Mineral Mapping

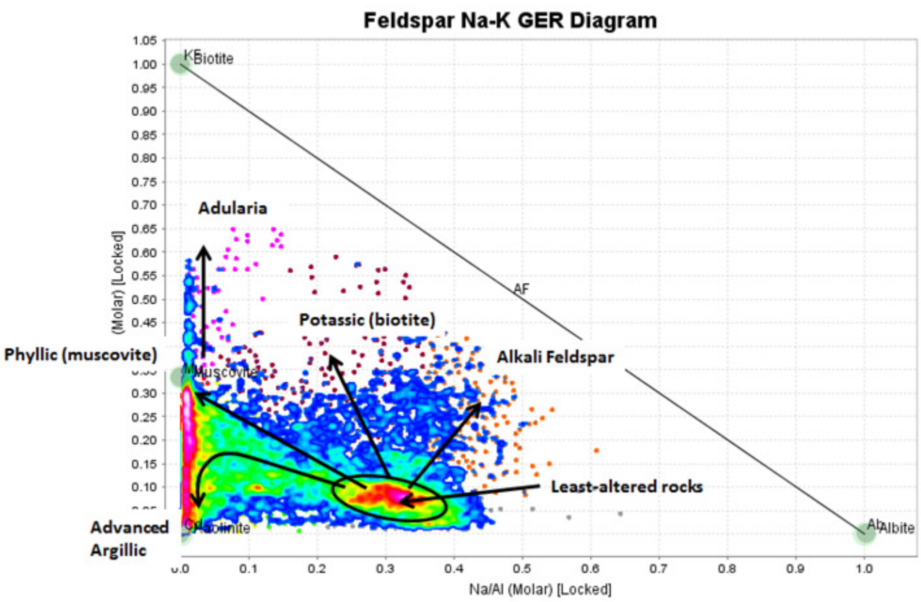
Scott Halley, 28/06/2016

Using ME-MS61 or ME-ICP61 to characterize alteration in porphyry Cu systems.

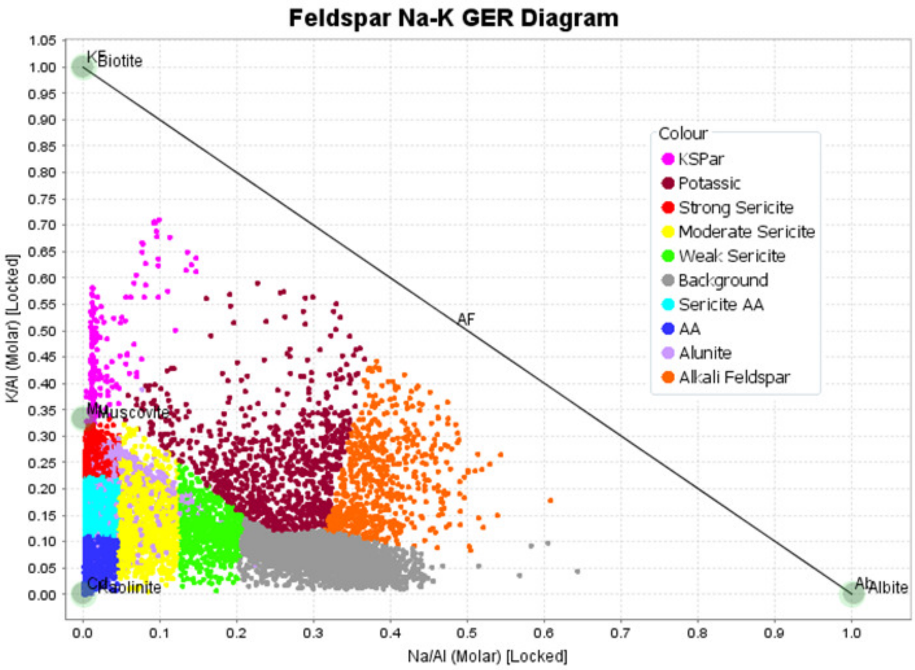
The following is a recommended scheme for classifying alteration mineralogy in porphyry copper systems.

1. Plot K/Al(molar) vs Na/Al(molar).
2. Plot Al-K-Mg ternary.
3. Plot Fe vs S.
4. Plot Ca-Fe-S ternary.

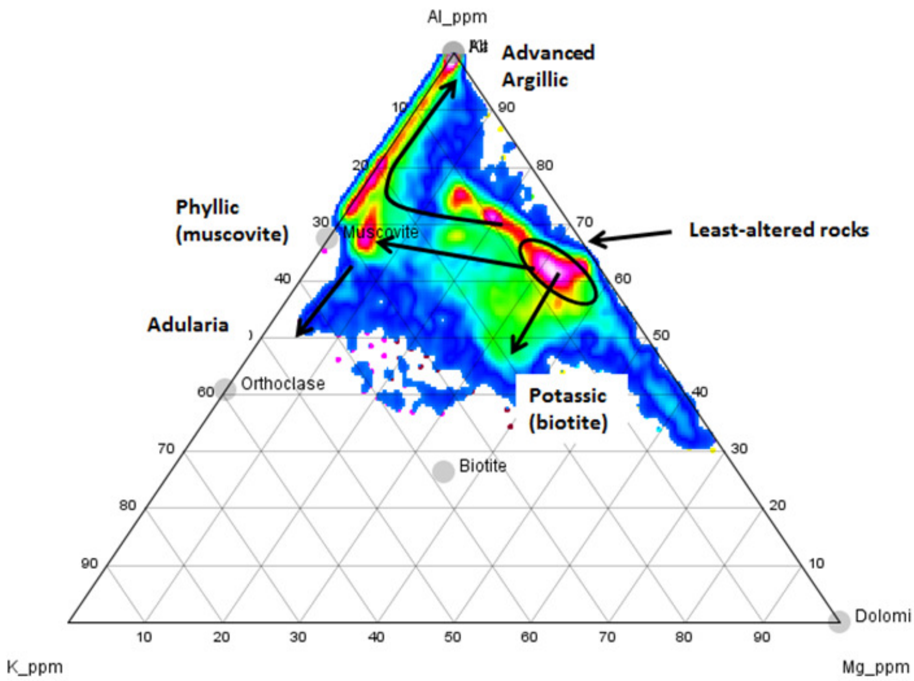
One of the most useful plots is K/Al versus Na/Al, calculated on a molar basis. Creating this plot is a one-click option using the ioGAS software. Consider a rock that is totally sericitized. The mineralogy of the rock might be muscovite-quartz-carbonate-pyrite. All of the K and Al in that rock will be within sericite. Muscovite has a composition of $KAl_3Si_3O_{10}(OH)_2$. Therefore the ratio of K:Al in the sericitized rock is 1:3. Similarly, a totally K feldspar ($KAlSi_3O_8$) altered rock will have a K:Al ratio of 1:1. In the same way, albitisation can also be tracked. Albite is $NaAlSi_3O_8$: Na:Al =1:1.



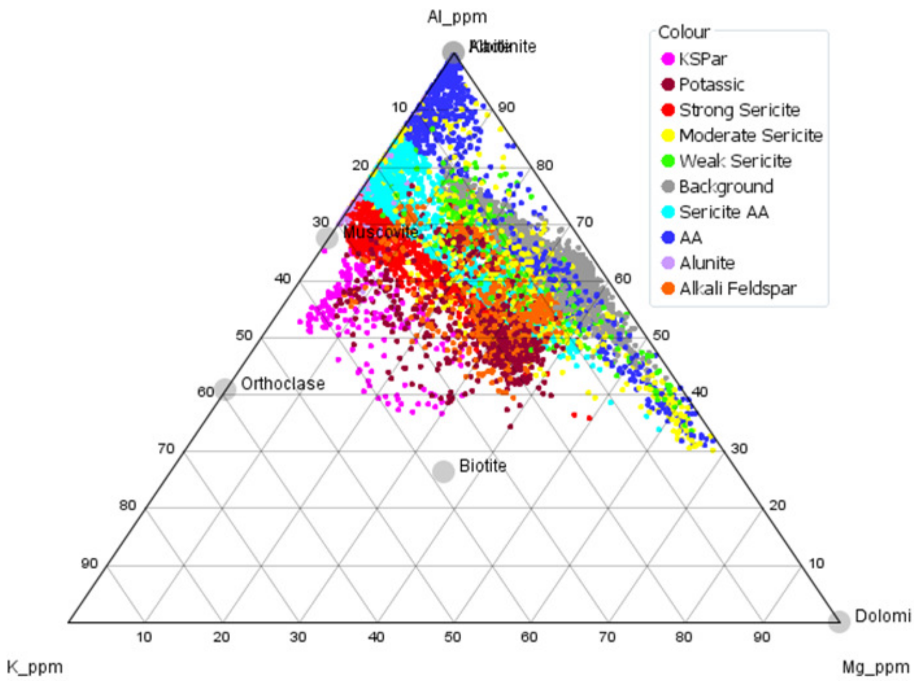
A typical K/Al versus Na/Al plot in a porphyry copper system looks like this. From this plot, a quite reasonable first pass interpretation of the likely alteration mineralogy can be made. Use a point density contour, or the standard rock composition projections in ioGAS to determine where the least-altered rocks should plot on this diagram. In this example, there is a large population of samples that are strongly depleted in Na. These fall between the projected position of muscovite and an aluminous clay plotting at the origin.



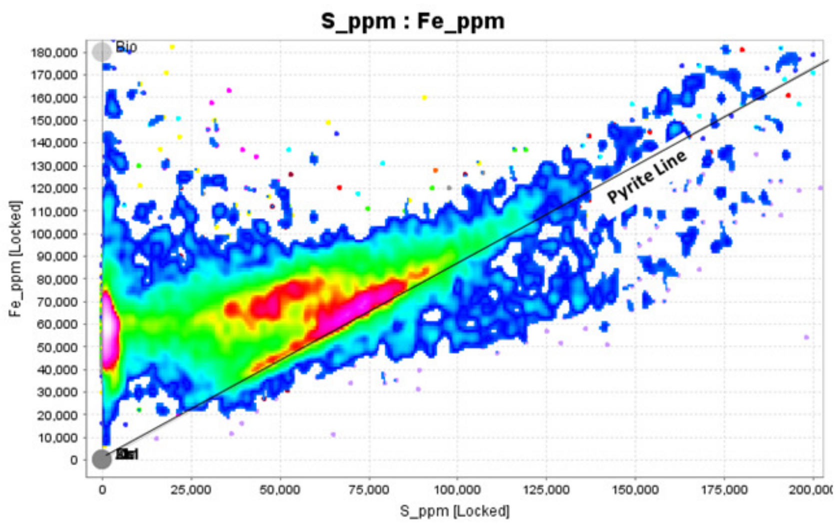
From this plot, there is no way to know what the aluminous phyllosilicate mineral is; it could be kaolinite, dickite, pyrophyllite, smectite or chlorite. One way to test this is to look at an Al-K-Mg ternary plot.

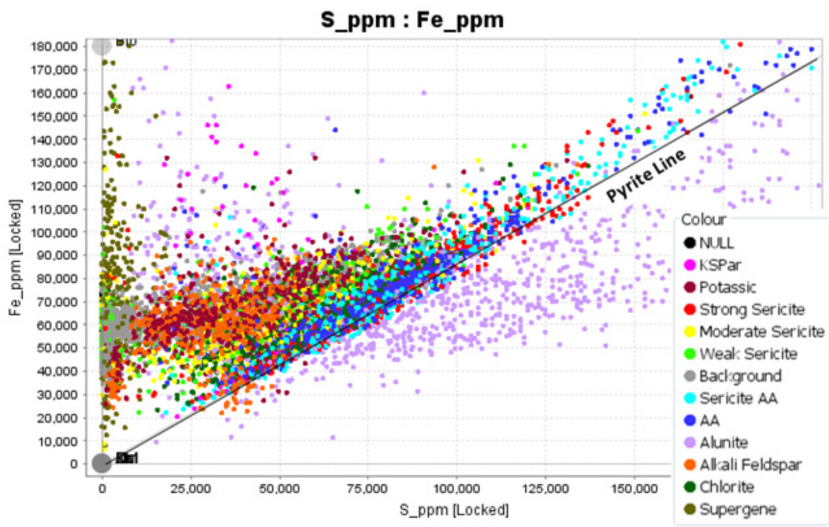


In advanced argillic alteration, all of the Mg-bearing minerals are altered to alumino-silicate phases and the rocks are depleted in Mg. In this plot, the true advanced argillic alteration plots along the K-Al join, between the projected composition of muscovite and the Al-apex. The blue, yellow and green points that still have Mg and plot along the Al-Mg side of the triangle contain chlorite and/or smectite and/or relict amphibole, but not kaolinite or dickite. For the points that plot around the Al apex, SWIR mapping with the ALS TerraSpec or TerraCore system is required to determine whether the what alumino-silicate phase is present.



Plot Fe versus S. On this plot, the pyrite line shows Fe to S ratios that match the stoichiometry of pyrite, ie, Fe:S (molar) = 1:2 In the vast majority of hydrothermal systems, pyrite precipitation is just a sulfidation process; the reaction just utilizes Fe that is already present in the rock. The trend of increasing Fe and S up the pyrite line maps samples that contain additional pyrite in veins. Points that plot of the Sulfur-rich side of the pyrite line contain sulfates. Samples in this data set that have a silicate signature that looks like advanced argillic alteration but have no S or Ca, are saprolitic material.





Alunite-bearing samples can be recognized from the Fe versus S plot, but not anhydrite-bearing samples. Alunite occurs in advanced argillic alteration, and all of the Fe is usually present in pyrite. Anhydrite usually occurs in potassic alteration and much of the Fe occurs in biotite, so the anhydrite samples do not plot on the S-rich side of the pyrite line. To pick the samples that contain anhydrite, use a Ca-Fe-S ternary plot.