AN OVERVIEW OF GEOLOGICAL INFLUENCES ON SOUTH AFRICAN VINEYARDS

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Abstract
The role of soils and bedrock geology has long been acknowledged as a fundamental component of terroir. In South Africa the influence of geology is misunderstood and some important geological components will be highlighted in this paper.

In South Africa's Coastal Region the oldest rocks comprise the Late Proterozoic – Cambrian shaley sediments of the Malmesbury Group, and the Cambrian age granitic intrusives of the Cape Granite Suite. Locally these are overlain by sediments of the Klipheuwel Group. These units are unconformably overlain the Middle Ordovician–Early Carboniferous Cape Supergroup, whose basal portion comprises the sandstones of the Table Mountain Group which produce the dramatic mountain scenery of the area.

The Breede River Region covers the valley of the Breede River, to the east of the Coastal Region. The Worcester fault is the major feature defining the geology of this area. To the east of the fault the geology is essentially similar to the Coastal Region. To the west the upper portions of the Cape Supergroup, the Bokkeveld and Witteberg Groups, are present comprising sandstone and shaley sediments. Late Carboniferous–Permian age sediments of the Karoo Supergroup overly the Cape Supergroup and Upper Jurassic-Early Cretaceous sediments of the Uitenhage Group are preserved locally as unconformable remnants.

The following geological features are important for the Coastal Regions vineyards. Soils are often acidic and potassium rich, whilst granites weather to produce both saprolites and kaolin, which are possibly unique in terms of vineyard soils. River gravels are noted in two scenarios, firstly vineyards are planted in river floodplains and secondly fossil gravel terraces exist above the current river level.

In the Breede River Region river gravels are important whilst a significant portion of vineyards are planted on loam soils containing calcareous layers. These calcareous layers are formed as a result of excess evaporation over precipitation in this low rainfall region. A geological control may exist for the formation of these calcareous layers above specific bedrock strata. These soils are unique in the South African context, as they are naturally alkaline.

In addition topography resulting from differential weathering of the geological units is significant in the local terroir. Factors such as warm or cool slope orientation and the effects of altitude on mean temperatures and rainfall are important.

Le rôle des sols et de la géologie de roche en place a été longtemps reconnu comme composant fondamental de terroir. En Afrique du Sud l'influence de la géologie est mal comprise et quelques composants géologiques importants seront accentués en cet article.

Dans la région Côtière du Sud d'Africa les roches les plus anciennes comportent les sédiments argileux fin du Protérozoïque ou debut du Cambrien de la groupe de Malmesbury, et les intrusives granitiques du Cambrien de la Suite de Granit de Cap. Localement ceux-ci sont recouverts par des sédiments du groupe de Klipheuwel. Ces unités sont non conformément recouvertes mi-Ordovician au debut du Carbonifère le Cap Supergroup, dont la partie basique comporte les grès du Groupe de Table Mountain qui produisent le paysage dramatique de montagne du secteur.

La région de fleuve de Breede couvre la vallée du fleuve de Breede, à l'est de la région côtière. Le défaut de Worcester est le dispositif principal définissant la géologie de ce secteur. A l'est du défaut la géologie est essentiellement semblable à la région Côtière. À l'ouest se trouvent les parties supérieures du Cap Supergroup, les groupes de Bokkeveld et de Witteberg, comportant le grès et les sédiments argileux. Des sédiments de la fin du Carbonifère -Permian du Karoo Supergroup recouvrent le Cap Supergroup et les sédiments fin du Jurassiques- debut du Crétacés du Groupe d'Uitenhage sont préservés localement en tant que restes incompatibles.

Les dispositifs géologiques suivants sont importants pour les vignes de régions Côtières. Les sols sont souvent pleins d’acides et de potassium, tandis que les granits s’alterent pour produire les saprolites et le kaolin, ce qui sont probablement uniques en termes de sols de vigne. Des graviers de fleuve sont notés dans deux scénarios, premièrement des vignes sont plantées dans des lits majeurs de fleuve et deuxièmement les terrasses fossiles de gravier existent au-dessus du niveau courant de fleuve.

Dans la région de fleuve de Breede les graviers de fleuve sont importants tandis qu'une partie significative de vignes sont plantées sur des sols de terre grasse contenant des couches calcaires. Ces couches calcaires sont formées en raison de l'évaporation excessive au-dessus de la précipitation dans cette région de précipitation basse. Une commande géologique peut exister pour la formation de ces couches calcaires au-dessus des strates spécifiques de roche en place. Ces sols sont uniques dans le contexte sud-africain, car ils sont naturellement alkalins.

En outre la topographie résultant de la desagregation différentielle des unités géologiques est significative dans le terroir local. Les facteurs tels que l'orientation chaude ou fraîche de pente et les effets de l'altitude sur les températures moyennes et des précipitations sont importants.

Introduction

The role of soils and the geology of the underlying bedrocks is an important component of ***terroir***, the French term describing the natural environment influencing the grape vine and ultimately the taste and quality of the resultant wine. This is particularly true in the “old world” wine producing countries of Europe. Possibly the best documented examples are Burgundy and Bordeaux in France, however the importance of unique geological settings has spread to the “new world”, for example the Coonawarra region of South Australia, and the Rutherford Bench in the Napa Valley of California.

Since its return to democracy South Africa has become a significant player in the worlds wine industry. The industry, based around the towns of Stellenbosch and Paarl, in the Western Cape Province, has a long tradition dating back to 1659, when the Dutch East India Company first planted European vines. South Africa’s winelands can be broadly divided into four geographical zones. These are the Coastal Region, centred on Cape Town, Stellenbosch and Paarl, the more inland Breede River Region around Worcester and Robertson, the Olifants River Region to the north of the Coastal Region, and finally the vineyards adjacent to the Orange River and its tributaries in the Northern Cape Province. As with most wine producing regions the soils and geology of the vineyards are a much discussed topic and this paper will detail some of the features which potentially make vineyards unique.

Materials and methods

For a country rich in geological heritage, surprisingly little has been written specifically on the geology of South Africa's winelands. This paper aims to provide a brief overview of the geology of South Africa's most significant vineyard areas by introducing the reader to the local geology. The geological observations are based on data compiled by the author, some of which is published in Bargmann (2003). Other publications of significance in relating the local geology to wine production are geological field trip excursion guides by Joubert *et. al*., (1997); and Minter, (1998), whilst Wooldridge, (2000, 2003), details various aspects of geology affecting South African vineyards. The geological framework of the wine producing areas is described by Theron *et. al*., (1992) and Gresse and Theron, (1992) in the explanations for the Cape Town and Worcester 1:250 000 geological map sheets.

Geology, soils and topography, all essential elements of terroir, are inevitably interlinked. This paper will not focus specifically on the role of soils or topography, however some important observations will be highlighted here prior to discussing the geology in more detail. Three main types of vineyard soil are important. Firstly the residual and colluvial soils that are produced as a direct result of the weathering and chemical breakdown of the local bedrock. Here there is a direct association between the soil and the geology. In the Western Cape stable geological conditions have existed for the last 65 million years resulting in well developed residual soils of considerable antiquity. Secondly there are significant areas of alluvial soils, deposited by the action of water - predominantly by rivers. Alluvial soil characteristics can vary widely and be sourced from a variety of geological formations. These soils are significant in the Berg, Breede and Olifants river valleys. Finally aeolian soils deposited by wind action are present. These soils are typically sandy in nature.

In terms of topography the role of the sandstones of the Table Mountain Group is significant. The resistant nature of these sandstones results in the presence of the prominent mountain ridges and these topographic features directly impact on climate modifying factors such as vineyard altitude, warm or cool slope orientations and increased precipitation.

The most significant South African wine areas from the point of view of the geology are the Coastal and Breede River regions, which will be discussed in more detail below. The general geological setting will be described along with some observations on possible effects on vines.

Results and Discussion

- The Coastal Region

The Coastal Region occupies the coastal plain between the Atlantic Ocean in the west and the north-south trending mountain ridges, such as the Hottentots–Holland and the Stellenboschberg, in the east. The oldest geological units present are the Malmesbury Group, which were deposited 950–550 million years ago during the Late Proterozoic and Cambrian. These largely shaley rocks were deposited under marine conditions in an ancient ocean bordering a landmass known as the Kalahari craton (Gresse and Scheepers, 1993, Rozendaal *et. al*., 1999). Subsequently, during the Cambrian period, continental collision occurred and volcanic activity took place, which is marked by the presence of the 550–510 million year old granites of the Cape Granite Suite. These granites have a significant role as the parent geology of many Stellenbosch and Paarl vineyards. On a local scale tin tungsten deposits are present within these granites notably in the Bottelary area. Also during the Cambrian period the 540–522 million year old sediments of the Klipheuwel Group were deposited as a result of uplift and erosion of the local landmass. The Klipheuwel consists largely of conglomerates and shales and are a feature in the area between Paarl, the Simonsberg Mountain and Franschhoek. (Belcher and Kisters, 2003, Kisters *et. al*., 2002)

A period of erosion followed lasting until 450 million years ago when the Ordovician to Devonian age quartzitic sandstones of the Table Mountain Group were deposited in a shallow sea. These form the basal formation of the Cape Supergroup. A well developed unconformity marks their base where they rest on the older shales or granites. This unconformity is well exposed on the Cape Peninsula. The 440 million year old, late Ordovician glacial deposits, comprising tillite and shales of the Pakhuis and Cederberg Formations, mark the only variation to this sandstone dominated sequence. A later period of continental collision 250 million years ago, resulted in the formation of the Cape Fold Belt which produces much of the dramatic mountain scenery of the modern Western Cape (Bargmann, 2003, Theron *et. al.,* 1992).

The final phase of the geological history of the Coastal Region is marked by erosion for the last 65 million years which has produced the residual soil horizons and river gravels seen today. The most desirable soils are clay rich loams, an important factor as this allows for water to be retained for plant use during the dry summer months. Two scenarios of river gravels are present, firstly the modern river floodplains of the Berg and Eerste rivers, and secondly through the presence of ancient gravel terraces above the current river level, which are noted in the Eerste River west of Stellenbosch (Bargmann, 2003, Söhnge, 1991).

A feature of the Coastal Region is the acidic and potassium rich soils derived from the weathering of the granites. Weathering of granite also produces other specific characteristics. The first of these is the presence of large amounts of the clay kaolin. Significant accumulations of kaolin are recorded near Stellenbosch and Cape Town and are possibly unique in terms of vineyard soils (Bargmann, 2003, Heckroodt, 1992). On the Cape Peninsula rehabilitation of the Serina Kaolin mine at Fishhoek has included the establishment of vineyards and represents a good example of the direct role geology can have in vineyards. The second feature is weathering of granite bedrock to produce saprolites below the soil profile. In simple terms saprolites represent a stage of chemical weathering whereby the granite bedrock has not completed the transition from rock to becoming a soil horizon.

The predominantly shaley Malmesbury Group rocks are also noted for their acidic and potassium rich soils. The presence of hornfels from contact metamorphism by the plutons of the Cape Granite Suite is also significant. Hornfelsed Malmesbury sediments result in the formation of resistant hills in areas such as Durbanville and Bottelary. Also of significance from the terroir point of view are the occasional areas of limestones within the Malmesbury group, particularly near Riebeek Kasteel and Piketberg, with potential for alkaline rather than acidic soils (Belcher and Kisters, 2003).

- The Breede River Region

The Breede River Region covers the intermountain valley of the Breede River and includes the towns of Worcester, Robertson and on geographical and geological grounds the Tulbagh Region. (Tulbagh is included in the Coastal Region under countries Wine of Origin legislation). The mountainous Overberg Region will also be discussed here as it shares similar geology to the Breede River Region.

A major geological fault, the Worcester fault, is the most significant feature defining the geology of the Breede River Region. This fault system has a total displacement of up to 6 km and is still active, as the Tulbagh earthquake of 1969 testifies (Gresse and Theron, 1992). On the eastern side of the fault the geology is the same as the Coastal Region. However on the western side the 400–340 million year old, Devonian age, marine sandstones and shales of the Bokkeveld and Witteberg Groups are present. These form the upper units of the Cape Supergroup and overlie the Table Mountain Group. The Bokkeveld and Witteberg groups are developed between Worcester and Bonnivale in the Breede River Valley and in the Overberg Region at Elgin and the Hamel en Aarde valley. Overlying these sediments are the 300–275 million year old Carboniferous to Permian age sediments of the Karoo, comprising the Dwyka tillite and the shales Ecca Group. The Dwyka tillite was deposited during the last major glaciation to affect southern Africa (Gresse and Theron, 1992). Subsequently the area was subjected to the folding of the Cape Fold Belt as mentioned above, and finally in response to fault movements as the Atlantic began to open 140 million years ago, the Jurassic age Enon conglomerate was deposited (Gresse and Theron, 1992). The current preservation of the Karoo and Enon sediments is specific to small portions of the Breede River Valley, notably the Nuy, Vinkriver and Ashton/Bonnivale areas, however there presence has a significant impact on viticulture.

Three geological scenarios are noted for vineyards located in the Breede River Valley. Traditionally vineyards were planted in the flood plains of the Breede River and its tributaries. As the region is predominantly low rainfall, access to irrigation water is important. As the region has moved towards quality grape production a significant portion of vineyards are now being planted on non alluvial loam soils containing calcareous layers. These are located further away from the river in areas where the Bokkeveld, Witteberg, Dwyka groups and Enon Formation occur as the bedrock (Pienaar, undated). The calcareous layers are formed as a result of excess evaporation over precipitation in this low rainfall region. These soils are unique in the South African context as they represent the only naturally alkaline vineyard soils developed on a significant scale. The final geological scenario for vineyards are higher lying residual soils derived from shales which can be Malmesbury, Bokkeveld or

Witteberg in age. These soils are similar to those in the Coastal Region as they do not contain the calcareous layers.

Conclusions

The descriptions above provide a brief overview of the geological features of South Africa's Coastal and Breede River wine regions. Summarised below are aspects of the local geology, which the author believes may prove to be significant factors in the terroir of South Africa's wine regions.

Areas of granite bedrock are affected by the presence of acidic soils however these soils are also clay rich in nature and have a good water retention capability. The presence of kaolin and saprolites has been highlighted and their role in vineyards should be defined.

The Malmesbury Group again has soils that are acidic and clay rich nature with good water retention capability. Contact metamorphism to produce hornfels, and rare limestone units have important local effects on topography and soil acidity.

The Table Mountain Group with its resistant sandstones has a major influence on topography. Soils are acidic, and sandy in nature and as such are rarely used for vines. The exception within the Table Mountain Group are the glacial shales of the Cederberg Formation which are now being exploited for vineyards.

The Breede River Region contrasts with the Coastal Region through the presence of significant alluvial soils and characteristic calcareous loam soils. These calcareous soils are associated with Bokkeveld and Witteberg shales, Dwyka tillite and Enon conglomerate. This represents the only South African wine area with significant alkaline soils.

Topography and slope orientation is an important geologically related area and a significant component of terroir in its own right. Geology is fundamental in producing the landforms seen in South African vineyards through the presence of bedrocks with differing resistance to weathering. Climate modifying factors such as vineyard altitude, warm or cool slope aspects and orientation towards prevailing wind directions have become important to local viticulturists, in addition increased precipitation results from the presence of the mountains.

Literature cited

Bargmann, C. J., 2003. Geology and Wine 7. Geology and wine production in the Coastal Region, Western Cape Province, South Africa. Geoscience Canada 30, 4, 161–182.

Belcher, R. W., and Kisters, A. F. M., 2003. Lithostratigraphic correlations in the western branch of the Pan-African Saldania belt, South Africa: the Malmesbury Group revisited. South African Journal of Geology 106, 327–342.

Gresse, P. G., and Theron, J. N., 1992. The geology of the Worcester area, explanation of sheet 3319. Geological Survey of South Africa, Pretoria.

Gresse, P. G., and Scheepers, R., 1993. Neoproterozoic to Cambrian (Namibian) rocks of South Africa: a geochronological and geotectonic review. Journal of African Earth Sciences 16, 375-393.

Heckroodt, R. O., 1992. Kaolin Resources of the Republic of South Africa. Handbook of the Geological Survey of South Africa, 13, Pretoria.

Joubert, P., Toerien, W., Fey, M. V., and Minter, W. E. L. M., 1997. Geology of the Cape Winelands. Guidebook, 6th International Conference on Fluvial Sedimentology, University of Cape Town, South Africa.

Kisters, A. F. M., Belcher, R. W., Armstrong, R. A., Scheepers, R., Rozendaal, A., and Jordaan, L. S., 2002. Timing and kinematics of the Colenso Fault: The early Palaeozoic shift from collisional to extensional tectonics in the Pan-African Saldania Belt, South Africa. South African Journal of Geology 105, 257-270.

Minter, W. E. L. M., 1998 (ed). Geology of the Cape Winelands. International Volcanological Congress, Cape Town, Field Excursion B3, Guide Book.

Pienaar, J., (undated). Introduction to the wine growing regions of South Africa. KWV, Stellenbosch.

Rozendaal, A., Gresse, P. G., Scheepers, R., Le Roux, J. P., 1999. Neoproterozoic to Early Cambrian crustal evolution of the Pan-African Saldania belt, South Africa. Precambrian Research 97, 303-323.

Söhnge, A. P. G., 1991. Alluvial history of the Eerste River, Stellenbosch. South African Journal of Geology 94, 299-312.

Theron, J. N., Gresse P. G., Siegfried H. P., and Rodgers J., 1992. The geology of the Cape Town area, explanation of sheet 3318. Geological Survey of South Africa, Pretoria.

Wooldridge, J., 2000. Geology: A central aspect of terroir. Wineland, December, 87-90.

Wooldridge, J., 2003. Geology and terroir in the Western cape winelands. Wynboer December, http://www.wynboer.co.za/recentarticles/1203geology.php3