Frondelite or Rockbridgeite? An attempt at optical identification

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Tom Mortimer's newsletter article (Nov '23) on specimens from the Fletcher Mine, Groton, NH. mentioned rockbridgeite and frondelite as two visually indistinguishable minerals that form a series.

On his mindatnh.org website, Tom notes that:

"The frondelite-rockbridgeite series presents substantial difficulties for the amateur mineral collector. Ignoring oxidation states, end member frondelite is MnFe4(PO4)3(OH)5 and end member rockbridgeite is Fe5(PO4)3(OH)5. Dana's System of Mineralogy, seventh edition, provides analyses that indicate ferroan frondelite and manganoan rockbridgeite exist, blurring species definitions. A frondelite formula including oxidation states is given as (Mn2+,Fe2+)Fe3+4(PO4)3(OH)5. Dana continues, "Divalent manganese and iron [tm, the Mn2+ & Fe2+ in the formula] substitute mutually and probably a complete series extends between the manganese and iron end-members.The names frondelite and rockbridgeite are applied to the halves of the series with Mn2+ > Fe2+ and Fe2+ > Mn2+ respectively. EDS analysis (BC368A) suggested this Chickering sample is frondelite, although the computed chemistry is not an optimal fit."

I was hoping the frondelite-rockbridgeite series had some unique optical properties that could help distinguish them. Fortunately the end members of the series have different pleochroic colors under polarized light which should mean a fairly easy id - but I had never tried it for these minerals before.

I contacted Tom to see if he had some small fragments I could attempt to identify and he was happy to send me some. Pleochroic colors are seen under polarized light and change when rotated every 90 degrees because the crystal structure absorbs a particular wavelength depending on the direction of the vibrating light passing through. To make things more confusing in this case, there are three between members of the series with slightly different optical properties.

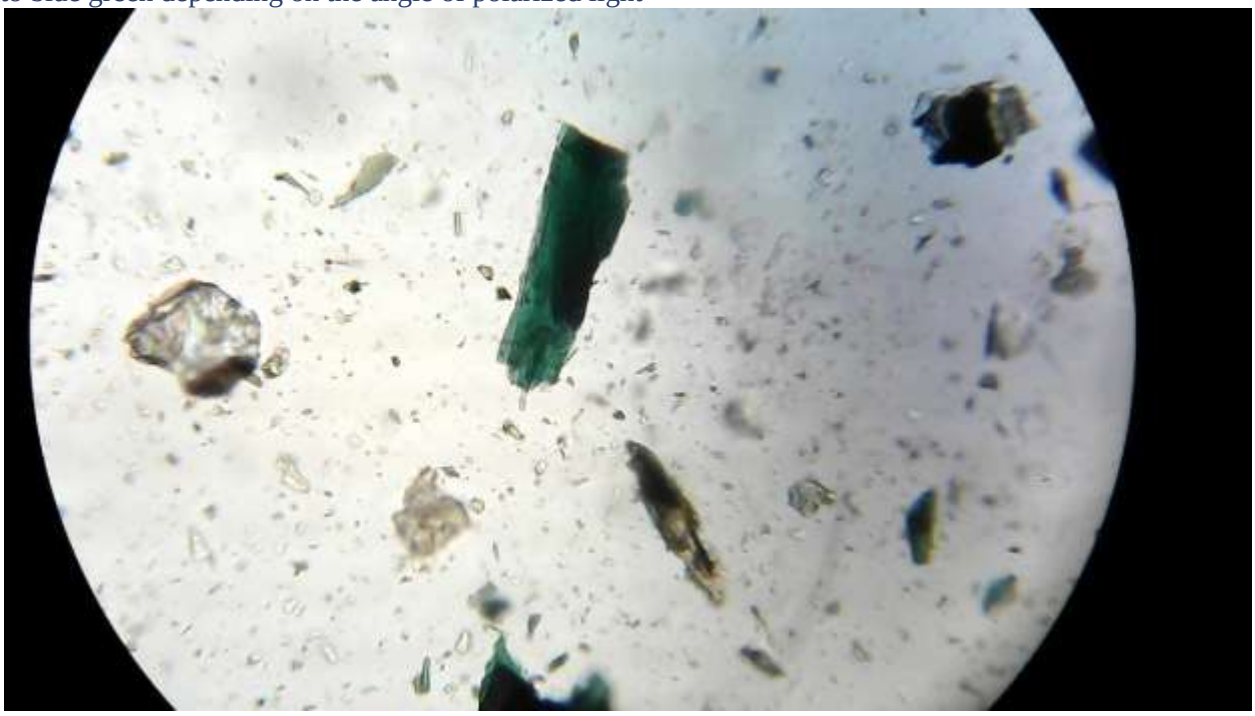
The pleochroic colors for the series members are:
Frondelite, X = light yellow-brown, Y = orange-brown, Z = orange-brown
Manganrockbridgeite, X= blue-green, Y = yellow-brown, Z = light yellow-brown
Ferrirockbridgeite, X = yellow brown, Y = olive brown, Z = dark olive green
Ferrorockbridgeite, X = blue green, Y = olive green, Z = yellow brown
Rockbridgeite, X = light brown /yellow-brown, Y = bluish green, Z = dark bluish green

*Only Frondelite has no optical direction that shows any blue or green, only yellow brown to orange/brown

In reflected light the minerals are opaque radiating green or brown fibers sometimes forming ball like masses, but when crushed between two glass slides down to a thickness range of 0.1-0.03mm and under transmitted polarized light they are translucent enough to allow light to pass through and show their interesting pleochroic colors. An important thing to note is that we can usually only see 2 of the 3 colors since the crushed grains tend to lay on their sides.

The sample of rockbridgeite from the Valencia Mine showed the expected pleochroic colors of light yellow brown

to blue green depending on the angle of polarized light



The most interesting result was sample u2205 labeled Frondelite from Palermo (below), the grains did NOT show the expected pleochroic colors of Frondelite (light yellow brown to orange brown) but instead shows the colors for Rockbridgeite (light yellow brown to blue green)

Rotated 90 degrees

Disappointed we could not get a match for Frondelite, Tom sent me another sample of suspected Frondelite, this one (u1232) from the Chickering Mine, NH

The first fragment I broke off of it seemed to be a mix of rockbridgeite and frondelite - it has a good percentage of grains that match the expected pleochroic colors for frondelite (light yellow brown to orange brown) and others that matched the colors for Rockbridgeite (light yellow brown to blue green)

*It's usually easier to see the color change by rotating the lower polarizer 90 degrees instead of rotating the whole sample on the slide, since the fragments stay in place

Confusingly, another fragment I broke off of the same suspected Frondelite (u1232) from the Chickering Mine, NH seeming to be just green and black in reflected light had all grains match the pleochroic colors for rockbridgeite, no matches for frondelite.
In conclusion, this ID was difficult due to the similar series members and it seems:

- There can be banded areas of different members of the series in some specimens and multiple sample areas should be inspected in case of this mix
- The pleochroic colors for a Mn dominant series member, Frondelite or at least Manganrockbridgeite, was found in the Chickering mine sample
- To be absolutely sure of the Frondelite optical identity, grains that show only yellow brown / orange brown in the 2 optical dimensions that can be seen when laying flat on a slide should be mounted on a spindle stage (basically the tip of a needle that can rotate the grain in the 3rd dimension) to verify that ALL THREE optical directions (X,Y,Z) show no blue / green.

My thanks to Tom “The Motivator” for his encouragement to continue my learning curve in optical mineralogy.