The geodiversity of the Ligurian vineyards as a tool to protect the territory

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Introduction

"The annual revenue of the italian agro-food sector is about 37 billion euros per year. The most important analyst of the sector recently estimated in about 50-60 billion dollars the value of the annual trade of illegally counterfeited products passed off as Italian"1.

Among the agri-food products it is necessary to distinguish between those for the food industry and those intimately linked and deeply rooted with the territory. The last ones, including the wines, and are those that better comply with our project aimed to determine the peculiar geo-pedological features that could represent the fingerprint of high-quality and guaranteed agri-food products. In particular as outlined by Dougherty (2012) "wine is undoubtedly the agricultural product that best mirrors the environmental, social, and economic conditions under which the grapes grow".

The geo-pedological characterization of vineyards represent a good tool for the development and the promotion of terroir2. The idea originates from the concept of pedogenesis, i.e. the set of processes which progressively converts the parent rocks (bedrocks) to soils; during these processes the soil inherits unique features resulting from the interaction of a number of factors including the mineralogy and chemistry of the bedrock, the geographic location, the climate, the geomorphological context, the biological activity.

Several questions have been at the base of our project: if soil has unique characteristics then has the agricultural product inherited specific peculiarities? What are the main geo-pedological features of the best terroir? Is it possible to correlate the geological and physico-chemical characteristics of soils to the organoleptic properties of the product? Based on these assumptions our research focused on the importance of geodiversity on the quality of ligurian DOC wines by comparing, thanks to the collaboration with Associazione Italiana Sommelier (AIS), the geo-pedological features of vineyards with the organoleptic characteristics of Liguria's most significant wines.

Analytical methods

Sixty soil samples and a variable number of outcropping rocks were collected for each selected vineyard. Each sampling point was geo-referenced using a global positioning system (GPS) and mapped using open source geographical information systems softwares (QGIS and GRASS).

About 1 kg of soil were collected with hand soil auger and sieved in situ to remove the fraction > 2cm. Several aliquots for granulometric, minero-petrographical and chemical analyses were obtained by quarting. Soil color were determined in situ and in laboratory (on dry samples) by comparison with Munsell Soil Color Charts.

The chemical composition of soils were determined by means of Field Portable X-ray Fluorescence Spectrometer (FP-EDXRF) X-MET7500 Analyser (Oxford Instruments) on the granulometric fraction < 2mm. At the used analytical conditions3 quantitative analyses were obtained from trace level (ppm) to 100% for elements with atomic number ≥ 12 (Mg). Selected samples were also analyzed by ICP-MS4 and ICP-AES for calibration purpose.

Minero-petrographical analyses were assessed by polarized light optical microscopy and scanning electron microscopy (SEM) and microanalysis (EDS)

Soil pH, Eh, and electrical conductivity (EC) were measured using the e WTW 340i e WTW PH 330i handheld meters equipped with the Sen Tix41" e Sen Tix ORP electrodes.

Finally, agronomic soil analyses were performed at the "regional laboratory for soil analysis" located in Sarzana (La Spezia).

The results were inserted in the GIS database and used either to produce contour maps for the evaluation of the spatial distribution of selected chemical elements, minerals and environmental parameters. Selected results can be reported in illustrative brochures as well as retrieved from the Geospectra s.r.l. website using a QR-code or a NFC Tag.

Ligurian's vineyards

The methodology described above was applied to selected Ligurian DOC vineyards aiming to determine the geological variability and its relationship with agricultural soils. As reported in figure 3, Liguria has eight DOC appellations corresponding to the excellence of the regional wine production and located in geographical areas (Fig. 1) characterized by high geodiversity (Fig.2). The eight ligurian DOC appellations are: Rossese di Dolceacqua or Dolceacqua, Pornassio or Ormeasco di Pornassio, Riviera Ligure di Ponente, Val Polcevera, Golfo del Tigullio, Colline di Levanto, Cinque Terre and Cinque Terre Sciacchetrà, Colli di Luni.

Most all of the Ligurian vineyards occurs in terraced landscapes. The terraces were built by several generation of peasant-farmers using dry stone walls. This fatiguing collective work progressively modified the slope profile to obtain optimal conditions in terms of exposition, drainage and wind exposure as well as slope stability. The terraced systems adapt themselves to the local peculiarities that derive from geomorphological diversities, as it is possible to observe in the structures of the walls (from Finale stone-blocks in Finale Ligure to the subtle slate slabs near Lavagna), in the cultural forms of vineyards (from traditional low pergola in the Cinqueterre, to the trees of Rossese in Dolceacqua) in the drainage and irrigation systems (see the water retention system in the Romaggi site or the "beodi" -little channels- around Sanremo). The soil within terraces is an "artificial soil" which is not always indigenous because it could be sometimes transported to the terraces, although from the adjoining areas. It can thus contain elements which are extraneous and not related to the geological substrate. For this reasons soil analyses should include the determination of the mineralogy and chemistry to evidence the presence of strict relationships with the geological features of the area. This approach is also necessary to deal with several issues, including the interactions between soils and grapes, and to define the geological and geographical peculiarities of an area that are not "outsourceable".

Soil and organoleptic properties

Although several scientific researchers5 pointed out the lack of correlations between the chemical composition of soils and the organoleptic properties of wines (such as visual aspect, fragrance and flavor) it is still necessary to understand the complex interactions between soil properties and vine growth to know the underlying reasons behind a high quality wine. For example, some vine variety give rise to great wines only in some restricted geographical areas (such as the case of Rossese di Dolceacqua). On the other hand, within a single grape variety there are significant differences from one region to another region because the wines acquire taste and other peculiar organoleptic properties which are strictly related to the local geography. Examples are the significant differences between the Ormeasco di Pornassio and the Dolcetto of the Piedmont Region and the different wines obtained by the Moscato grape variety that in the coastal zone of Taggia (Liguria) give rise to a dry wine (Moscatello di Taggia) that is extremely different from those produced in the more continental locations of the Piedmont region. In the wine scents, the "minerality" cannot be directly related to the soil, but the peculiar "sapid" taste of Ligurian wines is certainly typical of the terroir. It is very complex to understand what is relevant to determine the identity of a wine that can be tied to its territory: many different components are involved (among them the style to produce the wine and the way to let it age are significant, together with the wine grapes and the characters of the vineyard). This study wants to deepen the knowledge of soils in Ligurian vineyards, as important element to define the terroir.

Preliminary results: the case study of the Moscatello di Taggia

The "Moscatello di Taggia" was a famous sweet dessert wine (made with withered grapes) that, together with Sciacchetrà from Cinqueterre, was exported on the nobles' tables of all Europe in the XVI and XVII centuries. The wine grape has actually been recovered, thank's to the work of the Producers' Association: it is a local adaptation of piedmontese white muscat, that is able to offer dry and sweet wines in the Ligurian terroir, with characteristic floral scents, due to the terpenes of the aromatic grapes, with vegetal notes, remembering herbs. The flavor is touched by acidity and sapid verve, that balance with sweetness in the dessert versions, with complex aromas and pleasant taste softness. The Moscatello di Taggia is produced from vineyards occurring within different lithotypes (Fig. 3) of the Cretaceous San Remo - Monte Saccarello Tectonic Unit (Giammarino et al., 2010). The lithotypes belong to the following three main Formations: 1) San Remo Flysch Formation (fine-grained carbonatic turbidites), 2) Bordighera Sandstones Formation (coarse-grained siliciclastic turbidites), and 3) San Bartolomeo Formation (fine- grained silty basin plain turbidites). The investigated vineyard soils vary in granulometry from gravelly- muddy sand to sandy-mud and are characterized by neutral to slightly-alkaline pH which are suitable for grape development. The mineralogy is fairly homogeneous although systematic variation occurs due to local variation of the bedrock types (from arenaceous-, to carbonate-, to marly-, to argillitic-rocks). Quartz is by far the most important mineral in all the analyzed soils except for those occurring in correspondence of marly or calcareous bedrocks where calcite and clay minerals become predominant. Among the others significant minerals, Fe-oxides and -oxyhydroxides, feldspar, micas (muscovite and subordinate biotite), illite-sericite, apatite, and chlorite are always present in concentrations varying from 0.1 to 15 wt%. The most common accessory mineral is invariably zircon. The soil chemistry (Table 1) provides adequate conditions for Vitis vinifera cultivation (Sbaraglia & Lucci, 1994; Table 2). In fact, they are rich in essential macro- and micro-elements (Table 1 and 2) and most of the critical trace elements are below the toxicity limit. Moreover, all soil samples are rich in assimilable phosphorous (34- 109 mg/kg), nitrogen (1-1.5 mg/kg), and exchangable potassium (120-217 mg/kg).

The soil chemistry well agrees with the mineralogical and chemical composition of the rocks cropping out in the surrounding areas. In particular Ca, Ba, and Sr are directly correlated to areas with outcropping limestones, marls, and marly-sandstones, whereas K and Al are higher in areas with predominant argillitic rocks. Finally the high Zr concentrations well agree with the diffuse presence of zircon both in outcropping rocks and in the skeleton of the derived soils. Primary oxides and authigenic Fe-oxydes and -oxyhidroxides account for the high Fe content as well as for several trace elements (such as Zn and Co), whereas at least a part of S, Cu, and Pb can be attributed to anthropogenic origin.

Mineralogical and chemical results evidence the close relationships between the vineyard soils and the rocks cropping out in the studied area confirming that all terraced soils are strictly of local origin. Therefore, they clearly represent a geographical fingerpint which should be taken into account and valued as a specific element of the Moscatello di Taggia's terroir.

Conclusions

These preliminary results evidence the peculiarity of the Moscatello di Taggia vineyard soils. Although still to be completed, these results were confirmed also for the other investigated DOC's vineyard of the Liguria region (more than 60 samples from various geological and geographical contexts). The results are encouraging, and together with the other geographical and geological components of the territory they might be used as markers to demonstrate the uniqueness of high-quality wines as well as of other agricultural products. The uniqueness of geological and geographical settings together with the peculiar historical and cultural features might be a powerful tool for territorial marketing and enhancement of the territory. This complete set of information was recently included for the first time in the "Geological Label of the Product®" in a DOC wine from Cinqueterre (eastern Liguria); they can be retrieved quickly and easily from the Geospectra s.r.l. website (http://www.geospectra.it) using a QR-code or a NFC Tag.

The Geological Label of the Product® is a voluntary label which is neither complementary nor alternative to the mandatory certification provided by law.

Geological Label of the Product® might trigger a virtuous chain of cooperation among producers, It is designed to promote both high quality agricultural products and their territory thus representing an added value for the producer and a growth vector for regional and local development. It can represents also a further guarantee for the consumer which can perceive the intrinsic value of a specific product in terms of territorial uniqueness. We hope that the distributors, restaurateurs and consumers aimed to the enhancement of the product in terms of quality and uniqueness, the last representing a pivot quality for the development of terroir.

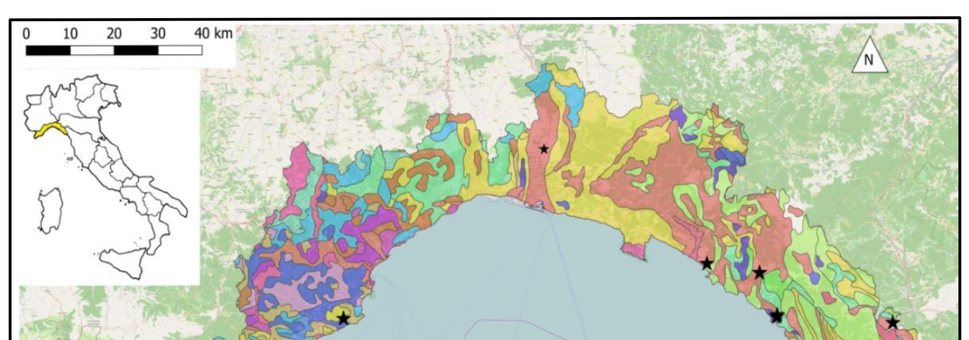

Fig. 1 - Geographical distribution of DOC appellation in Liguria. Black stars indicate the sampling points. From" Disciplinare di produzione della denominazione di origine controllata". Base map from http://www.openstreetmap.org/copyright

Fig. 2 – Simplified Geological map of Liguria. Black stars indicate the sampling points. Base map from http://www.openstreetmap.org/copyright

Photo 1 - Rossese's Vineyards (Dolceacqua, Imperia)

Photo 2 - In situ In situ chemical analyses with FP EDXRF

Photo 3 - Bunch of grape in Moscatello di Taggia vineyard (photograph by A. Carassale)

Fig. 5 – Microphotograps of the different lithotypes in the Rossese's, 5 Terre's, and Moscatello di Taggia's vineyards (Polarized Light Microscopy, Crossed Polars): left) fine grained lithic arenite with quartz, feldspar, muscovite along with siliciclastic matrix and carbonate cement (Rossese's vineyard); center (quartzitic calcarenite with calcite veins from Moscatello's vineyard; right) coarse-grained quartz arenite with siliciclastic matrix from 5 Terre' vineyard. Symbols within photographs as in Fig. 6

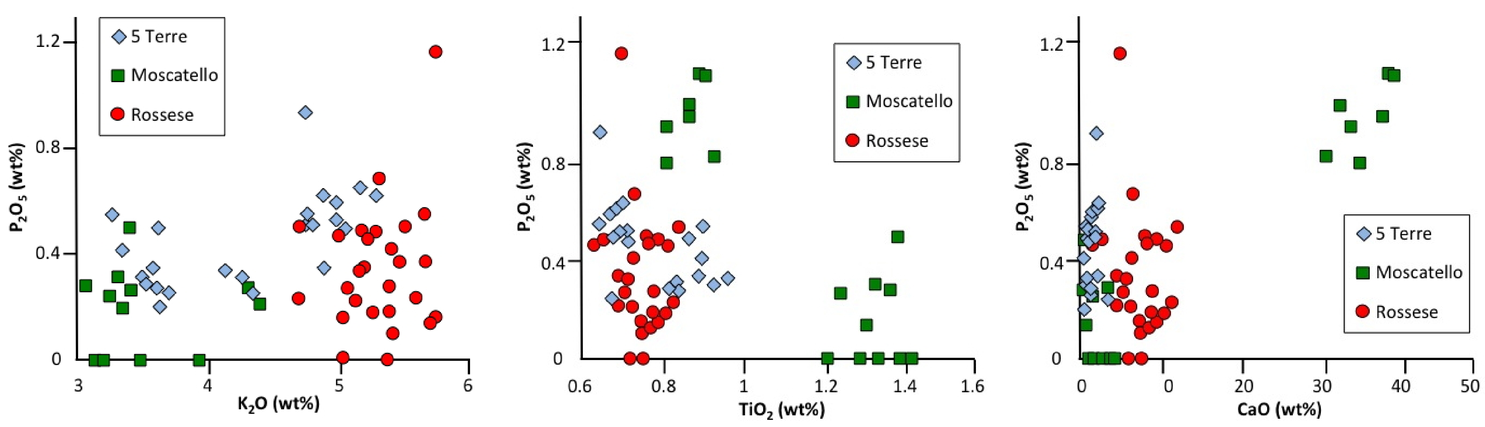

Fig. 6 – Although Rossese's, 5 Terre's, and Moscatello di Taggia's vineyards occur in similar geological contexts (i.e. flyschoid rocks lithologically variable from arenites to marles to siltites) significant chemical differences can be observed allowing to distinguish peculiar geochemical signatures, sometimes even in nearby vineyards of the same grape variety.

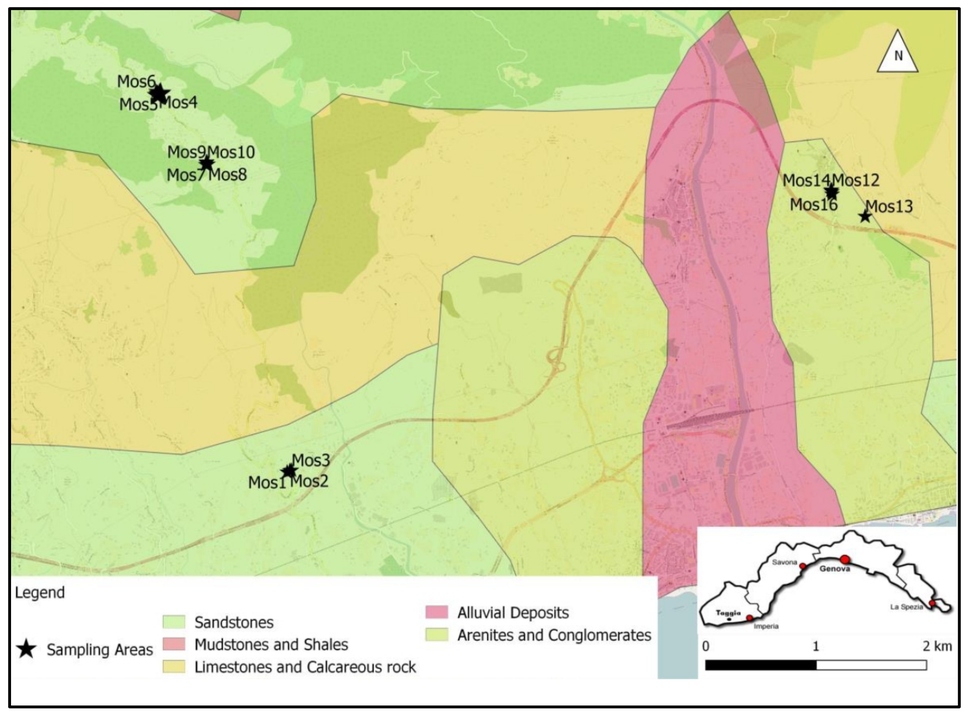

Fig. 3 – Sampling areas for the Moscatello di Taggia's vineyards. Base map from http://www.openstreetmap.org/copyright

Fig. 4 – The Geological Label of the Product® is a voluntary label designed to promote both high quality agricultural products and their territory thus representing an added value for the producer and a growth vector for regional and local development