Geology and Wine 1. Concept of Terroir and the Role of Geology

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SUMMARY
Although Peigi Wallace presented a paper on the geology of wine at the 1972 International Geological Congress in Montreal, until recently there have been few publications on this topic. However, a remarkable book by J.E. Wilson appeared in 1998 on *terroir* and the role of geology, climate and culture in the making of French wines. Wilson emphasizes vineyard geology as a precursor to the soil, and the subsoil through which the grape vine grows, and that geology controls the topography and landform type present, thus influencing drainage and microclimate. This paper examines the ideas of Wilson and other authors on the concept of *terroir*, and discusses the key role of geology in wine grape regions.

RÉSUMÉ
Depuis l'article de Peigi Wallace sur la géologie du vin présenté au Congrès international de géologie de Montréal en 1972, bien peu de publications sont parues sur le sujet. Cependant, en 1998, un livre remarquable de J.E. Wilson a été publié sur le terroir et le rôle de la géologie, du climat et des méthodes culturales dans la production des vins français. Wilson y fait état de l'importance déterminante de la géologie sur les couches du sol et du sous-sol où poussent les vignes; on y souligne également que c'est la géologie qui détermine la topographie et les formes du relief, d'où son importance sur le drainage et le microclimat. Le présent article analyse les idées de Wilson et d'autres auteurs sur le concept de terroir et discute du rôle clé de la géologie pour les régions vinicoles.

INTRODUCTION

In 1972, Peigi Wallace presented a paper on the relation of geology to wine entitled "Geology of Wine" at the 24th International Geological Congress, Montreal in Section 6: Stratigraphy and Sedimentology, convened by Digby McLaren and Gerry Middleton (Wallace, 1972). In true Canadian fashion, this Canadian first has been largely ignored in Canada, but oft-quoted in Europe by wine authors. At about the same time Peigi was presenting her talk, I had taken up a position in Shiraz, Iran, the type locality of one of the oldest-known wine grapes in the world, and was assisting a crew of Italian chemical engineers from the local oil refinery in drinking both their white Shiraz *vin nouveau* and the *grappa* that they were distilling from it.

During the lapse of 26 years until 1998, the only English-language publication on the specific role of geology to wine written by geologists was a French book by the BRGM (Bureau de Recherches Géologiques et Minières) edited by Pomerol, *Terroirs et Vins de France*, (1984); translated as *The Wine and Winelands of France, Geological Journeys* in the English version (1989). Although a definitive field guide to the geology of the French wine districts, full of interesting details such as the dates of wine festivals, and an essential accompaniment to a study of "wine and geology," it lacked information on climate and hydrogeology. Also, the geology presented, although excellent at the regional level of a French wine region (*e.g.*, the Côte d'Or of Burgundy) and often applicable at the meso-level of a wine district (*e.g.*, the Côte de Beaune, the southern part of the Côte d'Or), had only an indirect relation to the micro-level of a specific village area (*e.g.*, the *commune* of Aloxe Corton, the only Grand Cru area of Pinot Noir grapes in the Côte de Beaune).

By utter coincidence, 1998 proved to be an amazing *grande année* (vintage year) for geology and wine publications. In July, Lawrie Mintner (of Witwatersrand gold fame) led a field excursion, "Geology of the Cape Winelands," for the International Volcanological Congress in Cape Town; the guidebook (Mintner, 1998) is the only publication on the geology of African wine *terroirs*. The following month, I led a field trip, "Geology of Niagara Falls and Niagara's Vineyards and Wines," for the International Mineralogical Association meeting in Toronto, the guidebook of which (Haynes *et al.*, 1998) is the first geological publication on *terroir* and wine of the Americas, although there are previous geological field guides to the Niagara (Haynes, 1992, 1994a,b) and New York (Fakundiny *et al.*, 1989) wine districts.

However, the *crème de la crème* of the century was the publication in late 1998 of the 336-page singularly authoritative treatise, *TERROIR: the Role of Geology, Climate, and Culture in the Making of French Wines*. It was the culmination of about 20 years of post-retirement research by the ex-Shell Petroleum geologist, James E. Wilson (Wilson, 1998). The importance of this book cannot be overestimated, as it clearly outlines the major role of vineyard geology as both a precursor to the soil and the subsoil through which the grape vine will grow, as well as the determining factor for the topography and type of landform present, which themselves control the drainage and microclimate. It is the first publication illustrating the use of geology in defining a *terroir* not only at the micro level of a village but also, in some areas (*e.g.*, Aloxe Corton), down to the level of a specific vineyard, and the geologic reasons underlying its designation as Grand Cru, Premier Cru, or Commune wines. As far as I know Wilson (1998) is also the first person to use seismic and resistivity geophysical surveys to link vineyard designation to sub-surface bedrock geology and the hydrogeologic conditions of the overlying transported sediment.

TERROIR: MEANINGFUL OR MEANINGLESS?

The Concept in France

Most French-English dictionaries define *terroir* as "soil" and herein lies the source of a controversy that has been raging among English-speaking wine scientists and wine writers for decades. The implication is that, other than climate and the skill of the wine maker, soil controls the grape and hence the quality of the wine. The problem has been compounded in recent years by *terroir* having become the buzzword of the wine

industry, mandatory in practically everything written in English about wine, including the label on the bottle, often without any understanding. This has led to a profusion of English-language definitions, and understandable confusion as to the correct meaning of the word.

No such confusion exists in France where the word originated. This is because France, as the world's largest grower of wine grapes, has had two millennia of hands-on viticultural experience, coupled with the last millennia of trial-and-error scientific study undertaken by the monastic orders. Thus in France, it is almost a matter of religious belief that the suitability of a particular grape variety and the general characteristics (smell, taste, colour, body, texture, *etc.*) of the wine produced from it are determined by the regional climatic and geologic setting of that particular wine district in any given wine region. These characteristics must be different, not only from other regions but, also, between districts in the same region. Indeed, I can personally attest that wines from red Pinot Noir and white Chardonnay grapes grown at Aloxe Corton, Côte de Beaune, Burgundy are totally different from those grown at Bouzy, Montagne de Reims, Champagne.

To me, the very essence of the concept of *terroir* is that the specific quality of the wine produced from a particular grape variety at the micro-level of a vineyard is a fundament of the complex interrelationships of all the factors, above and below the ground, that affect the grape during growth, excluding pests, diseases, herbicides, mutations, *etc.* Generally, these factors may be divided into five main groups: meteorological, physiographic, pedological, geological and viticultural. Examples of these factors include, but are not restricted to:

1. Meteorological: temperature maxima and minima, hours of sunlight, wind conditions, and rainfall;
2. Physiographic: type of landform, elevation, slope aspect and gradient, and slope drainage;
3. Pedological: composition and porosity of overlying soils, soil mineralogy and chemistry, soil grain size and texture, and clay mineralogy;
4. Geological: geology of the subsoil and the geochemistry, petrology and texture of individual strata, surface water and ground water flow rates and chemistry, and;
5. Viticultural: trellising method, row spacing, grape-bunch thinning and allowable production, fertilizing, mechanical addition of soils or rock material, systematic tile-draining, and irrigation.

Outside France, it is not unusual for the geological and even physiographic groups to be dropped from consideration, they somehow being included as part of soil science; as if geology and physical geography are not recognized as separate sciences. Or is it that the sub-surface, being unseen, doesn't exist? The geological part of the complex equation that expresses *terroir* is exemplified in the book *Terroirs et Vins de France* by Pomerol (1984; English version, 1989). Notwithstanding the above, *terroir* is claimed by the French to be untranslatable, as it is an experience of the wine lands gained by the *vigneron*: the "wine grower." The French stress that they are the only nation that has wine growers, everyone else has grape growers. From my personal experience in Champagne and Burgundy (August, 1999), the word *vigneron* appears to be used mainly for owner-growers of Grand or Premier Cru vineyards, the lower quality 3^{me} classe (3rd class) *commune* and *vin du pays* vineyards being attended by viticulturists or agriculturists.

James E. Wilson in his book (Wilson, 1998) illustrates better than anyone the geological logic of the concept of *terroir*. An example of his studies, the Hill of Corton, is given in Figures 1 and 2 (see also the photograph on the cover of this issue). Here, for hundreds of years, the *vignerons* have known from trial and error where the vineyards that produce Grand Cru (Corton red and Corton Charlemagne white), Premier Cru red, and Commune wines should be located (Comité Interprofessionel des Vins de Bourgogne, undated). However, it took geologists to demonstrate that the boundaries of these vineyard designations corresponded exactly with the stratigraphic limits of: the Pernand marl (for the Grand Crus), with a layer of ferruginous oolite marking its lower boundary; the Dalle nacrée, an oyster-shell fossilferous lime flagstone (for the Premier Crus), and; the Digonella divionesis marl and limestone (for the Commune wines). The Hill of Corton is only one of two small *terroirs* in the Côte d'Or that supports Grand Cru white wine from Chardonnay grapes and, along strike of the Pernand marl, the only terroir of the Côte de Beaune supporting Grand Cru red wine from Pinot Noir grapes. Wilson (1998) suggests that the Chardonnay grapes prefer the cooler conditions of the west-southwest face of the hill more than the Pinot Noir on the south and south-southeast face (Figs. 1, 2), and that, " ...apparently the Pernand marl develops a particularly clayey facies on the slope which the Corton-Charlemagne occupies." Figure 1 shows the boundaries (from Comité Interprofessionel des Vins de Bourgogne, undated) of individual Grand and Premier Cru vineyards (the largest of which is 800 m along strike and 200 m across strike; most are less than 200 m in either direction) in the commune of Aloxe-Corton. Distribution of these vineyards is: Corton Charlemagne Grand Cru (four vineyards, in total 35 ha), Corton Grand Cru (14 vineyards, in total 85 ha), Corton white and red (Grand Cru) (three vineyards, in total 16 ha) and Premier Cru (eight vineyards, in total 29 ha). Each of these vineyards has a name (omitted in Figure 1 for the sake of clarity), which is its *terroir* and the name put on the label of all bottles of wine from this vineyard. The wineries may have land in several of these vineyards, so individual winemakers may produce wine with the same winemaking techniques from different vineyards, although bottled separately. This allows direct comparison of differences in the wine (colour, taste, bouquet) to differences in *terroir*, such as down-dip geologic changes and along-dip slope aspect changes. Such distinction of *terroir* at this micro-level is unique because the land has been split into smaller parcels over the long history of land-ownership in Burgundy.

One thing that must be stressed is that the French have never downplayed the skill of the winemaker. Like a good chef, the winemaker is restricted by the quality of the product he is handling, and that quality depends significantly on the five factors noted above. Unfortunately, in the New World this is usually forgotten and good wines are often attributed only to the skill of the winemaker and/or the viticulturist, with total disregard for the effects of Mother Nature on grape quality. In France, however, it is a matter of faith that only the best wine is possible from the best *terroir*, that good wines may/may not be produced from an intermediate *terroir*, and that a poor wine is the product of a poor winemaker and/or an unacceptable *terroir*. In coun-

tries outside France, the concept of *terroir* is best endorsed in the German and Italian vineyards and is endorsed in principle for the vineyards of South Africa's Western Cape, many of which were established in the 17th century. In the New World, *terroir* has either not yet been adequately quantified (Argentina, Canada and Chile) or has been rigorously opposed, as in California, Australia and New Zealand where the success of certain California wines in beating out French wines in several competitions has had a profound influence. Here, opposition by the growers to the concept of *terroir* has been supported by academics from: geography, such as Moran (1988) from New Zealand, who considers *terroir* a myth used as an excuse for increased land values, or; agriculture, like Gladstone and Smart (1994) from Australia, who wrote the following paragraph, highly detrimental to geology, as part of their explanation of the term "terroir" in Jancis Robinson's (1994) wine glossary, *The Oxford Companion to Wine*:

> An implication is that GEOLOGY, often cited as a basis of terroir, has in general no more than an indirect role. To varying degrees parent ROCK materials do contribute to the natures of the soils derived from them; they also shape local topography and therefore MESOCLIMATE. Occasionally the parent materials contribute directly because vine roots can penetrate them, as in the case of CHALK subsoils and the recent ALLUVIAL deposits of the Médoc. In the broad sense, however, it remains the soil itself, and its water relations, that play the decisive role. *The study of terroir is one of soil and mesoclimate, not of geology*" (capitalized words in the original; italics added by SJH).

Notwithstanding that they appear to restrict geology to petrology and lithology (in their section, they list geomorphology and hydrology separate from geology), it is instructive to compare their views with the quintessentially French opinion of Madame Bize-Leroy, the head of Maison Leroy and co-owner of Domaine de la Romanée-Conti (the Grand Cru estate in Burgundy), who in a letter to James E. Wilson wrote:

> Suppose that one day we might know the nature of all the elements which compose this nourishing "new earth" between the pebbly surface [the topsoil] and the Jurassic sub-basement [bedrock], would we then be able to determine exactly the physical and chemical influence of these elements on the intrinsic, fundamental character of the wine issued from them ? Personally, I do not believe so, for all of this is too dynamic – I would say almost alive – to put in an equation. *I remain convinced, however, that the fundamental character of each wine depends on the nature of its subsoil*. (italics added by SJH) (Wilson, 1998, p.118)

ROLE OF GEOLOGY

Although geology and pedology must play a vital role in wine quality, the other factors of *terroir* — climate, drainage and viticultural practices — must play

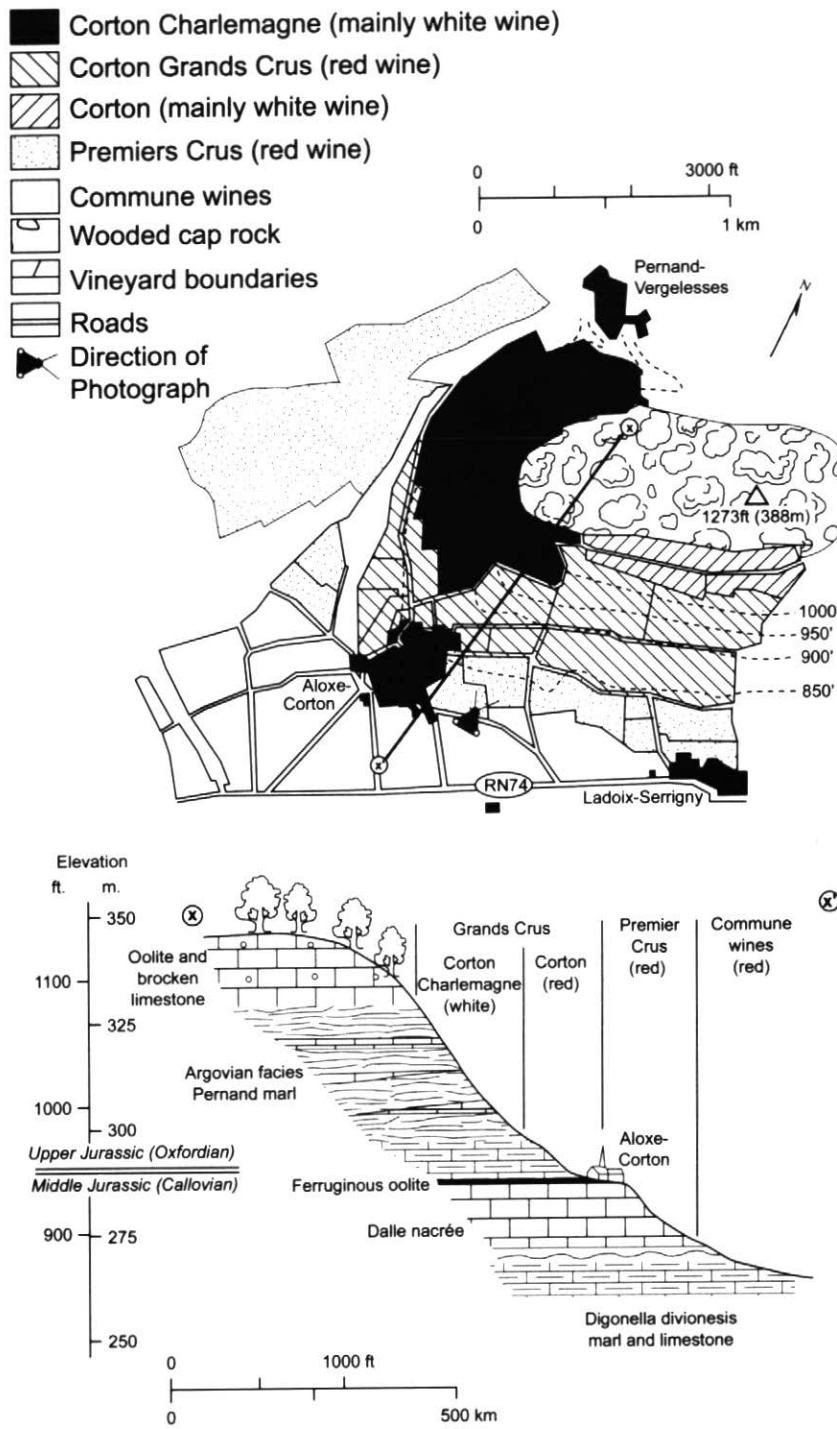

Figure 1 Plan and cross-section of the Hill of Corton, Côte d'Or wine-producing region of France, (a butte) showing the relationship of the geology to vineyard designations as Corton Charlemagne Grand Cru, Corton Grand Cru, Corton (white and red), Premier Cru (red), and Commune wines. Based on Figure 4.15 of Wilson (1998) with modification and additions of vineyard boundaries and designations from Comité Interprofessionel des Vins de Bourgogne (undated).

their part too; hence the fact that local meso- and micro-climates control the yearly difference (a good or bad "vintage"). However, given the same climate, viticulturist and winemaker, I hope Madame Bize-Leroy is right because I believe that the subsoil geology is the determining factor controlling the taste and bouquet of a wine (the very essence or "soul" of a wine). I consider that the soil primarily affects young vines in their early growth stages, but once the vine is established it is affected mainly by the geological conditions of the subsoil. Evidence for this is that it is well known from areas of old-growth vines that the wine from old vines tastes different than young vines (often better but sometimes worse). Grapes are exceptionally deep-rooting plants that dislike wetlands and grow best on well-drained soils. In older plants, the roots can penetrate more than 4 m in coarse-textured, porous sediment (Wilson, 1998, Fig. 6.3). Moreover, Bryan Coombe (1994) in his section on "root" in the *Oxford Companion to Wine* states,

> Although most vine roots occur in the top metre of soil.....there are many examples where roots have penetrated to 6 m/20 ft or more. (Robinson, 1994)

Such depths are well below the A and B soil horizons, and usually below the C horizon, in either Quaternary or Tertiary unconsolidated sediments or underlying bedrock. The nature of the resultant wine encompasses the diverse facets of geology encountered by the deeply rooting grape vine as it penetrates ever downward, year after year, through the different lithologies, each with its own mineralogy, fabric and lithochemistry and specific ground water chemistry and flow rate. Thus, between different areas (communes) of a wine district, geology is highly unlikely to be a "fixed equation" as it must include, at a minimum, differences between the relevant inter-connecting factors of: physical geology (types of landform, elevation above sea level, azimuth to the sun, slope aspect and gradient.); petrology (mineralogy, texture, porosity and geochemistry of both the bedrock strata and/or the overlying unconsolidated sediments) and; hydrogeology (surface water and groundwater flow rate, direction and chemistry).

Although we are still awaiting the Ontario legislature to move on the issue of licensing geoscientists, in my opinion the professional associations of geoscientists of British Columbia and Nova Scotia (where geoscientists are licensed) should be insisting that Professional Geologists be involved in the decision-making process of the Provincial and Municipal governments and the Vintners Quality Alliance in all aspects of Canadian wine appellations and vineyard licensing. Why? Because in France, and do not forget this is the other half of Canada's cultural heritage, the refined Appellation laws of 1935 protect the quality of the winemaking regions by definition of the winery and vineyard management techniques as well as the physical environment of geology, soil and climatic conditions of the vineyards under the auspices of the INAO (Institut National des Appellations d'Origine). INAO employs a team of about six scholars, two of whom are geologists, to assess each situation. It would also appear that geophysicists may have a major input into vineyard *terroir* designation in the next century, given the evidence of Wilson (1998) that the historic distinction of several *terroirs* in Burgundy is supported by geophysical data that has revealed geological differences in the substrata.

Notwithstanding the obvious importance to geologists of the above, wine is indeed serious business, but fun to drink. And where else in the earth sciences, in the words of James E. Wilson, "can you drink on the job"? Since 1992, I have been taking time out to imbibe a large variety of wines all over the world, and ponder on their relationships to the geology of their root zones. These ruminations have led both to my offering a course, "Geology of Viticultural Regions," next year for Brock's Cool Climate Oenology and Viticulture Institute, and serving as series editor of this new *Geoscience Canada* Series.

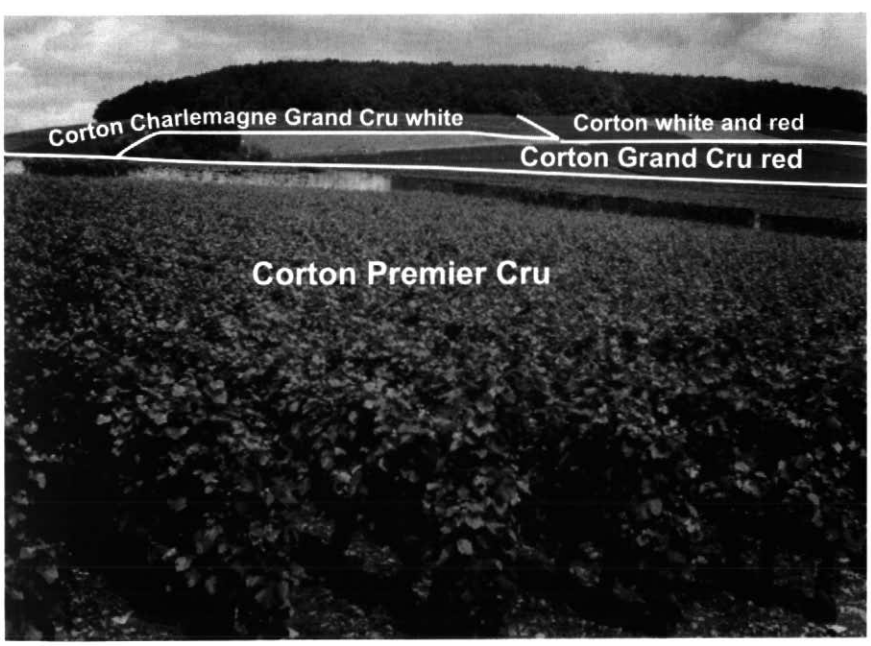

Figure 2 Hill of Corton, Côte d'Or wine-producing region of France, showing the vineyard locations for several famous wines: Corton Charlemagne Grand Cru white, Corton white and red, Corton Grand Cru red, and Corton Premier Cru. See the cover of this issue for a colour view, and Figure 1 and text for details (photo by Simon Haynes, August 1999).

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