Mid-Year Progress Report (January 2015)
Virginia Wine Board

The Role of Soil Mineralogy in Potassium Uptake by Wine Grapes

Principal Investigators: Ernest Beasley, MS, PG, *Geologist*; Lucie Morton, *Viticulturist*

Objective: To help Virginia winegrowers better understand the role that potassium-bearing soil minerals play in the potassium levels in their vines and fruit.

Introduction

Potassium (K) in fruit plays a critical role in the pH of must and wine (Keller 2010). pH is known to be a major influence on a number of wine quality factors including color, acid balance and microbiological stability (Zoecklein et al 1990). Potassium availability in the soil can vary greatly and deficiencies can occur; however, in Virginia excess K absorption by wine grapes is much more common than K deficiency (Wolf 2007). Growers are commonly led to believe by laboratory analysis that potassium levels in their soils are low, when petiole analysis from the same location often shows elevated K levels in the plant tissue.

Background

Rocks are the ultimate source of naturally occurring plant-available potassium in Virginia vineyards. Certain rock types (and associated soils) are known to contain specific potassium-bearing mineral phases that break down and release K from their structure over time. Variable geology across the Commonwealth manifests itself in the form of variable soil mineral assemblages with different amounts of K. Our study examines the relationship between bedrock geology, vineyard soil mineralogy and the potassium levels (and pH) of the fruit.

<u>Accomplishments/Benefits to date</u>:

Methodology

We implemented the following methods at each of our eight (8) research sites:

- Bedrock sample collection and mineralogical analysis via petrographic microscope (completed at 7 of 8 sites) Note: one site is in the coastal plain, where bedrock sampling is not practicable
- Soil auger holes at specific locations to log horizons and collect soil samples from discrete depths
- Soil mineralogical analysis via Scanning Electron Microscopy (SEM/EDS) and X-Ray Diffraction (XRD) at the James Madison University Geology Lab; samples analyzed from discrete depths at each auger hole
- Soil texture and moisture analysis; samples analyzed from discrete depths at each auger hole
- Soil chemical analysis by A&L Labs; samples analyzed from discrete depths at each auger hole
- Bloom and harvest petiole analysis from vines around soil sample points
- Fruit sample collection from same locations (at 7 of 8 sites) for analysis of K, sugar levels, TA and pH Note: fruit was not available to us at one site

a) b)

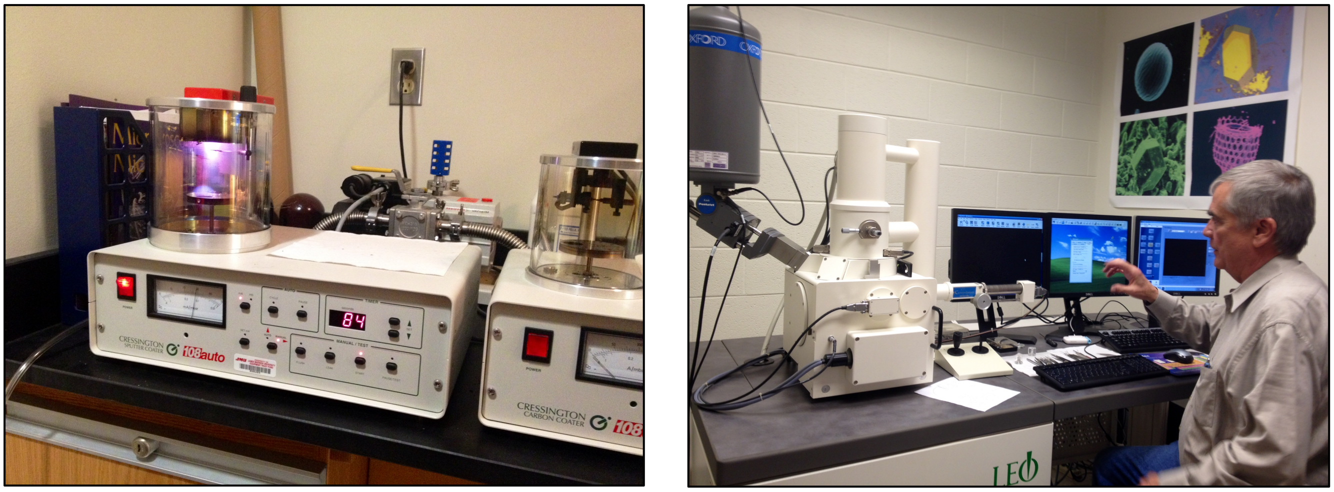


Figure 1 a) Sputter coating samples in preparation for mineralogical analysis via SEM/EDS at JMU. b) Dr. Lance Kearns analyzing samples in the SEM/EDS Lab at JMU.

Preliminary Findings

We noted that for all samples (even those with what the laboratory considers low soil K levels) petiole K levels fall into the range that is considered high to very high. We have consistently seen this phenomenon at every research site studied in this work. Such is the paradox encountered by commercial growers year after year.

Soil is an inherently complex medium and we have found that, particularly on sites with a farming history involving past additions of potassium, the contribution of bioavailable potassium from the rocks is difficult to study. We can identify the mineralogy and postulate about its contribution to plant tissue K and fruit chemistry, but collecting representative soil chemical data in the context of this study is not possible on such sites (5 of our 8 sites have reportedly undergone potassium additions at some point). We are preparing a questionnaire to be completed by all growers associated with this study to document the farming history and previous soil amendments applied at each site. We believe that the grower questionnaire will shed light on the potassium uptake dynamic at sites with previous K additions, adding meaning to the data we have collected so far.

Furthermore, the fruit data is based on a very small sample from each site of 5 or 6 clusters from vines adjacent to the auger holes. They were picked at the time we took harvest petioles and not necessarily at optimum ripeness. Also in a few cases there were vine age and rootstock differences due to replanting and also virus infections. We have saved the naturally fermented juices for further analysis. There are so many contributors to fruit pH beyond what is available in the soil, that we recognize the fruit data presented here is more tangential than substantive. That said, the fruit data did seem to trend in the direction of higher K levels in the soils corresponding to higher K levels in the fruit.

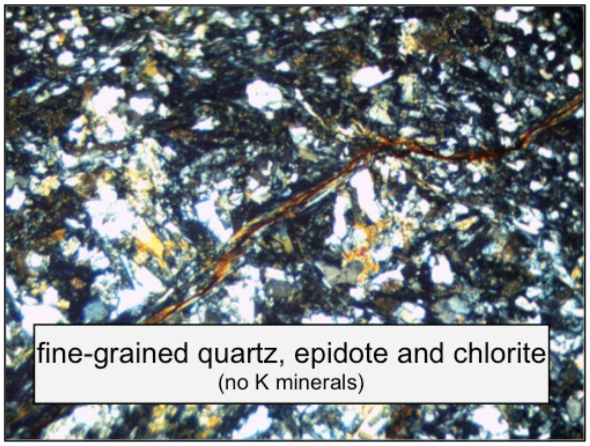
Each research site was assigned an anonymity code (A1-A8) to protect the identity of the Vineyards studied in this work. For the purpose of this mid-year progress report, preliminary findings from the three (3) sites that reportedly have no history of K additions are presented herein. In addition to K levels, K/Mg ratios are presented for both sites with two sample locations (Sites A5 and A6). These numbers are presented so that the two samples within each site can be compared against each other. Note that for each of the two sites, the sample location with the higher K parent material has the higher K/Mg ratio.

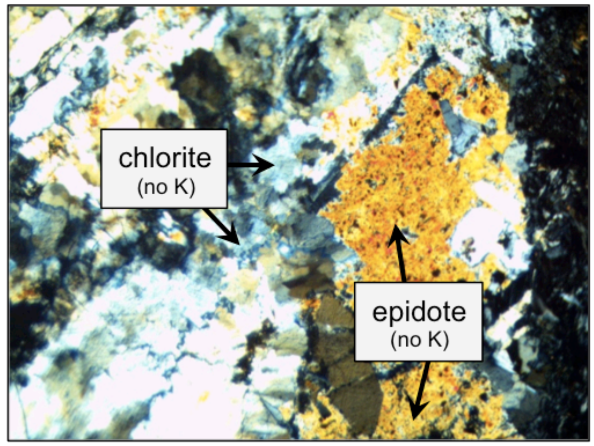
Future work should incorporate studies of magnesium supply, as its relationship to K is known to be significant. In Virginia soils it is common for Mg levels to read much higher than K, yet the vine uptake as measured by petiole analysis shows lower magnesium than potassium.

Site A5 (2 sample locations on 2 different soil parent materials)

A5-1: greenstone (low K)

Figure 2: Photomicrographs showing bedrock mineralogy for sample A5-1.

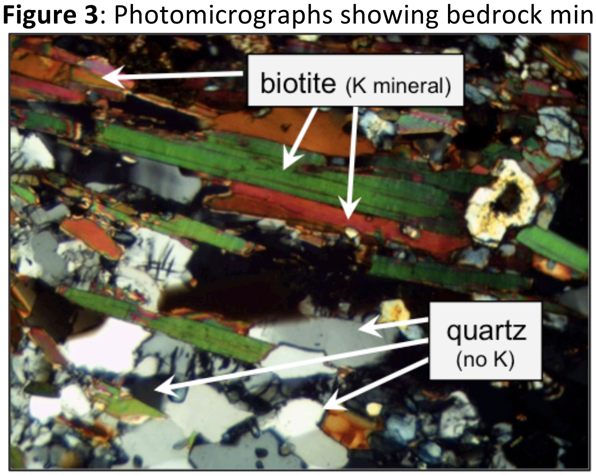


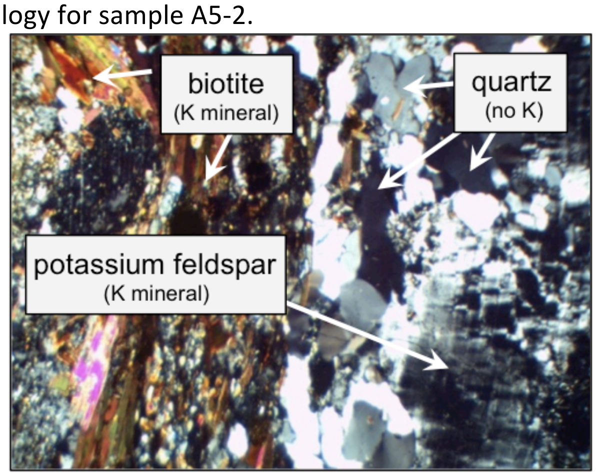


- Subsoil K level: 60ppm (very low)
- Merlot bloom petiole K level: 3.32% (high)
- Petiole K/Mg ratio: 7.4
- No fruit was obtained from this site at harvest

A5-2: granulite gneiss (high K)

Figure 3: Photomicrographs showing bedrock mineralogy for sample A5-2.



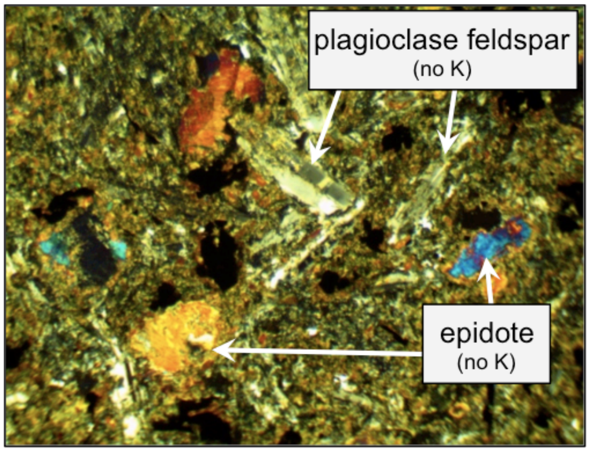


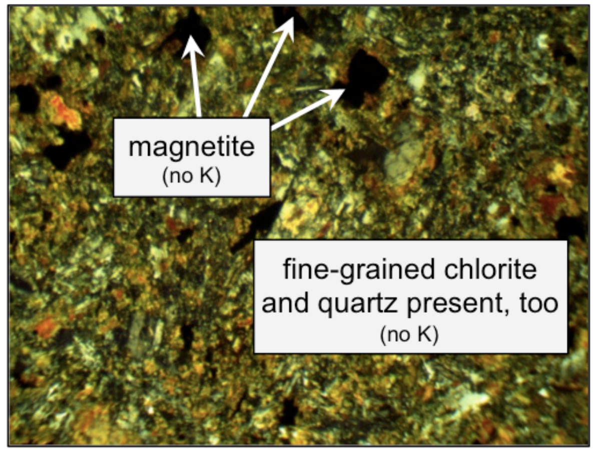
- Subsoil K level: 136ppm (high)
- Merlot bloom petiole K level: 3.88% (very high)
- Petiole K/Mg ratio: 11.88
- No fruit was obtained from this site at harvest

Site A6 (2 sample locations on 2 different soil parent materials)

A6-1: strongly altered diabase (low K)

Figure 4: Photomicrographs showing bedrock mineralogy for sample A6-1.

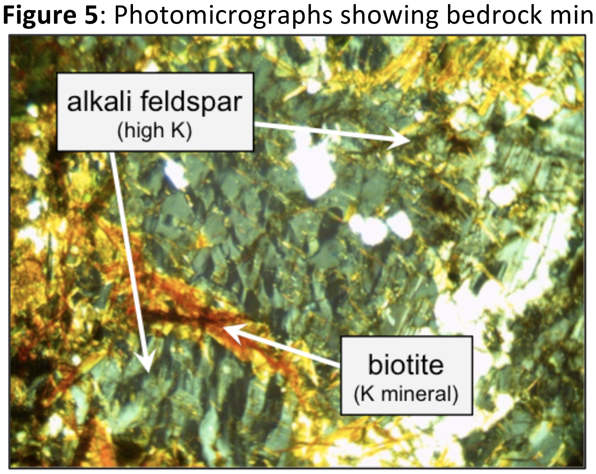


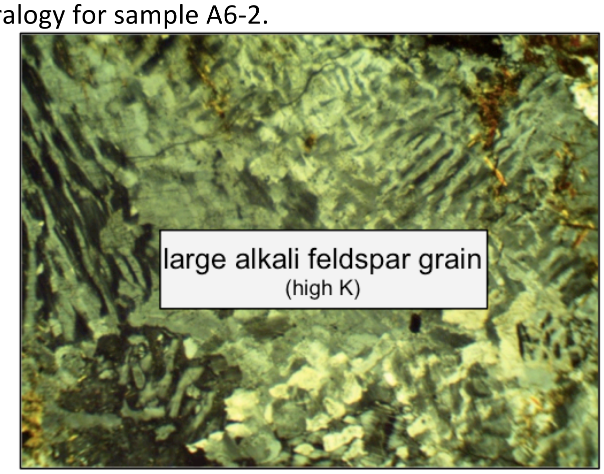


- Subsoil K level: 48ppm (very low)
- Merlot bloom petiole K level: 2.84% (high)
- Petiole K/Mg ratio: 3.8
- Berry brix: 20.9
- Berry pH: 3.35
- Berry K level: 1800ppm

A6-2: alkali syenite (high K)

Figure 5: Photomicrographs showing bedrock mineralogy for sample A6-2.



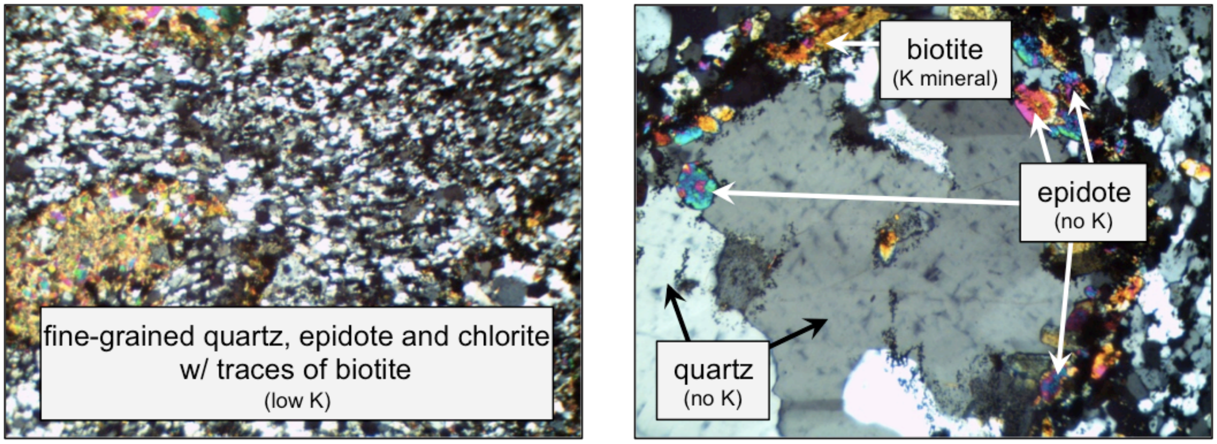


- Subsoil K level: 251ppm (very high)
- Merlot bloom petiole K level: 3.41% (high)
- K/Mg ratio: 5.8
- Berry brix: 21
- Berry pH: 3.54
- Berry K level: 2000ppm

Site A7 (1 sample on a single parent material)

A7-1: greenstone (low K)

Figure 6: Photomicrographs showing bedrock mineralogy for sample A7-1.



- Subsoil K level: 24ppm (very low)
- Petit Verdot bloom petiole K level: 3.41% (high)
- Berry brix: 20.4
- Berry pH: 3.15
- Berry K: 1700ppm

These preliminary data suggest a direct link between bedrock potassium supply, the concentration of bioavailable potassium in the soil, and potassium levels in the plant tissue and fruit. Sites A5 and A6 are both premier vineyards sites with consistent viticulture practices that both happen to be underlain by 2 different rock types. Each site contains Merlot vines growing over a high K rock and Merlot vines growing on a low K rock with similar aspect. As we hypothesized, the relative potassium supply from the rocks is reflected in the plant tissue and berry chemistry analysis.

Significant Outreach Activities:

- February 2015: Research Update Presentation at 2015 VVA Winter Technical (Lucie Morton and Ernest Beasley; Charlottesville, VA)
- February 2015: “Soils, Geology and Wine Quality” Keynote Presentation at Maryland Grape Growers Association Winter meeting (Ernest Beasley; Baltimore, MD)
- February 2015: “Soils, Geology and Wine Quality” Presentation at NC State University Cooperative Extension Winter 2015 Grape School (Ernest Beasley; Hendersonville, NC)
- March 2015: “Postmodern Winegrowing Forum” Craft Beverages Unlimited Panel Discussion (Lucie Morton; Richmond, Virginia)
- March 17-19 2015: “7 Best (and Worst) Ways to Start a Vineyard” Presentation at the Eastern Winery Exposition (Lucie Morton; Syracuse, NY)

We have also been in constant contact with research professionals at Virginia Tech and commercial laboratories regarding our potassium studies. Our goal is to communicate to the industry that potassium additions are very seldom needed for wine grapes in Virginia and that additions of K, if needed, should be based on petiole data – not soils data, as it so often grossly underestimates the reservoir of K available to the vines. Tony Wolf already recommends this approach, yet the commercial laboratories continue to recommend adding K to vineyards based on soil tests, which we know do not accurately represent bioavailable K. We hope to stop this harmful practice of unnecessary K additions, as it is wasteful and most likely detrimental to Virginia wine quality.

Appendix

i. Impact Statement

The impact of this study will be to alert grape growers, commercial soil labs, and agronomists to the specific factors to consider before making nutrient additions: soil depth, texture, structure, farming history, and subsoil parent material are all important. Shallow composite sampling methods appropriate for lawns and field crops are not useful for vineyards and this study helps highlight why this is the case.

ii. Publications (Presentations)

- February 2015: Research Update Presentation at 2015 VVA Winter Technical (Lucie Morton and Ernest Beasley; Charlottesville, VA)
- February 2015: "Soils, Geology and Wine Quality" Keynote Presentation at Maryland Grape Growers Association Winter meeting (Ernest Beasley; Baltimore, MD)
- February 2015: "Soils, Geology and Wine Quality" Presentation at NC State University Cooperative Extension Winter 2015 Grape School (Ernest Beasley; Hendersonville, NC)
- March 2015: "Postmodern Winegrowing Forum" Craft Beverages Unlimited Panel Discussion (Lucie Morton; Richmond, Virginia)
- March 17-19 2015: "7 Best (and Worst) Ways to Start a Vineyard" Presentation at the Eastern Winery Exposition (Lucie Morton; Syracuse, NY)

References

Keller, Markus 2010. *The Science of Grapevines: Anatomy and Physiology*. Academic Press. 255-257.

Wolf, Tony, ed. 2007. *Wine Grape Production Guide for Eastern North America*. Natural Resource, Agriculture and Engineering Services Cooperative Extension Publication: NRAES-145. Ithaca, New York.

Zoecklein, Bruce *et al*. 1990 *Production Wine Analysis.* Chapman & Hall, New York. 74-76.