MMNE Field Trip to the Audley Quarry, Merrimack, NH
May 20, 2017

Tom Mortimer with photo contributions from Peter Cristofono and Bob Wilken

Thanks to the networking of our well-connected, professional quarry manager and MMNE president, Scott Reilly, a field trip to the R. S. Audley quarry, Merrimack, New Hampshire, was arranged as a follow-on to our May club meeting. Eleven members made the 20-mile trip north to the site off Exit 10, Rt. 3.

Figure 1. Audley quarry, Merrimack, NH   Peter Cristofono photo.

History

On my first collecting trip to the Audley quarry in August 2003, I noticed how similar the rock was to that of the Mine Falls Park locality in Nashua, about 5 miles to the south. Outstanding crystals of dark blue anatase were discovered at Mine Falls many years ago by Scott Whittemore, a former MMNE club member. The anatase crystals occurred in 1 to 3 mm quartz crystal seams in the host phyllite. I had visited the Mine Falls site – where blasting had been done for a new hydro station – a couple of times prior to Scott's visit. Other than some sulfides, I had not found much of interest. Scott's discovery was an eye-opening experience for me! I never would have found micro anatase crystals had it not been for him. Several photos of Scott's finds may be viewed on mindat.org.

In its early days of operation, the Audley Merrimack quarry was un-posted, un-gated. With knowledge that anatase might be found in seams in phyllite, I collected a bunch of it to bring home. I cleaned the specimens using Iron Out and many nice anatase crystals came to light, and a couple of brookite crystals too. Scott Whittemore, Bob Janules and I made a few return trips to acquire more, ultimately reaching saturation. How many anatase specimens does one need? Years later, the quarry was fenced in and posted. However, it's easily visible from the Route 3, and over the years whenever I drove by, I noticed that the once moderate-size hill was being reduced to crushed stone. I would guess that only twenty percent of the original hill remains. Currently, the quarry is not active, though several large piles of small to mid-size stone remain to be carted off. In 2014, I contacted Ryan Audley to see if I might gain access. The reply was "not at the present, maybe later." It Never happened. When I broached the topic of Audley Merrimack access with Scott Reilly, he indicated that it might be possible through his contacts.

May 2017 Visit

I was apprehensive that with so much of the hill removed, the minerals I had found in the past would no longer be present. My anxiety quickly dissipated after whacking a few phyllite boulders that had obvious thin seams. Using my eye loupe, I spotted the characteristic shape of a few coated, dirty, anatase crystals. I showed these to other members close by, pointing out the source seams. The quarry floor had two large (perhaps 30-feet high) piles of rock chunks – one foot size and larger. These provide ample material to safely collect without needing to approach the 50- to 60-foot high quarry wall. In addition to the phyllite rock, there were numerous white quartz boulders that contained occasional sulfide minerals (pyrite, pyrrhotite, chalcopyrite, and perhaps others) as well as quartz crystals to one-half inch plus.

Figure 2: MMNE members at the Audley Merrimack quarry, May 20, 2017 Peter Cristofono photo

Sorting, Trimming and Cleaning

With scope examination, I observed two types of quartz-filled seams. One type consists of coarse granular quartz. These seams contain no minerals of interest (that I could find). The other type consists of micro (usually clear) quartz crystals and well-formed adularia crystals. These are the ones that can contain anatase, brookite and small pyrite crystals. It is difficult differentiating these two seam types without a loupe or microscope, so I recommend a first-pass, quick look to sort them apart.

The thin quartz crystal seams containing anatase and brookite typically cross-cut the grain of the phyllite rock. In this circumstance, pieces containing a seam surface frequently have a lot of matrix attached. Often the only way to preserve some substrate matrix (to hold the specimen together) is to diamond saw the excess matrix away. I use a $70 Home Depot tile saw for this purpose. After sorting and sawing, I reduced my 20 or so pounds of "field returns" to about a half a pound of specimen-potential pieces.

The quartz-anatase-adularia pieces are easily cleaned in Super Iron Out. I use about a teaspoon of Iron Out in a cup of warm water, then place the specimens in a small plastic cup with the Iron Out solution and put the cup in my water-filled ultrasonic cleaner. A half-hour in the ultrasonic is sufficient. Rinse the specimens well after removing from the Iron Out solution.

The Minerals (All photos – Tom Mortimer, unless otherwise indicated)

Anatase This species is definitely the most desirable one from the Audley locality. The doubly terminated crystals feature steep bipyramids (Figure 3). These steep pyramid faces are frequently (but not always) laterally striated. The pyramid top may be truncated with a basal pinacoid. Anatase occurs in a wide range of colors: lemon yellow, orange, honey brown, pale blue to medium dark blue and nearly colorless crystals have been found. Anatase is found on quartz and adularia crystals and also on slightly rough, flat, milky quartz surfaces. The density of anatase crystals is very high on some specimens (Figure 5).

Anatase has long been a favorite of micromineral collectors. In the mid-1980s, Scott Whittemore and I visited the Poker Hill locale in Cumberland, Rhode Island. This was where New England collectors went for anatase. Poker Hill was a quartz knob located beside a well-traveled road. It was being leveled for a construction site. The quartz crystals had dark striated anatase crystals perched on them. At the time we visited, anatase was rare; all the “easy pickings” had been long ago harvested. The two-hour road trip (each way) netted me two mediocre specimens.

Figure 3: 1 mm anatase crystal on adularia

Figure 4: 0.5 mm crystal. Bob Wilken photo

Figure 5: A couple dozen anatase crystals in this 4 mm field of view

Figure 6: This 2 inch sawed slab has over two hundred 0.1 to 0.5 mm orange anatase crystals.

Brookite Anatase, brookite, and rutile are trimorphs: the three have the same chemistry, TiO_2, but different crystal structure. Brookite at the Audley Merrimack quarry is rare. I found only a few tiny crystals on a single specimen. And I found these somewhat by accident. I thought a sample with some massive calcite might have some prehnite underneath, so I plopped it into some muriatic acid to dissolve the calcite. No prehnite, but some tiny brookite crystals were exposed. These are paper thin and lustrous.

The light must be just right to spot them. I suspect they be more abundant than my experience suggests, but that winter freeze-thaw cycles destroy these fragile crystals. Mine were preserved because they were embedded in calcite. The photos of these brookites are at the limit of my capabilities. The brookites of Figures 7 and 8 are of ones from the MMNE field trip. A better Audley brookite is on my web page: http://mindatnh.org/Brookite%20sheet.html .

Figure 7: Brookite, 0.2 mm crystal (TINY!)

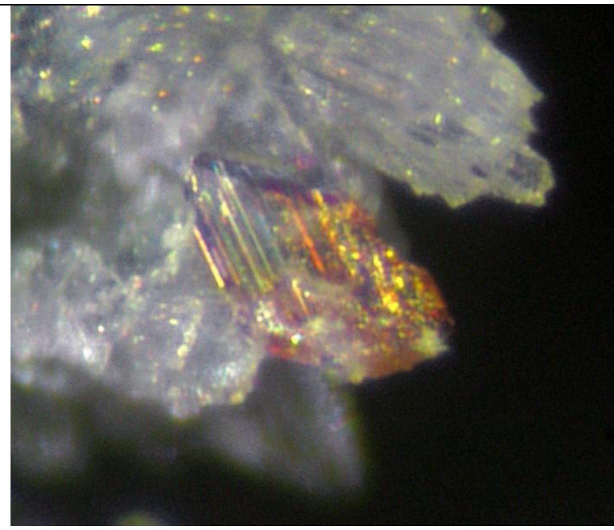

Figure 8: Brookite, 0.5 mm crystal

Titanite I had not seen titanite at the Audley Merrimack quarry before this May 2017 visit. It was found in seams with small milky calcite crystals on quartz and adularia. Color range is from flesh-pink to brown. Both Bob Wilken and Tom Mortimer found examples. The crystal form is monoclinic with a complex wedge-shaped habit.)

Figure 9 0.7 mm titanite crystal

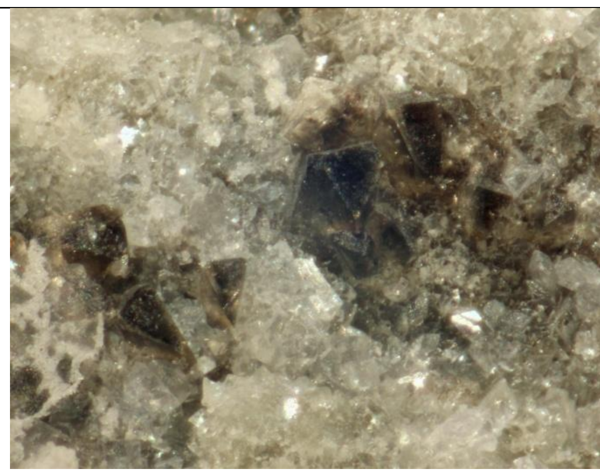

Figure 10 Brown titanite crystals, 4 mm field of view. Bob Wilken specimen and photo.

Chlorite group The specimens with titanite and calcite also had clusters of an unusual vermiform chlorite group mineral. These resemble tiny green worms (Figure 11). I have also seen this form of chlorite on specimens from the Rt. 101 – Rt. 101A, Amherst, NH, road cut.

Calcite Both massive, fracture-filling, and micro calcite crystals were observed at Audley Merrimack. The calcite crystal habits include stubby-prismatic and thin tabular, with a milky color (Figure 12).

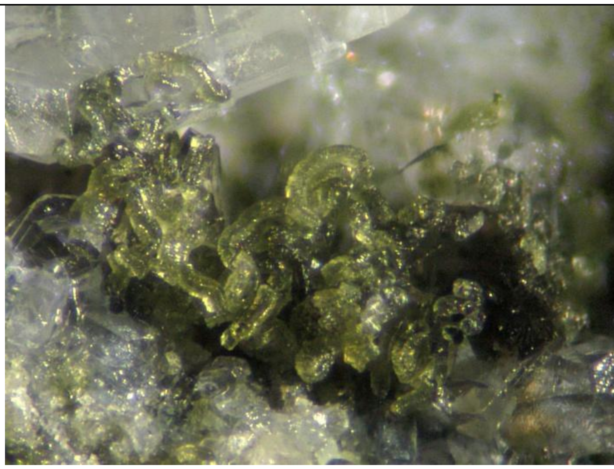

Figure 11 Vermiform chlorite group mineral.
2 mm field of view

Figure 12 Calcite, 3.5 mm crystal.
Peter Cristofono specimen and photo

Pyrite Crystals of pyrite to several mm were found in the quartz–adularia lined seams as well as embedded in massive milky quartz. The crystals occur as simple cubes. When exposed to weathering, they have a dull brown-black tarnish. Some are totally altered to limonite-goethite.

Hematite Thin black, lustrous, plates of hematite were also seen with the titanite, chlorite, specimens. Similar hematite is on specimens from the Rt. 101 – Rt. 101A Amherst, NH road cut. I suspect better specimens are present at Audley than those shown in Figure 14, (very difficult to photo, but included for completeness). Like the brookite, these thin, fragile, plates may be victims of the winter freeze-thaw cycle. These have not been tested and given the presence of titanium in other observed species, these black plates could be ilmenite, $FeTiO_3$.

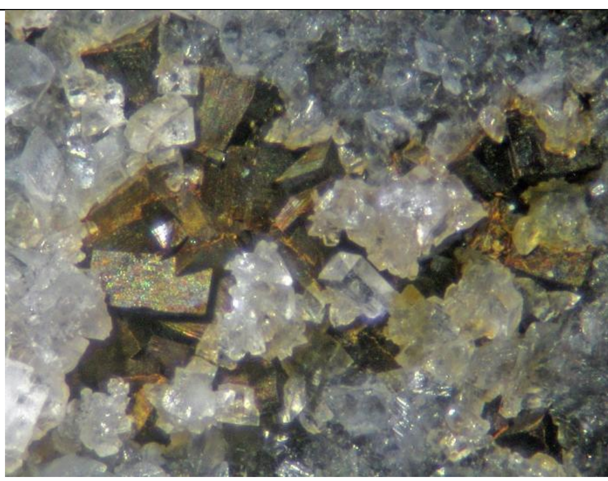

Figure 13 Pyrite crystals with adularia.

Figure 14 Hematite – 0.3 mm group

Chalcopyrite Massive chalcopyrite was observed associated with pyrite. Fresh broken chalcopyrite had the typical "peacock-ore" appearance.

Malachite Bright green malachite in contact with altered chalcopyrite was seen on one specimen (Figure 15). Larger, better specimens are a possibility.

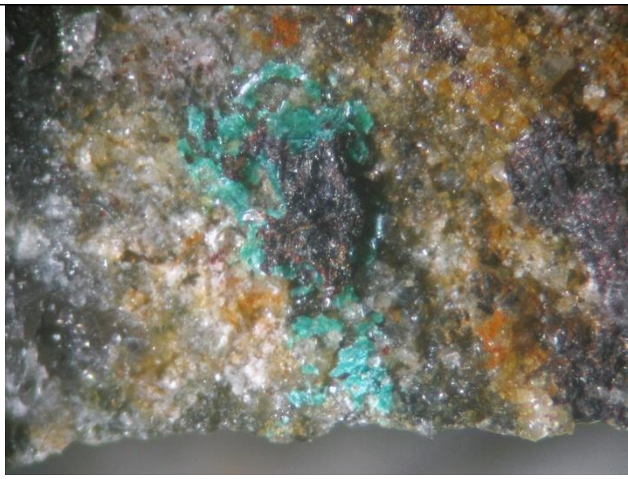

Figure 15 Malachite, Chalcopyrite, 4 mm field of view.

Figure 16 Quartz crystal cluster. Lateral crystal in the middle is 23 mm – almost 1 inch

Quartz Clear to milky quartz crystals to several mm line many of the thin seams in the phyllite rock. Large quartz boulders several feet across are also present on the quarry floor. Some of these have quartz vugs with crystals to an inch or more. I plucked the floater group of figure 16 from one of these vugs.

Adularia (K-feldspar) The adularia was another new mineral for me at Audley. Quoting from mindat.org: adularia is "*A more ordered low-temperature variety of orthoclase or partially disordered microcline. Individual localities should be verified because the adularia structural state is nearly equally represented by microcline and orthoclase specimens. Generally found in alpine-type parageneses.*" Therefore an XRD analysis is required to determine whether this Audley occurrence is **orthoclase variety adularia** or **microcline variety adularia** (because orthoclase and microcline are chemically identical dimorphs of $KaAlSi3O_8$).

The adularia exhibits simple orthorhombic-appearing prisms, although the crystal class is actually monoclinic. Deer, Howie & Zussman in *Introduction to Rock Forming Minerals* provide a line drawing of adularia, beside a drawing of anorthoclase, reproduced in figure 17. Some of the Audley adularia crystals have striated top surfaces, others do not. Many resemble the simple prism of the anorthoclase line drawing, (e.g. figure 19).

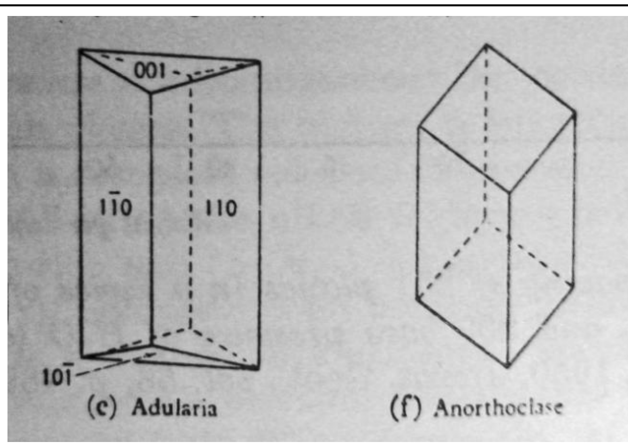

Figure 17 Potassium feldspar forms

Figure 18 Adularia crystals, 1 mm field of view

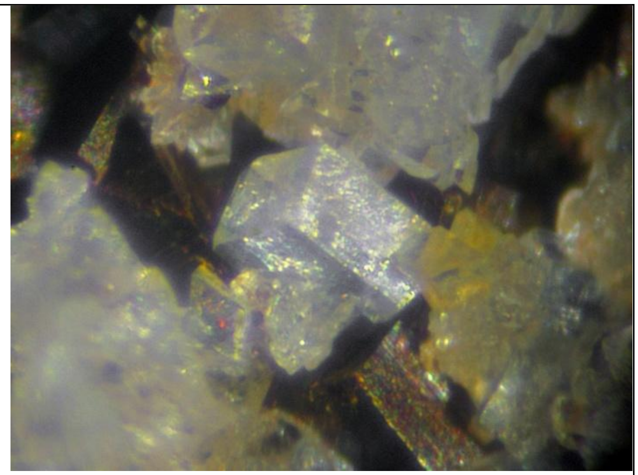

Figure 19 Adularia, 0.3 mm simple prism crystal

Sphalerite Massive sphalerite was found in milky quartz by Bob Wilken, figure 20.

Unknowns Peter Cristofono, Bob Wilken and myself all found some unknowns. Just one is included here. Figure 21 shows some unknown white balls with suspected black manganese oxide blebs on quartz crystals.

Figure 20 Sphalerite in milky quartz. Bob Wilken photo, specimen & identification.

Figure 21 Unknown white spheres with Mn oxide? on quartz crystals. Peter Cristofono photo & specimen.

My thanks to Bob Wilken and Peter Cristofono for their comprehensive review of this article.