Validation of Results

Unless we have some quantitative mineralogy from an XRD or SEM-based method, there is no direct method to test how accurate the Comet results are. However, we routinely test to see if the results are plausible.

To do this, I use ioGAS. I have a template set up in ioGAS that automatically generates a series of alteration diagrams. I can color the data points in these diagrams by the calculated mineral percentages and see where the mineral abundances plot relative to mineral composition nodes. These are the diagrams I routinely use.
K/Al vs Na/Al (molar)
Al-K-Mg ternary
Ca-Fe-S ternary
Ca-K-Na ternary
Fe/(Fe+Mg) *5 (molar) histogram

Total Feldspar

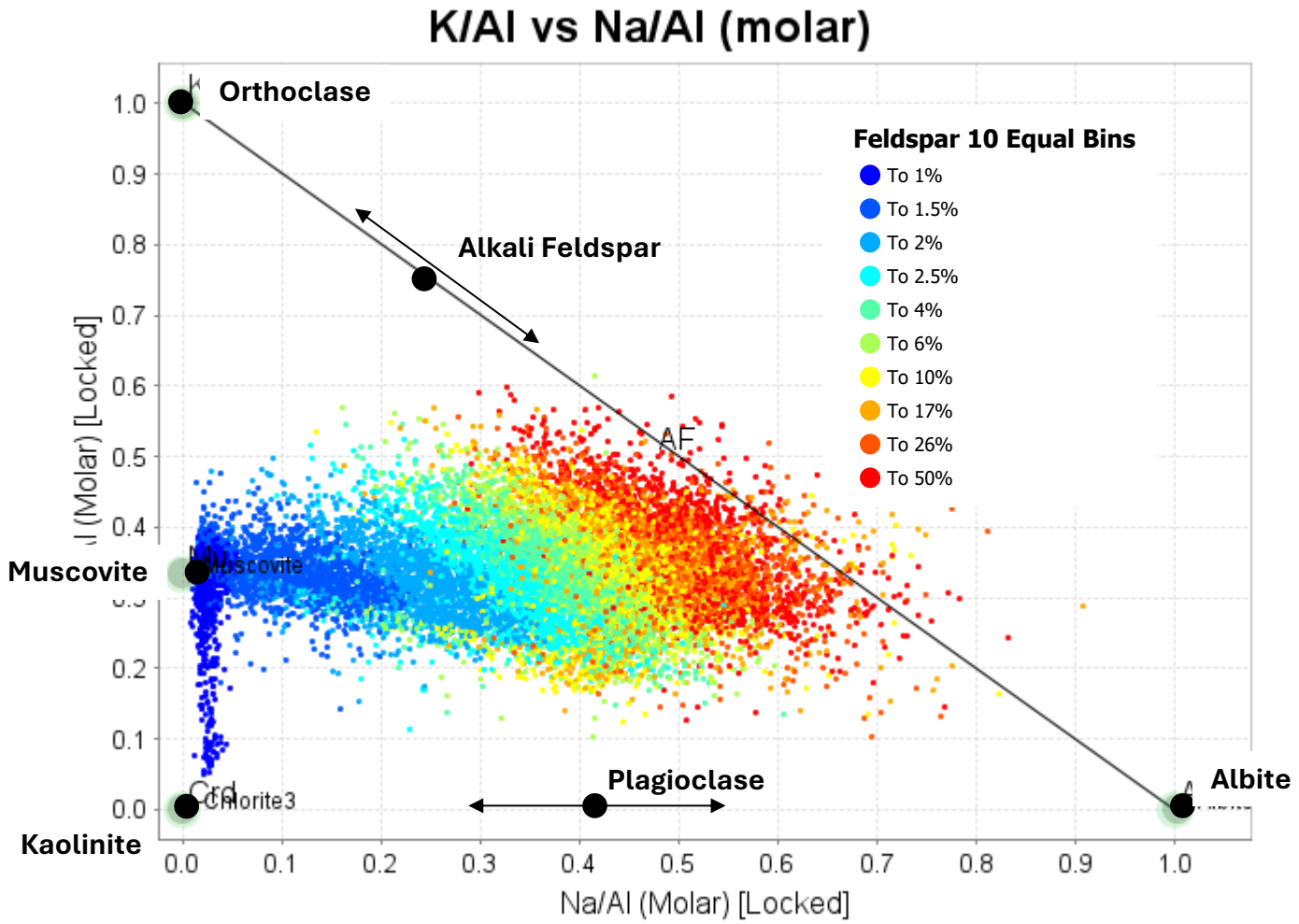
Igneous feldspars form a solid solution between Ca and Na endmembers (plagioclase) and between Na and K endmembers (alkali feldspars).

Hydrothermal feldspars are more likely to be close to albite and/or orthoclase endmembers.

All these components can be included in the Comet calculation, and the sum of the feldspar components is calculated as Total feldspar.

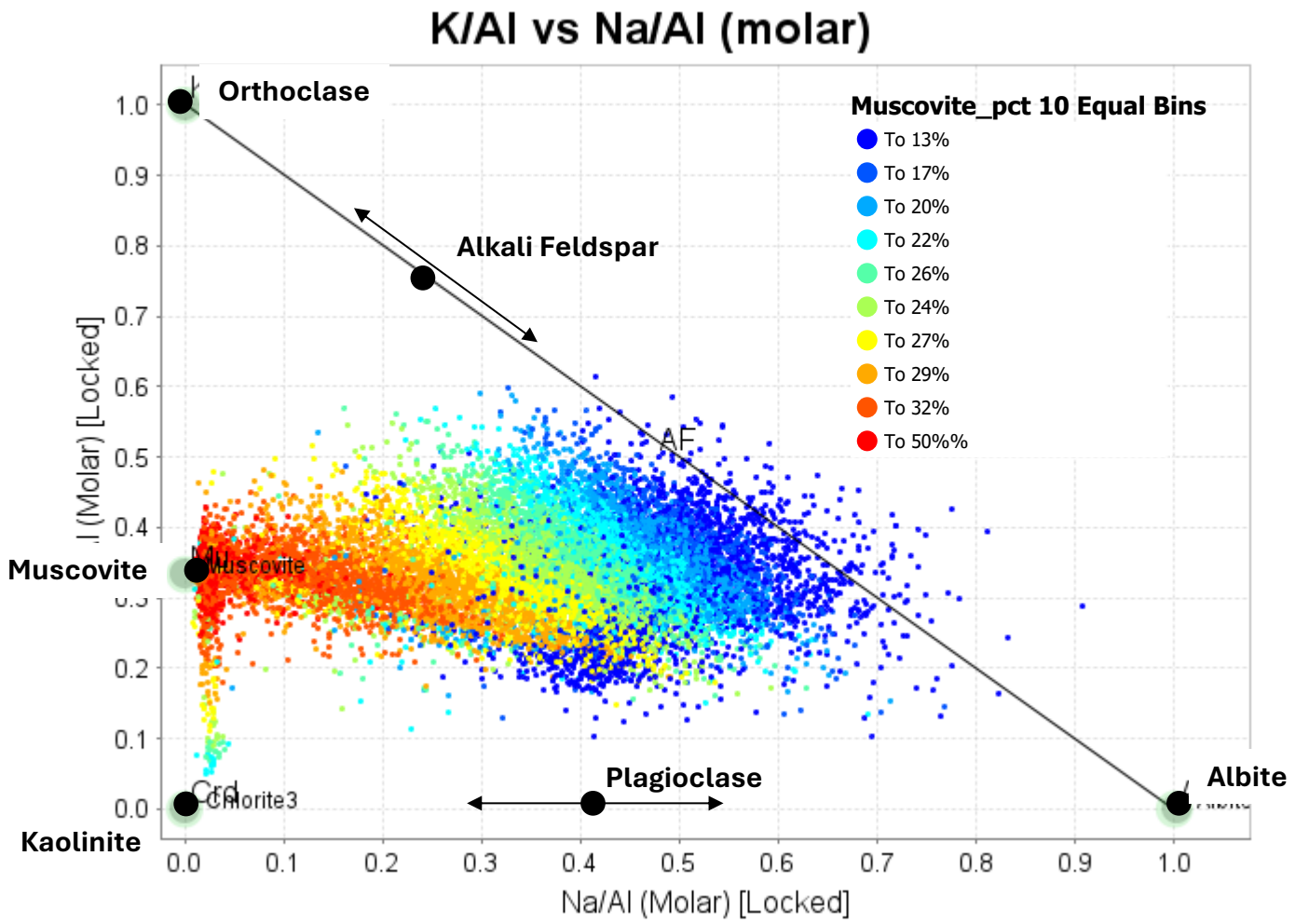
This plot is colored by total feldspar. Note the low values at the muscovite node and towards the kaolinite node, and increasing feldspar_pct along the alkali feldspar line.

This looks like a plausible result. There should in theory be no data plotting outside the alkali feldspar line. That will be a result of poor dissolution at the lab so there will be some inaccuracy due to data quality.



Muscovite

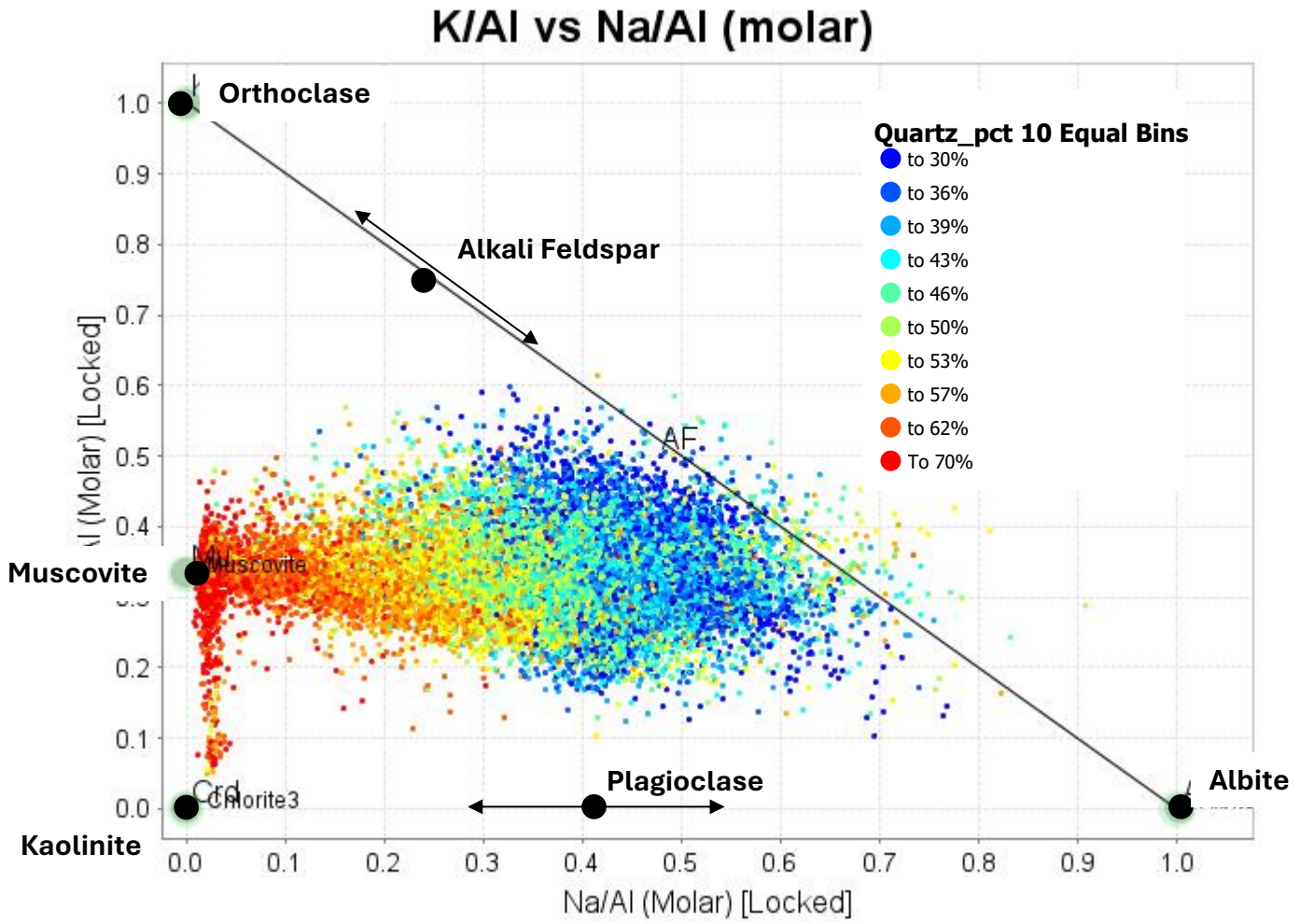
White mica shows a high abundance around the muscovite node, as expected, and decreases towards the origin and the alkali feldspar line. Topographically on the alteration diagram, this looks like a plausible result.



Quartz

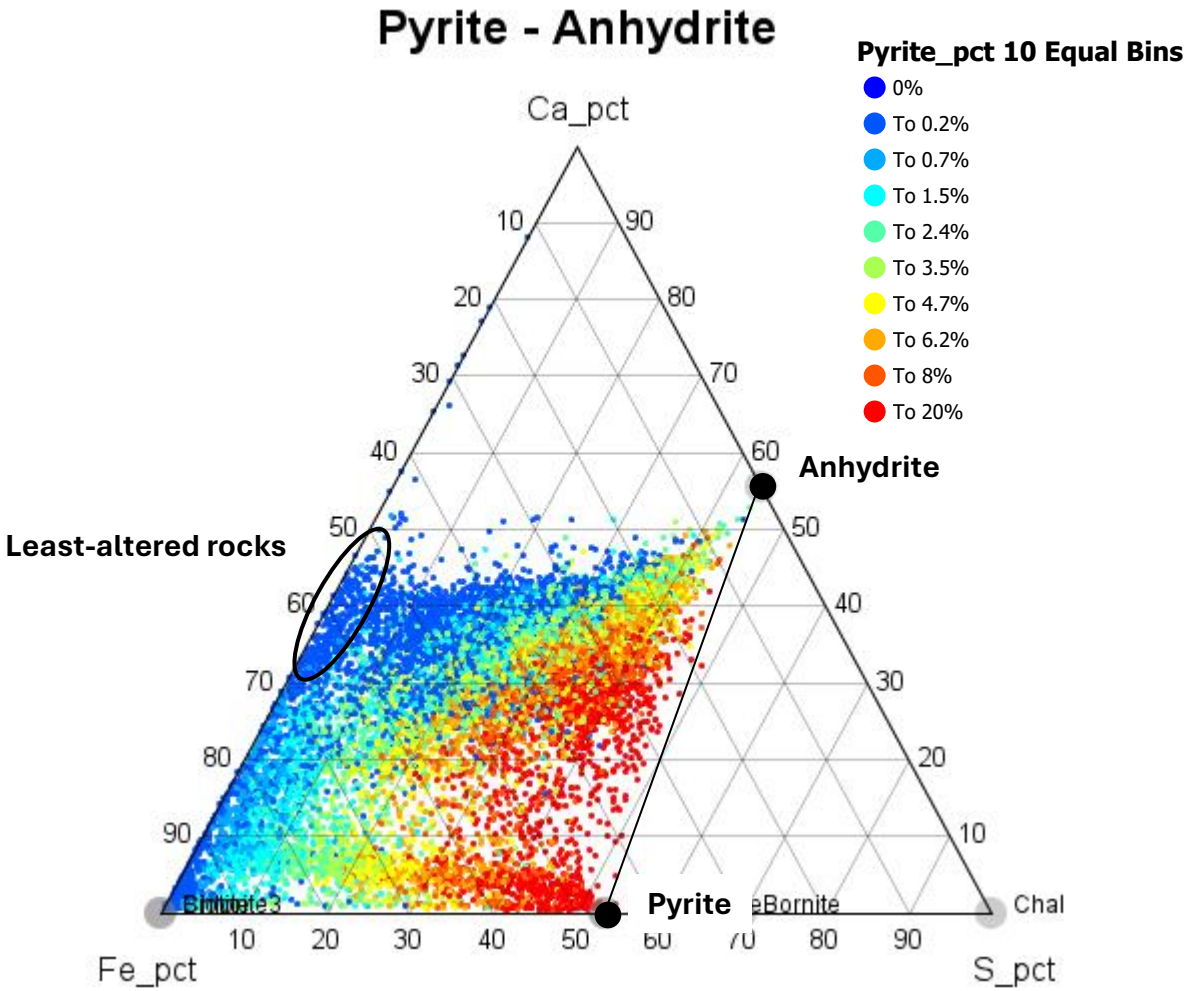
Even though SiO2 was not analysed, the estimations of quartz are surprisingly accurate. Variations in quartz could be due to differences in primary rock compositions, but also, in this case, mostly due to alteration.
The primary reaction driving this is;
Feldspar + acid = sericite + quartz + K,Na^{+}

Note the odd few samples plotting near or above the alkali feldspar line; they report relatively high quartz. This is an artefact of the poor analyses, with the aluminium analyses being under-reported.



Pyrite

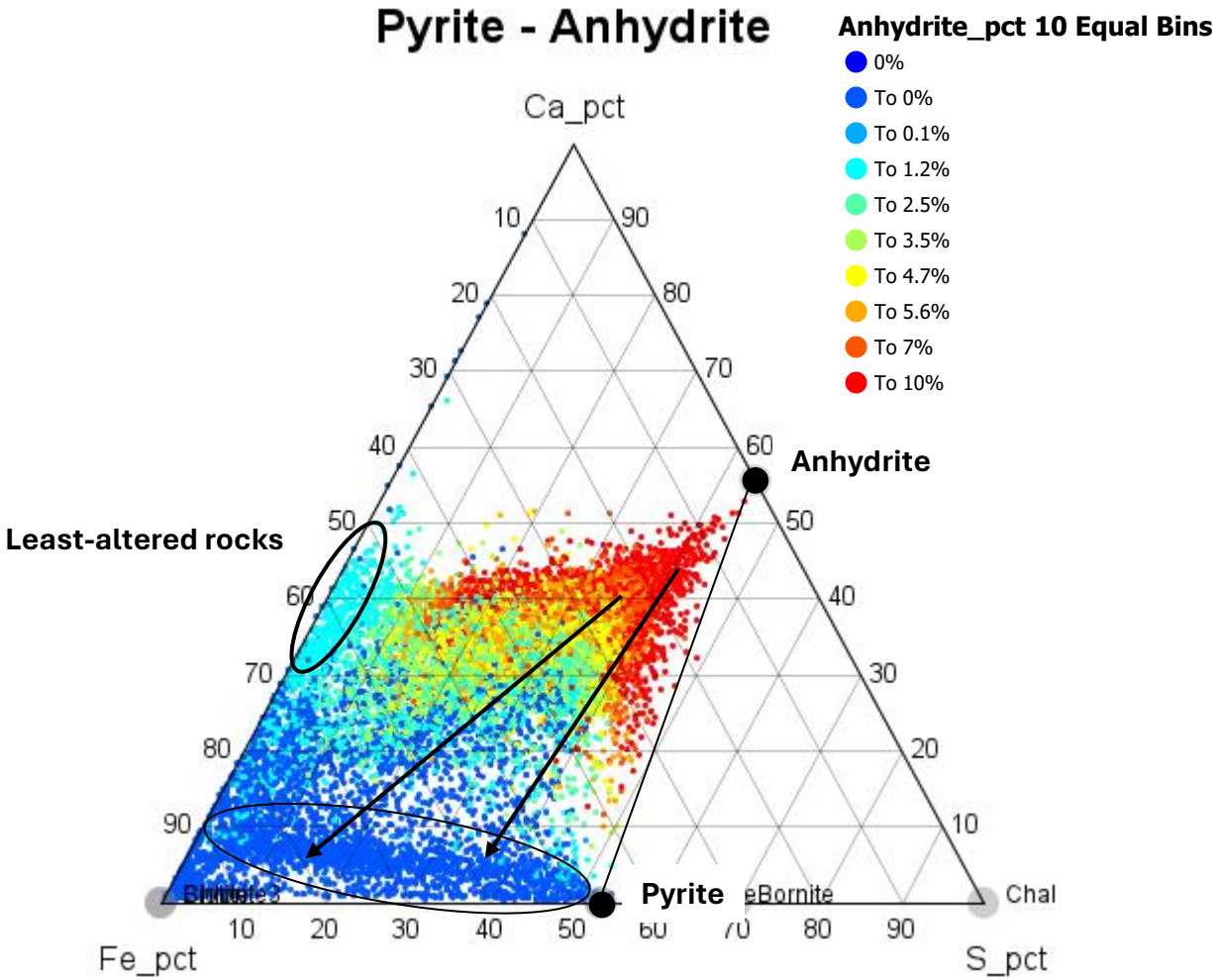
Most igneous rocks have close to equal amounts of Fe and Ca on a weight_% basis.
In most porphyry Cu systems, there is a distinct edge to the data cloud that follows the join from the pyrite node to the anhydrite node. Along this line, all of the Fe in the rock is hosted in Py+Ccp, and all the Ca is in Anh.
This example is a classic plot for a porphyry system.



Anhydrite

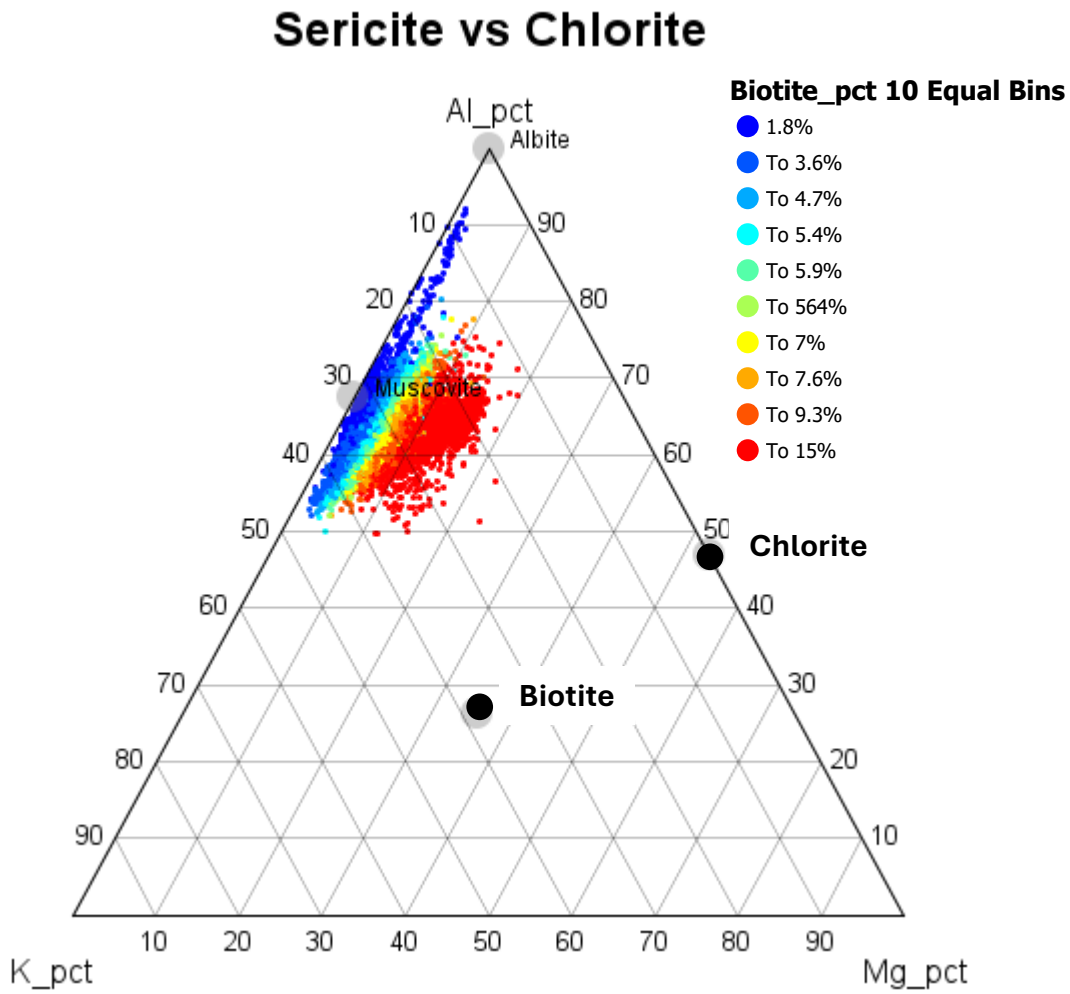
In most porphyry systems, gypsum (anhydrite) is leached from the rock by groundwater, producing the classic gypsum dissolution front.
On this figure, imagine the effect of removing anhydrite from the rock. The data point would move directly away from the anhydrite node (direction of the arrows) until no Ca sulfate remains in the rock (plotting in the lower ellipse).

This looks like a very plausible estimate for anhydrite in these rocks.



Biotite

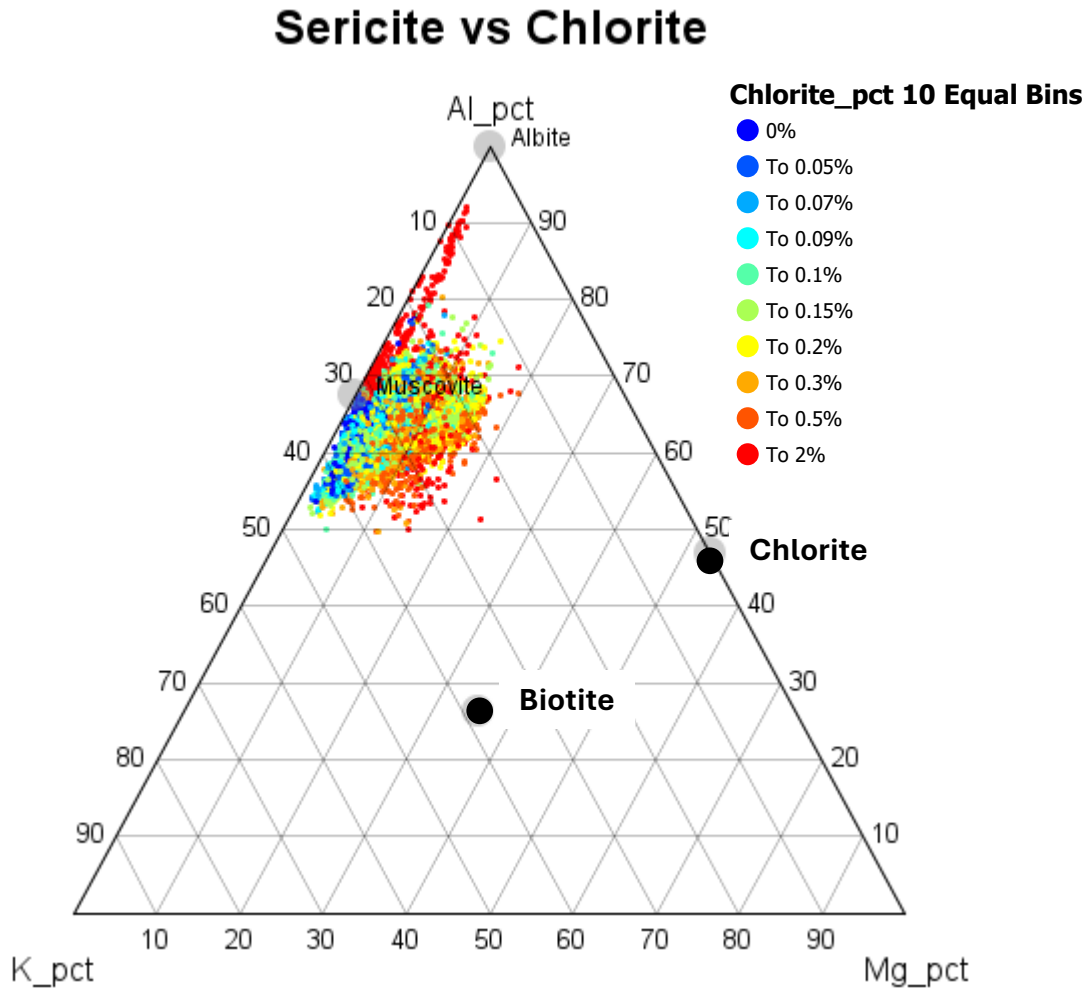
These rocks are quite alkalic, so likely to form more biotite than chlorite.
The amount of biotite and/or chlorite is largely determined by the primary rock composition.
With the Comet algorithm, the estimations of biotite vs chlorite are relatively imprecise.



Chlorite

In this case, almost all of the silicate-hosted Fe and Mg was assigned to biotite rather than chlorite (note the scale).

I can see an error in this plot. Look along the K to Al join between the muscovite node and the Al apex. This is where advanced argillic alteration plots, or in this example where the regolith plots. The Fe in these samples should be in goethite, not chlorite, and the Al in kaolinite or smectite, not chlorite.



Chlorite

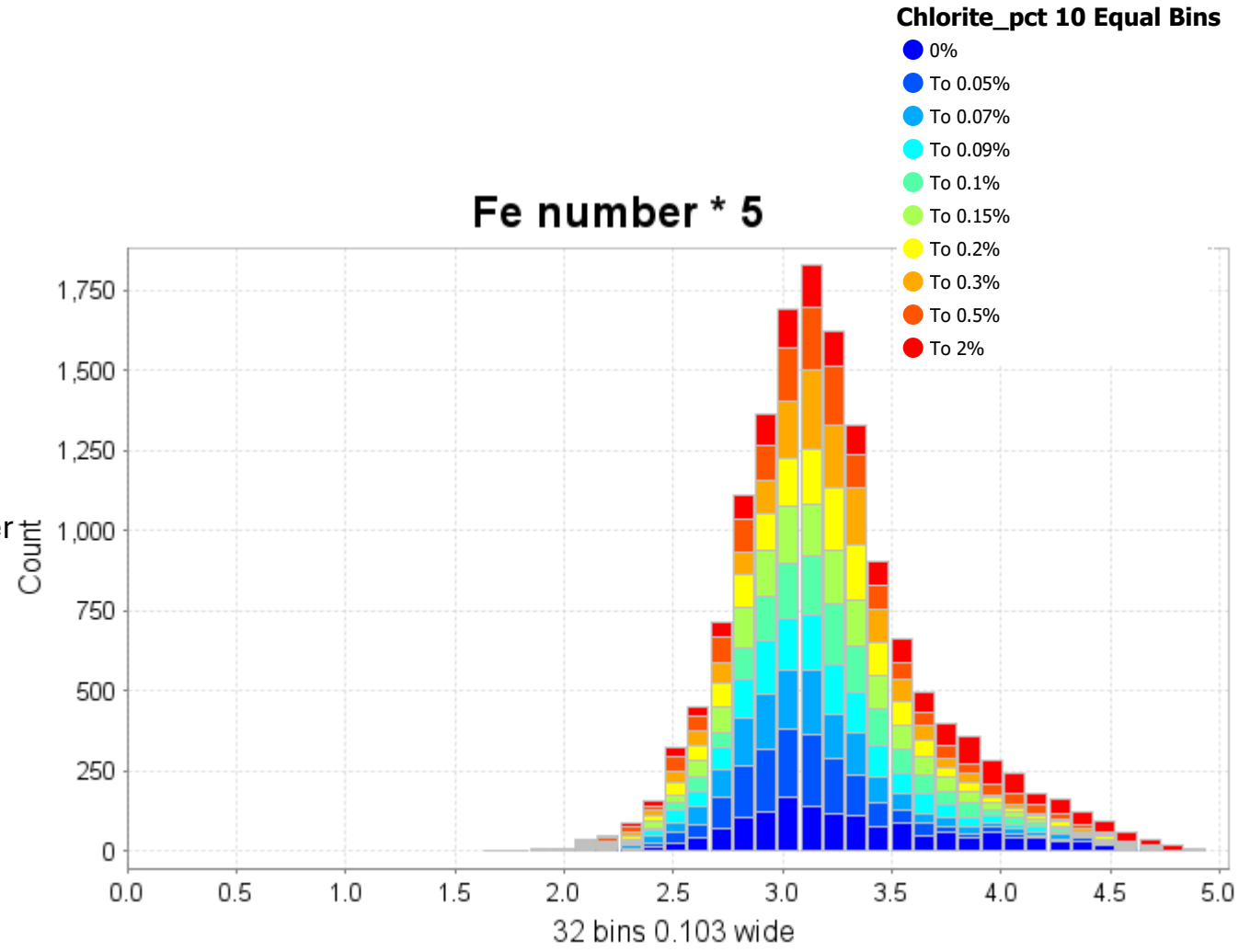
We write a generic formula for chlorite as;
$(Fe,Mg)_5Al_2Si_3O_{10}(OH)_8$

From the assay data, I can calculate a ratio of Fe/(Fe+Mg) on a molar basis, and then multiply that number by 5.

Now I can look at this plot and consider the possible chlorite compositions in terms of Fe (or Mg) atoms per formula unit (apfu).

On this plot most igneous rocks have a primary value around 3, although alteration will obviously change that.

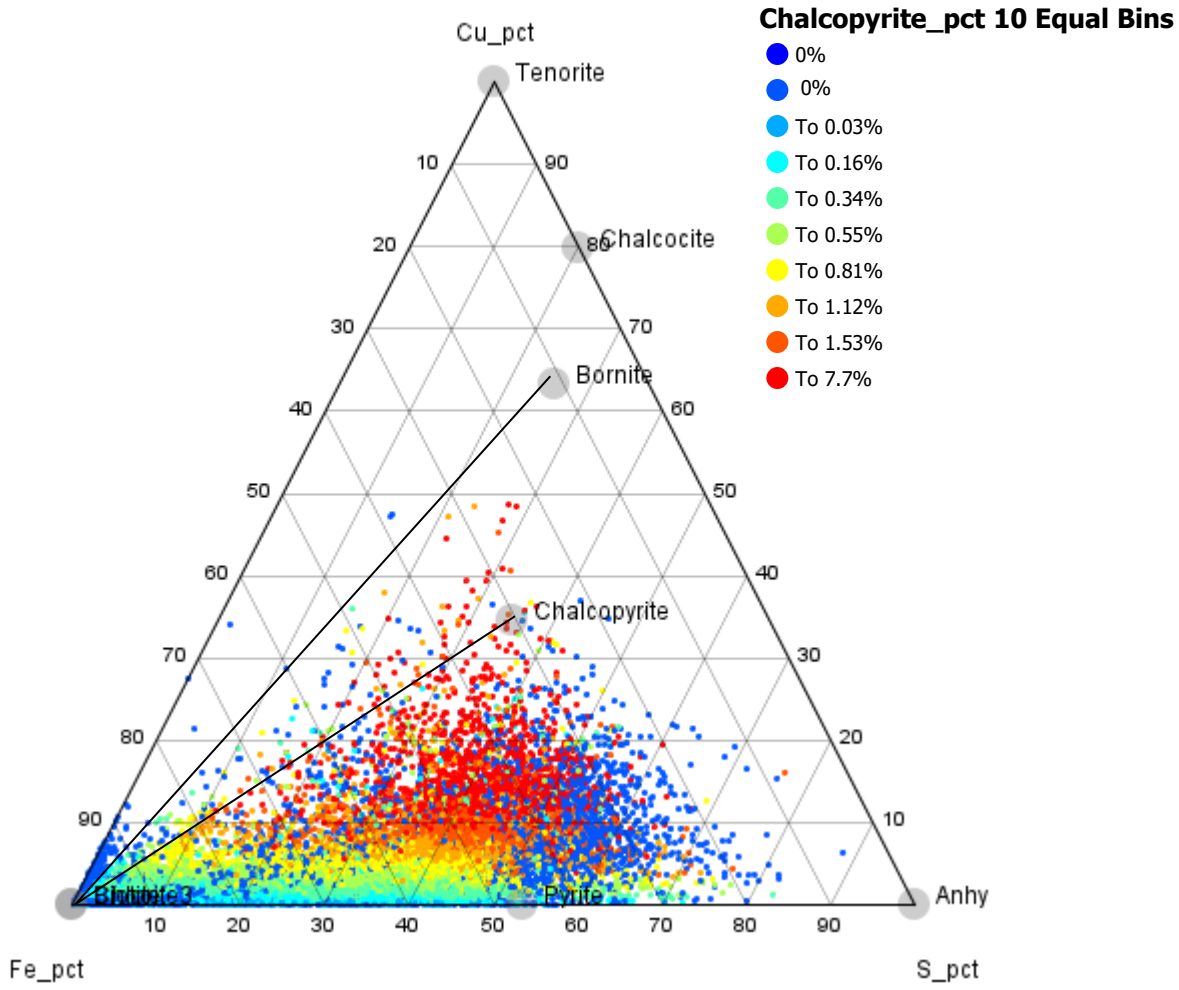
In the Comet configuration, it is very easy to change the upper limit for Fe-apfu in chlorite. If I lowered that limit for Fe in chlorite in this case study, I could prevent the algorithm from calculating chlorite in the regolith zone.



Chalcopyrite

Bornite-bearing porphyries are typically zoned from bornite to chalcopyrite to pyrite; thus we do not expect to see bornite with pyrite. In the absence of anhydrite, the proportions of bornite, chalcopyrite and pyrite could be estimated, using the Cu:S ratios to limit the range of the copper sulfide minerals.

If Ca sulfate is estimated accurately then bornite, chalcopyrite and pyrite can still be estimated, with the implicit assumption that bornite does not occur with pyrite.



Bornite

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