# INFLUENCE OF BASALT ON THE TERROIR OF THE COLUMBIA VALLEY AMERICAN VITICULTURAL AREA

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## ABSTRACT

The Columbia Valley American Viticultural Area (AVA) of the Pacific Northwest, USA is the world's largest officially recognized viticultural area with basalt bedrock. However, most Columbia Valley vineyards are planted in soils derived from thick loess and glacial flood sediments, rather than the underlying bedrock. Recently, vineyard plantings have expanded into parts of the AVA where basalt and basalt weathering products, derived either naturally or through mechanical ripping, are a major soil component. Tests were conducted to determine how the addition of a basalt component to soils could affect the terroir of Columbia Valley vineyards. To test for the chemical influence of basalt, samples were obtained from soils representative of the range of basalt influence and analyzed for iron content. Increases of 77% to 233% in available iron were observed in vineyards with basalt component relative to vineyards planted in grass-covered loess. To measure the thermal influence of basalt, temperature data loggers were installed within soils and grape clusters in basalt-covered and grass-covered vineyards. Temperature loggers in the basalt-covered vineyard recorded an 18% increase in average soil temperature at a depth of 5 cm, a 13% increase in average soil temperature at a depth of 25 cm, and a 4% in average cluster temperature relative to those in the grass-covered vineyard. Cluster temperatures in the basalt-covered vineyard were generally higher than in the grass-covered vineyard from late morning through early evening, equilibrating rapidly near sunset.

**KEYWORDS**
basalt - terroir - soil - Columbia Valley

## INTRODUCTION

Worldwide, the percentage of vineyards planted in basalt-derived soils is relatively small. Notable viticultural areas with soils developed in weakly weathered to unweathered basalt include the Canary Islands, the Azores, and Sicily's Mt. Etna. Regions that host vineyards planted in older or more deeply weathered basaltic soils include western India, southern Australia, Oregon's Willamette Valley, south-central France, northern Italy, and Hungary's Badascony region. The world's largest government-designated viticultural region with basalt-dominated bedrock is the Columbia Valley AVA, which encompasses over 45,000 km$^2$ of the states of Washington and Oregon (Gregutt, 2002). The basalt was erupted during the Miocene Epoch from volcanoes associated with the hot spot that now lies beneath Yellowstone National Park in Wyoming (Pogue, 2009). The Columbia Valley AVA presently contains over 2700 ha of vineyards that are located primarily on gentle slopes or on valley floors below 400 m in elevation. Almost all of the vineyards are planted in loess derived from the deflation of sediments deposited by a series of catastrophic Pleistocene glacial outburst floods, known as the Missoula floods (Busacca, Meinert, 2003). At elevations below 330 m, the loess commonly overlies sand, silt, and gravel deposited by the Missoula floods, while above this elevation, the loess directly overlies basalt bedrock. Despite its age, the basalt is not deeply weathered due to the combined affects of the region's arid climate and the protective mantle of flood- and wind-deposited sediment. The most obvious effects of weathering are fracture networks filled with calcium carbonate and iron oxide-stained clays within the uppermost 1 m of the basalt. The soils in most Columbia Valley AVA vineyards were derived by the glacial and fluvial erosion of regions dominated by granitic and metasedimentary bedrock that lie north and east of the Columbia Valley AVA. They are therefore rich in quartz, muscovite mica, and potassium feldspar, minerals not present in the underlying basalt bedrock. Since the thickness of these soils generally exceeds the rooting depth of the vines, basalt has had, until recently, almost no influence on terroir.

Over the last 10 years, viticulture in the Columbia Valley AVA has rapidly expanded. Vineyards have recently been planted at higher elevations, on steeper slopes, and in rocky, alluvial soils. The soils in these vineyards are commonly much thinner than those of the traditional valley floor sites, and therefore vine roots are able to directly interact with basalt bedrock or basalt-derived alluvium or colluvium. In preparation for planting, the thin soils are often mechanically ripped to a depth of 0.5 to 1 m to increase water holding capacity and available rooting depth. The ripping process crushes the upper parts of the weakly weathered basalt bedrock and incorporates fractured basalt and basalt weathering products into the overlying sediments, significantly altering their mineralogy and chemistry. The introduction of basaltic minerals into soils derived from a granitic parent should increase the concentrations of elements that are present in higher concentrations in basalt, such as iron. Iron is an important nutrient for grapevines and unlike most elements, the concentration of iron in grapes and vineyard soils has been demonstrated to be directly related (Negre, Cordonnier, 1953). Iron concentrations in musts, which vary according to soil iron content, have been shown to affect the stability, clarity, and color of wines (Riganakos, Veltsistas, 2003).

The incorporation of fractured basalt by ripping also significantly alters both the texture and color of soils derived from fine-grained light-colored loess. In some recently planted Columbia Valley vineyards, ripping has produced soils with a very high ratio of rock to loess, and basalt is exposed over a significant percentage of the ground surface. The physical properties of these basalt-rich soils are very different from the loess-dominated soils that are typical of most Columbia Valley AVA vineyards. Unlike the highly erodible loess-dominated soils, the rocky coarse-textured basalt-rich soils require no cover crop. Relative to a vegetated ground surface, bare soil rich in basalt should absorb, store, and radiate more heat and conduct heat to deeper levels of the soil more effectively (Gladstones, 1994; White, 2003). Winegrowers have long recognized the thermal properties of basalt. In Germany's Forst region, it has even been imported to warm vineyard soils (Clarke, 2002).

## MATERIALS AND METHODS

To test the influence of basalt on the chemistry of Columbia Valley AVA soils, samples were collected from diverse sites that typify the range of its involvement (Fig.1). Soil samples were collected from: 1) ripped alluvial soils rich in basalt cobbles, 2) ripped alluvial soils with scattered basalt cobbles, 3) steep hillsides with thin loess and basalt colluvium (unripped), 4) steep hillsides with thin loess and basalt colluvium (ripped), and 5) gently sloping topography with thick loess. In addition, as a control, an artificial soil sample (sample #6) was created by crushing unweathered basalt. All samples were sieved to <1mm particle size. The availability of iron in all samples was determined by a commercial soil laboratory using diethylenetriaminepentaacetic acid (DTPA) as an extractant.

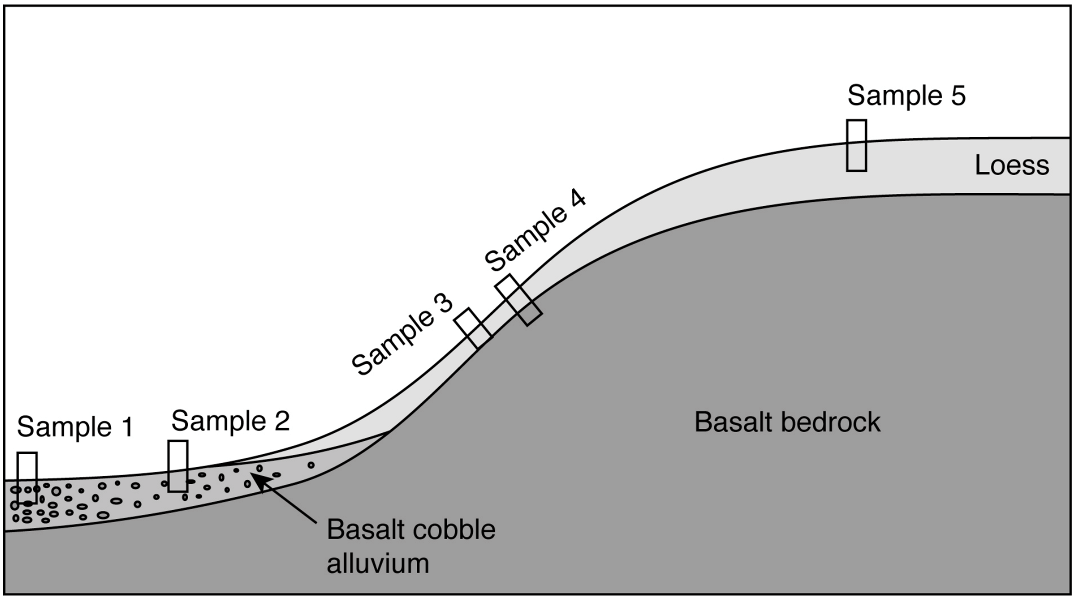


**Figure 1 Diagrammatic cross-section showing location of samples relative to soil type and slope.**

To measure the thermal effects of a basalt-covered ground surface, temperature data loggers were inserted into the interiors of grape clusters in two vineyards located 2.5 km apart. The surface of one vineyard is covered almost entirely by basalt cobbles while the other by a combination of dry, grassy vegetation and brown, loess-based soil. Data loggers were placed in 4 clusters in each vineyard. Clusters were selected to be approximately 0.5 m above the ground surface and shaded by leaves from direct sunlight. Data loggers were also buried midway between two rows in each vineyard at depths of 5 cm and 25 cm. The ambient air temperature in each vineyard was recorded by a radiation-shielded temperature data logger positioned 1.5 m above the ground. Data were collected at various times during July and August of 2007.

## RESULTS AND DISCUSSION

Fig. 2 shows the concentration of available iron in each sample in parts per million. As expected, sample #5 from the thick loess soils showed the lowest concentration (9 ppm). Relative to the other soils, these soils contain virtually no basaltic component. The highest concentration of iron (30 ppm) was measured in the alluvial soil with scattered basalt cobbles (sample #2). Being farther from the main stream channel, this soil is older and more deeply weathered than its cobble-rich counterpart (sample #1), which had a 37 percent lower iron concentration (19 ppm). The sample of unripped thin loess-based soil from a steep hillside (sample #3) contained 16 ppm iron, reflecting minor colluvial input from the basalt bedrock. The 44% increase in available iron in sample #4 (23 ppm) relative to sample #3 is likely related to the incorporation of weathered basalt by mechanical ripping. Sample #6, the artificial soil created by crushing unweathered basalt, had an iron concentration of only 14 ppm, which emphasizes the critical role of weathering in the production of plant-available iron.

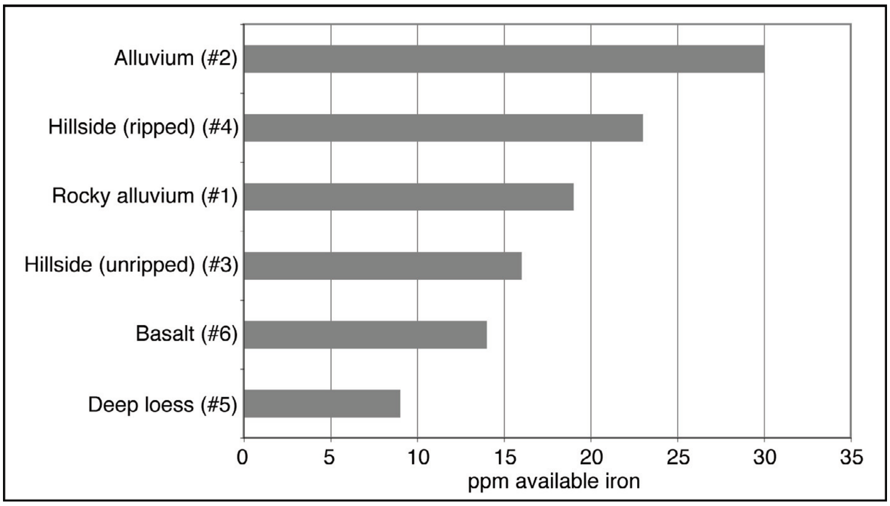


**Figure 2 Available iron in each sample.**

Fig. 3 shows a graph of the average temperatures of grape clusters in the basalt-covered and grass-covered vineyards and a graph of the difference in ambient air temperature in the two vineyards from 5 days in late July 2007. The grape cluster data loggers in the basalt-covered vineyard recorded higher temperatures between approximately 10:00 and 20:00 each day.

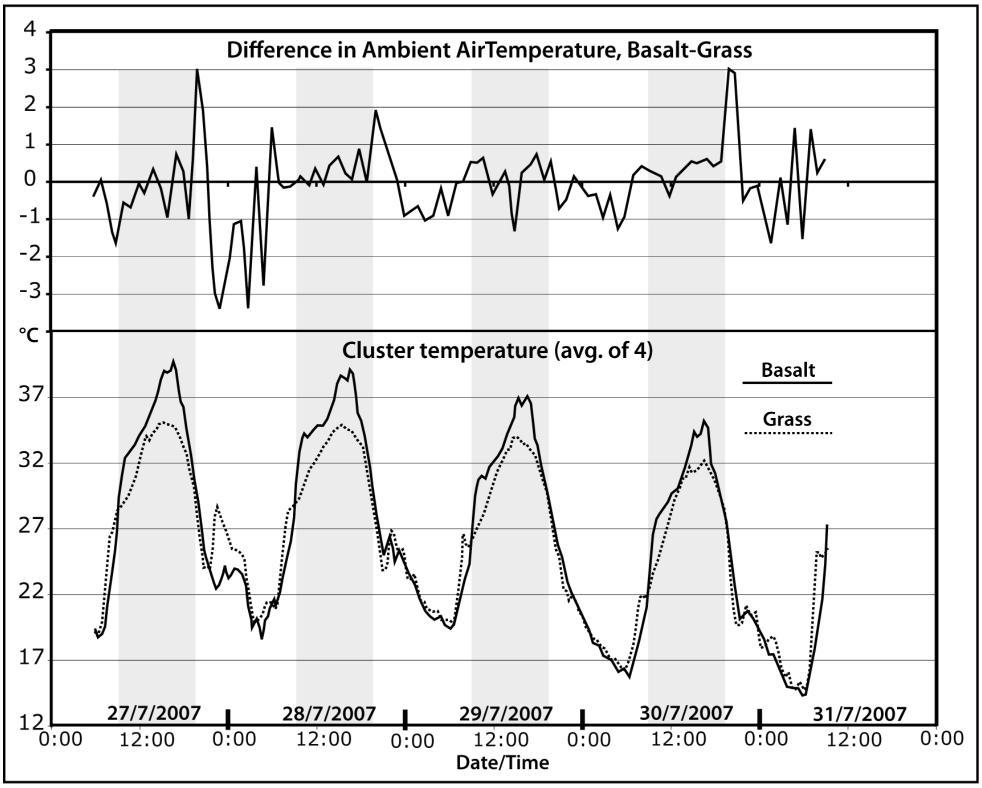

**Figure 3 Grape cluster temperatures and difference in ambient air temperature in basalt- and grass-covered vineyards.**

These time intervals are shaded on fig. 3. Although the ambient air temperature in the vineyards during these intervals generally differed by less than 1°C, the basalt-covered vineyard cluster temperatures were often 3° to 5°C higher than those in the grass-covered vineyard.

Fig. 4 compares the average ambient air, ground surface, subsurface, and cluster temperatures of the grass-covered and basalt-covered vineyards from 25 days in August of 2007. The higher ground surface and subsurface temperatures in the basalt-covered vineyard reflect the lower specific heat and higher thermal conductivity of basalt relative to grass and loess. Radiant heat supplied by the higher surface temperatures increased average cluster temperatures in the basalt-covered vineyard relative to the grass-covered vineyard. The relatively smaller increase in the average temperature of the basalt vineyard clusters reflects the high specific heat of water, which constitutes most of their mass. Variations in berry temperature have been shown to affect the production of phenolics, anthocyanins, and sugars (Bergqvist et al., 2001). The average ambient air temperature in the two vineyards was statistically the same, indicating that advection overwhelms the effects of the differing surface materials.

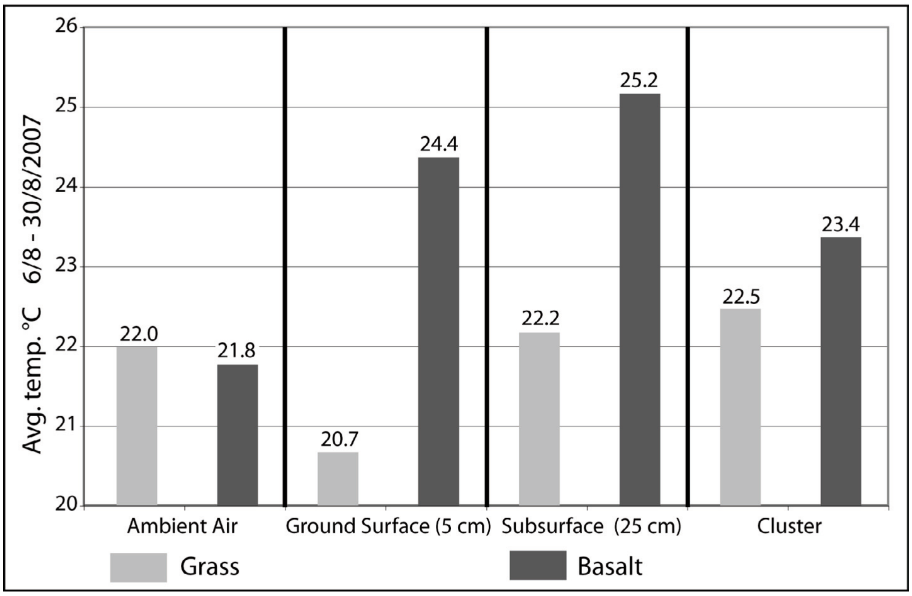


**Figure 4 Comparison of average temperatures in basalt- and grass-covered vineyards.**

## CONCLUSIONS

The terroir of some Columbia Valley AVA vineyards is significantly influenced by the chemical and thermal properties of basalt. Vineyard soils in the Columbia Valley AVA that incorporate basalt bedrock or basalt alluvium show substantial increases in available iron relative to the more widely planted loess-based soils. The largest increases are observed in older alluvial soils and in mechanically ripped soils that incorporate weathered bedrock. Since the iron content of grapevines is directly related to the availability of iron in vineyard soil, increased iron should also be evident in the grapes and wines produced from basalt-rich soils.

Vineyards within the Columbia Valley AVA covered by fractured basalt bedrock or basalt-rich alluvium have higher average ground surface and subsurface temperatures than their grass-covered counterparts. From late morning to early evening, grape clusters in basalt-covered vineyards are heated to higher temperatures than clusters in grass covered vineyards. The extra heat is derived from infrared radiation from the sun-warmed dark-colored basalt, not from conduction from heated air. Cluster temperatures within the basalt-covered and grass-covered vineyards rapidly equilibrate near sunset. No evidence was observed of the oft-cited ability of surface stones to store heat and release it after sunset, at least not to the above ground part of the grapevines. Due to advection, vineyard surface material appears to have little affect on ambient air temperature.

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