

METHODOLOGICAL APPROACH TO ZONING

V.A. Carey¹, V. Bonnardot²

1 Department of Viticulture and Oenology, Stellenbosch University, Private Bag X1, 7602 Matieland, South Africa. vac@sun.ac.za

2 ARC-ISCW, (current address: valbon@webmail.co.za)

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An appellation or geographic indication should be based on the terroir concept in order to ensure its integrity. The delimitation of viticultural terroirs must include two consecutive or parallel steps, namely (a) the characterisation of the environment and identification of homogenous environmental units (basic terroir units, natural terroir units) taking all natural factors into account, as well as (b) the characterisation of the viticultural and oenological potential of these units over time.

Une appellation ou indication géographique doit être basée sur le concept du terroir pour assurer son intégrité. La délimitation des terroirs viticoles doit inclure deux étapes consécutives ou parallèles, en l'occurrence (a) la caractérisation de l'environnement et l'identification d'unités environnementales homogènes (unités terroir de base, unités terroir naturels) prenant en compte tout facteurs naturels, ainsi que (b) la caractérisation du potentiel vitivinicole de ces unités à travers le temps.

Introduction

The concept of appellation or denomination of origin stems from man's desire to individualise that which he produces, uses or consumes (Quittanson & Vanhoutte, 1963) and wines have been denominated by origin since old-testament times (Bertozzi, 1995). In order to be effective, labels of origin must be a guarantee of both quality and product character (Carbone, 2002). The process of "zoning" involves a multi-criteria study of the natural environment in order to choose an optimal viticultural ecosystem (Falcetti, 1994) but in the past, due to the lack of scientific evidence, delimitation has often been performed empirically, based often on obvious geographical boundaries but also strongly affected by political and/or administrative considerations. Zoning or demarcation can have significant impact on the economy of land either side of the boundary (Unwin, 1996) and in Champagne land that is AOC (appellation d'origine contrôlée) classified is 100 times the price of non-AOC land (Fanet, 2000). Demarcation may therefore be susceptible to corruption and social disruption (Unwin, 1996). To prevent this happening, it is important that the choice of criteria for the delimitation of boundaries must be true and justifiable. It is also difficult to defend an appellation of origin or geographic indication that has not been based on the terroir structure of a region and the appellation thus becomes vulnerable (Laville, 1993). Stern & Léger (2000) suggest that in order for a geographic indication to have any form of integrity, assuring the consumer of an effective link between the product and its place of origin, the use of terroir for delimitation of geographical indications must be enforced. Despite most people probably agreeing with this statement, the notion of terroir, probably because of the empirical nature of delimitation, has become imprecise and as a result may be used erroneously, leading to a weakening of systems of denominations of origin (Laville, 1993).

The spatial nature of zoning studies and their intrinsic reliance on the knowledge of the agricultural aptitude of the agricultural environment means that they are generally based on terroir studies. Due to the increasing popularity of the term "terroir" and the perceived added-value to the product through its use, a number of "terroir-studies" have been launched globally (*inter alia* Scienza *et al.*, 1979; Morlat, 1989; Falcetti, 1990; Laville, 1990; Lebon, 1993; Laville, 1993; Bogoni, 2000; Panont & Comolli, 2000; Carey, 2001; Vaudour, 2003).

DEFINITION OF ZONING AND TERROIR

The most succinct definition of the terroir concept is that of Seguin (1986), i.e. that a terroir is the grapevine's ecosystem. Morlat (2001) describes the viticultural terroir as indicating two distinct groups of factors, namely, natural factors (climate, soil, geology) and human factors (viticultural and oenological practices) and it is the extent to which these two groups of factors contribute to the definition of terroir that probably cause the greatest amount of argument as well as the greatest resistance to the concept by the so-called "new-world" wine producing countries. Laville (1993) suggested that it is a mistake to include human practices and plant material in the definition of terroir as these should constantly evolve as a result of continuous experimentation. Terroir units, on the other hand, should be more stable, developing or changing very slowly. It is important to note that most proposed definitions, despite their differences, have some similar foci, namely that there is an **homogenous** or **stable** group of natural factors that can be **delimited**, that these factors have a potential to produce an original or **unique** product and that this difference must be recognisable over time and there is thus a **temporal** aspect.

Laville (1993) separated the natural environmental factors and the agronomic aptitude of these factors in his biphasic definition of terroir. He defined natural terroir units as a volume of the earth's biosphere that is characterised by a stable group of values relating to topography, climate, substrate and soil. This is not dissimilar to the basic terroir unit; the smallest practical unit with a sufficient homogeneity to be considered as a functional unit of the terroir / grapevine / wine system and which only encompasses the natural environmental factors (Morlat, 2001). The terroir, on the other hand, requires grouping of these units in relation to the characteristics of the product obtained (Laville, 1993) i.e. the terroir is integrally related to its product.

METHODOLOGY FOR TERROIR IDENTIFICATION

According to Falcetti (1994), it is possible to characterise the different approaches to terroir studies by means of the complexity of the environment studied and the factors which are judged to be of fundamental importance for a given environment and thus it is possible to subdivide all approaches according to the criteria used, namely, bioclimatic, soil-related or nutritional, cultivar aptitude, computational or integrated approaches. The use of the term "integrated" assumes that the criteria of climate, soil, geology and viticultural aptitude will be incorporated within a geographical information system in order to identify and characterise viticultural terroirs (Falcetti, 1994) and appears to be the approach favoured on a meso- or microscale.

Because the concept of the terroir relies on the intrinsic agronomic potential of the environment and is thus inseparable from the characteristics and "identity" of the final agricultural product, all studies to delimit terroirs will include two stages; firstly the mapping of pertinent environmental features in order to obtain relatively homogenous environmental units and secondly a study of the reaction of the crop to these delimited units (Morlat, 2001, Vaudour, 2003). The selection of a study method to identify terroirs is, however, a delicate operation, and the main difficulties of the approach lie in the large scale temporal and spatial variation of a number of components of the terroir system, the large number of variables involved and the complexity of the chain of factors determining the quality and the character of wines (Riou, Morlat & Asselin, 1995). It is important that a criterion selected for viticultural zoning of terroirs is pertinent with respect to grapevine physiology, has a compatible spatial variability and is easily acquired in the field (Riou *et al.*, 1995).

Characterisation of the natural environment: The environmental variables that must be considered include those of climate (rainfall, air temperature, soil temperature, direction and intensity of dominant winds), relief or geomorphology (slope, exposition, insolation, landscape form), substrate or geology and soil (mineralogy, compaction, granulometry, soil water reserve, depth, colour) (Laville, 1993).

Soil and geology: Widely varying methodology can be used to study the soil, notably its chemical and physical characteristics, its geological origin and its pedogenesis (Falcetti, 1994). It appears from numerous studies that the soil water supply to the grapevine is one of the most important variables affecting the functioning of the grapevine and thus berry composition and wine character and quality (Rankine *et al.*, 1971; Saayman, 1977; Saayman & Kleynhans, 1978; Seguin, 1986; Morlat *et al.*,

1992; Panont & Comolli, 2000; Choné *et al.*, 2001; Van Leeuwen *et al.*, 2003) and this has formed the basis of more complex methodology for terroir identification and characterisation (Morlat, 2001, Vaudour, 2004). The general outcome of these soil studies is a map of soil-landscape units, soil types or of chemical or physical soil characteristics and as such they often form one of the first steps of an integrated study of terroir characteristics.

Climate: There are generally three scales at which climate is described and these are related to differences in the scales of area (or surface) and time. The macroclimate describes the climate of a region, extending over hundreds of kilometres (e.g. the South Western Cape) and is studied over a long time-period (usually 30 years or more), using annual, seasonal or monthly data. The macroclimate is influenced by the geographic location (latitude) and proximity to large, climate-moderating bodies of water. Various indices, combining various climatic components (mainly temperature, be it minimum, maximum or mean, but also rainfall, humidity, sunshine duration etc.), may be used to describe the viticultural potential of a macro-region (*inter alia* Branas *et al.*, 1946; Constantinescu, 1967; Winkler *et al.*, 1974; Smart & Dry, 1980; Huglin, 1986; Gladstones, 1992; De Villiers *et al.*, 1996; Tonietto, 1999. Some use monthly data or daily data only, while others are a combination of different scales (daily with monthly data). They are usually summed for different periods of time (growth season or whole year), but can also use a single month. They are established for a specific country or region, and then may be adapted to other regions or used for a systematic global classification of the climate. The mesoclimate describes the climate within smaller areas, extending from less than a hectometer to many kilometres (e.g. vineyards or districts) and over shorter periods of time (using hourly data). It is influenced by the topographic factors of elevation or altitude, slope inclination and aspect, and proximity to bodies of water. For instance, we can notice the sea breeze influence in the vineyards of the Western Cape of South Africa (Bonnardot, 1999; Carey & Bonnardot, 2004). The microclimate is the climate immediately within or surrounding a plant canopy and differences occur within a few metres/centimetres and minutes or seconds. It is influenced by the growth vigour of the grapevine and cultural practices (canopy management, row orientation, row spacing etc.). The scale at which climate is monitored depends on the study aims. In case of terroir studies, the most appropriate scale is the meso-scale. These climatic descriptions are dependent on the presence of an automatic weather station network.

However, for maritime wine-regions, such as the extreme south west of South Africa, the maritime influence, the sea breeze and its implications for the region are notoriously difficult to identify by means of surface data (Bonnardot, 2002) and the use of a meso-scale atmospheric model, for example the Regional Atmospheric Modelling System (RAMS, the non hydrostatic, paralleled and 4.3 version) (Pielke *et al.*, 1992), proves itself to be necessary to explore the sea breeze induced patterns (Bonnardot *et al.*, 2002). It takes the large-scale weather conditions, land cover, soil data, sea surface temperature and topography into account and also gives an adequate and continuous interpolation of climatic data, which could also be of interest in regions with poor climate monitoring. Simulations have been performed over the Western Cape in order to draw a "limit" of the sea breeze or at least to assess the "limit" of its influence in view of the zoning of terroirs for wine production (Carey, Bonnardot & Knight, 2003).

Topography: Topography of a region is determined to a large extent by the geological formations present, with their inherent resistance to weathering shaping the landscape (Wooldridge, 2000, 2003). Topography also determines the local climate either directly as a result of the change in the incidence of the sun's rays on the earth's surface or indirectly as a result of altered soil drainage patterns, exposure to wind and ventilation (Crowe, 1971). Climate is one of the dominant soil forming factors (De Blij, 1983) and there exists thus an inherent relationship between soil and topography (Wysocki, Schoenberger & LaGarry, 2000). Variation in drainage characteristics of the landscape can be defined with the aid of terrain morphology (Kruger, 1973).

The use of digital elevation models in a geographic information system allows one to model topographic characteristics of a landscape e.g. slope shape, slope inclination, elevation, slope aspect.

Identification of natural terroir units: Environmental parameters can be combined to predict homogenous environmental units by means of intersection of data layers (Carey, 2001), principal

component analysis and clustering (Laville, 1990, 1993; Vaudour *et al.*, 1998a, b, 2002) or fuzzy clustering (Liu & Samal, 2002).

Determination of the agricultural aptitude of the natural environment: Many studies have focussed on the adaptation of various cultivars to their growing environment through the evaluation of their viticultural aptitude and the resulting wine style and / or quality (Rankine *et al.*, 1971, Guinard & Cliff, 1987, McCloskey Arrhenius & Sylvan, 1996; Hoppmann & Schaller, 2000, Conradie *et al.*, 2002; Tesic *et al.*, 2002 a, b). The research team at Agro-Montpellier focus their terroir research on the whole plant-berry approach (Deloire *et al.*, 2001), suggesting that it is justified for situations where soil and / or climatic data are not easily accessible at vineyard level as it integrates the environmental context of the grapevine. These studies, although focussed on an increased understanding of the physiology of the grapevine to provide advice on viticultural practices and winemaking techniques and to assist in harvest planning by a cooperative cellar, would be of value for zoning. The agricultural aptitude of the environment includes both above and below ground conditions and a study of the grapevine's reaction should reflect as many aspects of its functioning as possible. These include, *inter alia*, root distribution, ratio between thick and fine roots, grapevine phenology (Barbeau, Asselin & Morlat, 1998), canopy development and quality, plant water relationships, photosynthesis, berry growth, yield, dynamics of ripening and berry composition.

The influence of the environment on the functioning of the grapevine should be reflected in the wine characteristics and vinification on a microscale or semi-commercial scale, if possible, is a necessity for zoning studies. Sensory evaluation of wines is a science on its own and will not be dealt with in further detail in this paper, excepting to mention that descriptive analysis as well as discriminatory tests should be used.

Statistical analyses: Studies of the reaction of the grapevine to its immediate environment result in punctual data of a widely diverse nature. In order for this information to be of use within zoning studies it must be placed within the context of the pertinent terroir in order to provide a spatial result (Vaudour, 2000, 2001). Probably one of the most difficult tasks within a zoning study is the relation of the viticultural and oenological data to the environmental data. It is necessary to determine a hierarchy for the environment factors with respect to their relevance to viticulture in the region as well as to determine rules that may be used for spatialisation of the results. Traditional analyses of variance are difficult to use as it is difficult to lay out a trial with statistically correct repetitions and the inclusion of a number of vintages results in time scale data. Factor, principal component and discriminant analyses have traditionally been used but these merely indicate an underlying structure to the data. Furthermore, any missing data, of which there may be many when working in commercial vineyards, results in the loss of the full row of data for the analysis. Classification and regression tree analyses (Breimann *et al.*, 1984) may, however, overcome these limitations. These types of analyses result in if-then arguments and it is possible to determine the relative importance of each independent variable with respect to each dependent variable.

CONCLUSIONS

Despite labelling by origin being practiced since Old Testament times and the ancient knowledge that origin affects wine style and quality, the zoning of homogenous areas for production of wines with unique characteristics has only recently formed a scientific research focus with a multitude of methods and varying degrees of completeness. Consensus must yet be reached as to the definition of "terroir" and a standardised method for the delimitation of terroirs. Although the EU and TRIPS agreements have encouraged the formation of geographical indications or appellation systems in many countries, the lack of consistency undermines the concept as a whole and may lead to the disenchantment of the consumer. It is important, especially within the higher price brackets, to maintain integrity in labelling by origin, an integrity which can only be provided if the terroir concept is used as a basis for delimitation.

The methods used to identify viticultural terroirs are numerous and divergent and few have been tested in more than one region and it is, therefore difficult to identify a specific dominant methodology, although the integrated method appears to be the most comprehensive. It is clear, however, that it is important in a study to delimit viticultural terroirs, that all pertinent environmental factors are

considered, that these environmental factors may vary slightly from region to region, but that rooting depth and soil water holding capacity are dominant, and that every terroir study based on the integrated method includes two consecutive or parallel steps, namely (a) the characterisation of the environment and identification of homogenous environmental units (basic terroir units, natural terroir units) taking all natural factors into account, as well as (b) the characterisation of the viticultural and oenological potential of these units over time.

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