SOIL ORIGIN

Nature of the beast

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The following briefly describes how soil forms, some of its resulting characteristics, and some general viticultural implications. Subsequent reports will address more specific aspects of irrigation, vine nutrition, fertilization, soil management, and long-term planning.

Though this information emphasizes experience in the North Coast viticultural district of California, specific comparisons with other grape-growing regions around the world are included where appropriate.

An old North Coast grape-growing tradition holds that we think about and manipulate only the above-ground portion of the vine, as we are "often forced to accept what the subsurface environment provides." Those of us not bound by such fatalism have found, through experimentation and analysis, practical ways to significantly improve the subsurface environment, where desired, through management of nutrition and water. We evaluate success in terms of wine quality, or yield and quality.

In order to favorably manage soil, we must first understand the medium in general and then the specifics of a particular site. Remember, variation in soil will make a given approach to nutrient management that may be very successful in one location fail miserably in another. All dirt was not created equal!

Soils in the North Coast are as complex as any in the world, so it is instructive to review the origin and nature of this region's *terrior*.

Soil formation

Mineral soils are produced by the decomposition of rock. (Organic soils, formed in swamps and bogs, represent a very small fraction of vineyards worldwide and are not discussed here.)

Rock breaks down slowly via chemical, physical, and biological weathering processes. Upland soils form in place from weathered rock; their physical and chemical nature is determined by the types of rock decomposing. The underlying geology profoundly influences the soil characteristics of a site in a great many ways. As we shall see below, this may be the predominant factor in establishing the axiom that 'hillside vineyards' produce wines of outstanding quality. It is not the hillside *per se* that is vital, but rather what the hill is made of!

Rainfall and runoff erode upland rocks and soils, carrying them down to the valleys. As the water subsides, the eroded material settles at the bottom of stream channels where the weathering processes continue, often at an accelerated rate. During periods of high water flow, these materials may be deposited near the stream channels by flood waters, thereby creating valley soils, or carried farther downstream. (A great deal of eroded soil ends up in the ocean.)

Upland and valley soils have distinctly different origins. Understanding these differences is important in their management and in the production of fine wine.

Upland geology and soils

The hills and mountains of the North Coast region fall predominantly into four geologic units: the Sonoma Volcanic group (rhyolite, andesite, basalt, and volcanic ash); the Franciscan formation (sandstone and shale); the Merced sandstone; and widely scattered deposits of serpentine.

Comparable complex geology may be found in western Oregon and Washington, Chile, South Africa, New Zealand, and parts of Australia and Italy. (The limestone and chalk so common in France and parts of Spain and Italy are essentially absent on the west coast of the United States.)

Soils formed from the rocks of the Sonoma Volcanics closely resemble volcanic soils throughout the world. At one end of the volcanic rock spectrum is rhyolite (or its coarse-grained equivalent, granite), which is naturally high in potassium and low in magnesium —a mineral balance that is very important for grape nutrition and wine quality.

Rhyolite typically occurs as mixed deposits of well-fractured rock and beds of volcanic ash. It is quite porous, usually well-drained, and forms what are arguably the best viticultural soils in the North Coast. Indeed, many of the 'hillside' vineyards so famous for their superior wine quality owe their reputations to the chemical and physical nature of rhyolitic soils! Examples in Sonoma Valley include: upper Beltane Ranch Chardonnay, Upper Weiss Ranch Zinfandel, and some small Cabernet Sauvignon vineyards whose grapes are blended into Kenwood Winery's 'Artist Series.'

The other end of the volcanic spectrum is basalt (whose coarse-grained equivalent is called gabbro), which is much higher in magnesium and notoriously low in potassium. Basalt is also highly fractured and usually well-drained, but owing to its inherent chemical composition, it commonly weathers into soils that are less desirable because they are nutritionally out-of-balance for premium wine grapes.

Andesite is intermediate between rhyolite and basalt in overall chemical composition, as are the soils formed on it. One well-known andesite deposit occurs in the Chalk Hill American Viticultural Area (AVA) of Sonoma County. Andesitic ash was deposited at such a high temperature that it welded itself into a massive, nearly impervious bedrock with few fractures known as tuff or tuffa. The chalk-like appearance of the ash led to a geographical misnomer — there is no chalk in Chalk Hill!

The impervious bedrock means that winter and spring rains don't percolate, resulting in 'perched' water at the subsoil/bedrock interface and saturated subsoil early in the growing season. This can impede root function at a time vital to nutrient uptake from soil, especially in years of heavy rainfall. It also makes these soils more susceptible to landslide and erosion, requiring great care if developed into vineyards.

The sandstones and shales of the Franciscan formation are typical of the coastal mountain ranges of the western U.S. and have counterparts in the nonvolcanic portions of the Andes. Soils formed on these rocks often have clay subsoils high in magnesium, comparable in many ways to basaltic soils. In a few specific locations, they may be high in lime (calcium carbonate) and lower in magnesium, though rarely approaching the lime content of French soils.

The much softer Merced sandstone underlies much of the Green Valley AVA and nearby portions of the Russian River district. This deposit was laid down several million years ago when the area was a large bay, similar to Monterey Bay today. Analogous deposits are scattered the length of the west coasts of North and South America. Soils formed on such deposits are leached of nutrients; that is, they are nearly inert chemically. Though inherently not as favorable as rhyolitic soils, they qualify as some of the best for producing fine wine as they are readily improved via fertilization.

The bane of viticulture is serpentine, which is scattered through much of the western coast ranges. The only nutrient it contains is 'hydrated' magnesium, which contains only magnesium, silicon, oxygen, and hydrogen. Soils developed on serpentine are typically deficient in most other nutrients (potassium, phosphorus, calcium, nitrogen, etc.) rendering them toxic to most plant species. Very few plant species can survive on such soils; grapevines do not. On serpentine in the uplands, and on valley soils derived from those deposits, vines tend to do very poorly unless fertilization is aggressively pursued.

The negative impact of upland serpentine on valley soils should not be taken lightly. Massive quantities of magnesium from serpentine have eroded or leached down from the hills, much to the detriment of many valley vineyards. The net effect of this influx ranges from a detectable chemical fingerprint to a massive footprint.

Valley soil: a marble cake

Where a stream channel emerges from the hills into a valley, an alluvial fan often forms from the particles of rock that the stream carries down from the hills. Near the hills, the particles range in size from boulders and cobbles to silt and clay. Farther from the hills, one generally finds fewer and fewer large particles and a more uniform size distribution of particles. In the North Coast region, some alluvial fans are more than 100,000 years old.

The flatter portions of valley floors generally represent flood plains. When streams overflow their banks, large amounts of sediment can be deposited. Sand and gravel settle out near the stream, while silt and clay settle farther away. During the so-called Ice Ages, the North Coast received far heavier rainfall than today, resulting in some year-round valley lakes in which the predominant type of sediment was clay. These former lake beds, represented today by the Clear Lake soil series, are some of the most problematic for growers and vintners because the heavy magnesium footprint of serpentine diminishes grape quality and productivity.

Over thousands of years, streams change their courses regularly; a stream will meander all over a flood plain. It is sometimes rather difficult to imagine that a spot miles from the nearest river was, a long time ago, actually in mid-stream! The alternating actions of deposition during floods and subsequent 're-working' by meandering streams often result in complex three-dimensional soil patterns. This change in pattern results in considerable variation in vine growth over short distances. Perhaps the best way to visualize such soil deposits is to think of them as a sort of marble cake of available soil types.

Since valley soils are derived from the uplands, it should not be too surprising that valley soils are heavily influenced by the geology of their respective watersheds. In regard to alluvial fans, this effect is often fairly simple and direct. On the flood plains, it is seldom this obvious, however, owing to this complex history of deposition and re-working.

Due to changes in stream course, a given watershed will contribute sediment to different parts of a valley at different times. Then, to 'spice' things up, volcanic ash gets tossed around from time to time. Some of it ends up in distinct layers in valley soil profiles. (Around 300 AD, a heavy ash deposit covered New Zealand's North Island. It has a major impact on those soils today. People living downwind from Mount St. Helens know all about this sort of thing!) So valley soils generally reflect a mixed and averaged marble cake of the geology of the watershed.

What soil(s) do you have?

The only way to adequately determine what soils you have is to dig holes in the ground, take samples, and analyze them using standardized procedures. You won't learn much from looking at the soil surface or from reading about someone else's soil in a book. Hearsay is often worth what you pay for it, and local mythology is often as useless as it is creative.

Referring to a soil survey can give you a good indication of the kinds of soil found in an area, but don't be surprised if what you find by digging is not what is marked on the map. (This is no fault of those who compiled the survey, merely a result of inadequate resources. It is not feasible for a limited staff with limited funding to evaluate large areas in fine detail. Much of the soil survey work must be done from aerial photos rather than by digging.)

Your best sampling tool is a backhoe, and don't be shy about digging down eight to ten feet if possible. Some very interesting subsoil changes can occur below four feet, so you won't even discover them if you stop at two or three feet. (In New York, you may have to stop at three feet, as that may be as much soil as the glaciers left you!)

Sample topsoil and subsoil separately. If there is a visible change in the subsoil, sample the different layers separately. Soil analysis should be the basis for a great deal of your long-term decision making. Lack of information may cost far more than you 'save' by cutting corners.

In order to compare the results of your analyses with other vineyards and published research, it is vital that the lab you use follows established standard analytical procedures. In California, these standard procedures were developed through the effort and cooperation of the University of California labs and the California Fertilizer Association.

Results from different labs following the same procedures may be compared directly with each other and with (past and future) published research. Numbers coming from labs which follow 'proprietary' procedures cannot be compared with results from standard analysis, rendering them, in my opinion, inferior.

Food for thought

After centuries of trial and error, European viticulturists have long since concluded that *terrior* is a critical contributor to wine quality. In the North Coast, this view is steadily gaining favor, as arcana and anecdotal history give way to basic plant science and modern methodology.

This increased understanding of soil's contribution to winemaking means that the AXR/phylloxera cloud does have a silver lining — our industry has the opportunity to take a hard look at soil types and to use our knowledge as a vital determinant of what materials will be chosen for new plantings and where the vineyards will be located. If we seize this opportunity, we will improve overall wine quality while vastly increasing productivity and profitability. ■

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