, Mont Saint-Hilaire, Rouville County, Quebec.

References:

1. Ercit, T. Scott & Van Velthuizen, Jerry, *Gaultite, a New Zeolite-like Mineral Species from Mont Saint-Hilaire, Quebec, and its Crystal Structure*, Can. Min. 32, 855-863 (1994).

Maricopaite



Named for the county in Arizona where it was found.

Type locality: Moon Anchor Mine, near Tonopah, Maricopa County, Arizona.

Structure

Crystal System: Orthorhombic

Space Group: Cm2m

Crystal axes: a=19.434 Å

b=19.702 Å

c=7.538 Å

Type of Structure: Similar to the structure of mordenite. The 12-membered ring channels parallel to c are somewhat different in cross section. A second channel system, also parallel to c, is cruciform in shape and contains tetrahedral clusters of Pb ions, each bonded to 6 to 8 framework anions or water molecules.

Physical Properties

Color: white to colorless

Streak: white

Luster: silky to vitreous

Hardness: very soft and friable

Density: 2.94 g/cm³

Fracture: fibrous

Cleavage: imperfect, {010}

Twinning: none

Optical Properties

Refractive Index:

$\alpha = 1.563$

$\beta = 1.582$

$\gamma = 1.592$

biaxial negative

$2V = 70^\circ \pm 10^\circ$

X:Y:Z = a,c,b

Morphology

Thin bundles of acicular crystals extremely elongated along [001]. Also radial sprays up to 1.0mm in diameter and as mats with admixed mimetite.

Forms:

Chemical Composition



Occurrence

From the hanging wall of a calcite-fluorite vein possessing many square voids, presumably due to dissolved galena. Specimens are usually on quartz associated with orange mimetite. Other secondary minerals include cerussite, fornacite, phoenicochroite, duftite, chrysocolla, and wickenburgite.

United States

Arizona

Maricopaite occurs with orange to yellow mimetite on quartz at the Moon Anchor Mine, approximately 15km west of Tonopah, Maricopa County.

References:

2. Peacor, Donald R., Dunn, Pete J., Simmons, William B., Wicks, Frederick J., & Raudsepp, Mati, *Maricopaite, a new hydrated Ca-Pb, zeolite-like silicate from Arizona*, Am. Min. **26**, 309-313 (1988).
3. Rouse, Roland C. & Peacor, Donald R., *Maricopaite, an unusual lead calcium zeolite with an interrupted mordenite-like framework and intrachannel Pb tetrahedral clusters*, Am. Min. **79**, 175-184 (1994).

Partheite

$\text{Ca}_2 \text{Al}_4 \text{Si}_4 \text{O}_{15} (\text{OH})_2 \cdot 4 \text{H}_2\text{O}$. $Z = 4$

Named in 1979 for Edwin Parthe, crystallographer at the University of Geneva.

Type locality: 7 km east of Doganbaba, Burdur Province, Taurus Mountains, southwestern Turkey.

Structure

Crystal System: Monoclinic

Space Group: C2/c

Crystal axes: a=21.555 Å
b=8.761 Å
c=9.304 Å
 $\beta=91.55^\circ$

Type of Structure: Tetrahedra connected via corners to form a network of low density, built of 4, 6, 8, and 10 membered rings. Due to the presence of OH groups, the framework is interrupted every second Al-site. The 10-membered rings form the perimeter of zig-zag channels which are filled with water molecules. Related to the structure of gismondine. Partheite is dimorphous with the mineral lawsonite.

Physical Properties

Color: colorless to white

Streak: colorless to white

Luster: vitreous

Hardness: ~4

Density: 2.39- 2.45 g/cm³

Fracture: ?

Cleavage: {100} and {110} distinct

Twinning: none

Optical Properties

Refractive Index:

$\alpha = 1.545-1.550$

$\beta = 1.549-1.552$

$\gamma = 1.559-1.565$

biaxial positive

$2V = 48^\circ$

$Y=b, X^c = 27 \pm 3^\circ$

Morphology

Radial fibrous crystals to 0.1-0.3mm.

Forms:

Chemical Composition

$\text{Ca}_2 \text{Al}_4 \text{Si}_4 \text{O}_{15} (\text{OH})_2 \cdot 4 \text{H}_2\text{O}$ with traces of Na_2O (0.3%) and K_2O (0.2%).

Occurrence

Russia

In a gabbro pegmatite at Denezhkin Kamen, Ural Mountains.

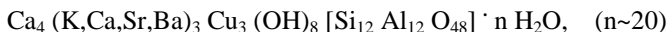
Turkey

In an Ophiolite zone in rodingitic rocks with prehnite, thomsonite and augite at Burdur Province, Taurus Mountains.

References:

- Sarp, H., Deferne, J., Bizouard, H., & Liebich, B.W., Bull. Suisse Min. Petr. **59**, 5-13 (1979).
- Engel, N. & Yvon, K., *The crystal structure of Partheite*, Acta Cryst. A **40**, C-247 (1984); Z. Kristallogr. **169**, 165-175.

Tschortnerite



Named in 1998 for Jochen Tschortner, a mineral collector who found the mineral.

Type locality: Bellberg volcano, near Mayen, in the Laacher See volcano area, Eifel, Germany.

Structure

Crystal System: Isometric

Space Group: Fm3m

Crystal axes: $a=31.62 \text{ \AA}$

Type of Structure: Al-Si tetrahedra form a spatial network containing double 6-rings, double 8-rings, sodalite cages, a larger truncated cubo-octahedral cage of 48 members, and a huge 96-membered cage unique to this structure. The sodalite cages contain Ca-O clusters while the Cu-Ca-O clusters are at the centers of the 48-member cages. The huge cages contain loosely bound water molecules. The other ions are located in the double 8-rings. The Al and Si appear to be disordered.

Physical Properties

Color: light blue, transparent

Streak: ?

Luster: vitreous

Hardness: 4.5

Density: 2.10 g/cm³

Fracture: conchoidal

Cleavage: none

Twinning: none

Optical Properties

Refractive Index:

$n = 1.504$

isotropic

Morphology

Isolated, well formed cubes up to 0.15mm, or rarely as parallel intergrowths

Forms: {100}.

Chemical Composition



Occurrence

Tschortnerite occurs in the fragments of one Ca-rich xenolith in leucite tephite lava.

Germany

Bellberg volcano, near Mayen, in the Laacher See volcano area, Eifel.

References:

6. Effenberger, H., Giester, G., Krause, W. & Bernhardt, H.-J., *Tschortnerite, a copper-bearing zeolite from the Bellberg volcano, Eifel, Germany*, Am. Min. **83**, 607-617 (1998).

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This is the new version from the Los Angeles Museum of Natural History. I have seen some of the photos that will be used in this version. A number of them will be done using multi focus photography and are quite stunning. This remains superior to the Photographic Guide to Mineral Species put out by Excalibur. In their new version, more mineral data is included and more photos. The Photo Atlas of Minerals still has better photography.

Another program worth considering would be Atlas der Krystallformen published by Mindat.org. It is very reasonably priced and produces excellent prints from the scans. It is on a DVD. I have found it far superior to the version available on the net or previous attempts to publish it on CD.