

Geopedological and climatic zoning of northern Malaga vineyards region: Fuente de Piedra, Humilladero and Mollina (southern Spain)

Zonage géopédologique et climatique des vignobles du Nord de Malaga: Fuente de Piedra, Humilladero et Mollina (Sud d'Espagne)

Patricia PANEQUE*, Consuelo Paloma OSTA, Celia ESPINO, Guillermo PANEQUE

Dpto de Cristalografía, Mineralogía y Química Agrícola. Universidad de Sevilla. c/ Profesor García González 1. 41012 Seville. Spain

*Corresponding author: pipaneque@us.es

Summary

The vineyards placed in the municipal areas of Fuente de Piedra, Humilladero and Mollina constitute a wine-growing important area of the "Zona Norte" of the province of Málaga. Its products are protected by the Regulatory Council of the Origin Denomination "Málaga", " Sierras de Málaga " and " Pasas de Málaga". A study of viticultural zoning of the areas belonging to those municipalities, in which diverse varieties of recommended and/or authorized grapevines are cultivated, have been realized taking in consideration principally geological, pedological and climatic characteristics.

In the region, the formations of the Mid Subbetic -constituted by limy materials of different facies- dates of the Jurassic Period mainly, and they are the original constituents of the mountainous zones with altitudes superior to 500 m a.s.l.; from North to South they form *La Camorra* (686 m), *Sierra Mollina* (796 m) and *Sierra de Humilladero* (656 m). The lower zones have altitudes less than 450 m. They are constituted by karstic areas, that operate of sink of the Fuente de Piedra lagoon; by the Quaternary low areas associated with this one; by those areas of the edge of the fluvial valley that feeds it, and by the southeastern edge of the municipal area of Mollina, related to the hydrographic network of the Depression of Antequera and Guadalhorce River.

The zones of medium altitudes, those of major agricultural interest for their extension, phisiografy and geopedological characteristics, are constituted by Postorogenic Tertiary Formations of the Miocene (Tortonense - Andalucense), and by those ones dating of the Trias -marls, sandstones and gypsum- which are highly represented in the surface of the eastern Mollina. They can be divided in several basins; the two principal ones are those of the East (Mollina) and of the West (Humilladero and Fuente de Piedra); in addition, one at the south of Sierra de Humilladero, and another one at the north of Fuente de Piedra, Humilladero and Mollina.

The zones of medium altitudes includes tabular reliefs -concerning those three municipalities-; plains and hills of dissection, glacises of coverage that surround the mountainous formations; and conical hills of the trias from the northwestern and eastern sectors of the region.

The soils of agricultural interest (olive grove, vineyard and dry and irrigated cereals) are very degraded; they are principally on Tertiary and Quaternary limy materials and, in minor extension, on the eastern Trias of the region. On the Postorogenic Tertiary they are formed soils (Calcisols and Cambisols) on calcarenites with a limy crust ("*blancales*"), and others on marls (Regosols, Cambisols and Vertisols). On Quaternary sediments and/or on marls and limy sandstones of the Trias, Regosols, Cambisols and Luvisols are formed; and in very minor extension some Fluvisols ("*vegas*", "*cubrijales*").

Finally, four climatic zones have been delimited in the region according to the rainfall and temperature -differentiating four periods according to its viticultural interest (C1, C2, C3 and C4)- by using series of 20 years from five metereological stations. The climatic zone of the South is considered to be as Thermo-Humid; that of the North as Subthermo-Subhumid; the eastern area as Mesothermo-Humid and that at the West, Mesothermo-Subhumid.

Diverse maps of zoning have been made: Z-1, geology, altitude and fluvial network; Z-2, geomorphology, altitude and fluvial network; Z-3, Soil groups and geomorphology; Z-4 geology and geomorphology; and map Z-5, viticultural areas. A global appraisal of the areas has been carried out, resulting four classes of suitability of the same ones on the basis of the studied characteristics and requirements for the grapevine growing.

Finally, several pictures and descriptive and analytical tables contain detailed information of the different representative "areas", "pagos" or "terroirs" in this region.

Key words: Málaga Norte, geology, soil, climate, zoning.

Introduction

The vineyards of Fuente de Piedra, Humilladero and Mollina –together with those of Antequera and other municipalities- constitute the vine-growing North Zone area of the province of Málaga. Their products are protected by the Regulatory Council of the Denominations of Origin "Malaga", "Sierras de Málaga" and "Pasas de Málaga ". The three municipalities have a total extension of 20100 ha, the vineyard plots occupying the 4.0 %.

Geologically the region belongs to the Mid Subbetic; it is in general depressed and dominated by limy postorogenics sediments of the Tertiary and Quaternary from the *Cordillera Bética*. The principal soils are Regosols, Calcisols and Luvisols, each of them with diverse units of lower order. The climate is Mediterranean, with characteristics associated with its geographical position in the structural and climatic regional frame.

Apart from the vineyard, the principal cultivations are oil olive grove and cereals (wheat), and in smaller extension, fruit trees and horticultural produces. Pastures, bushes and mediterranean forest constitute the natural vegetation of the high areas of *Sierra de Mollina* (796 m o.s.l.) and *Sierra de Humilladero* (656 m); halophytes plants grow in the low zones of the Fuente de Piedra Lagoon (420 m), which acts as an important nail for the nest building of flamingos.

The varieties of grapevine authorized for "Malaga" appellation white wines are small grain Muscatel, Pedro Ximénez and Lairen or Doradilla; and for "Sierras de Málaga" appellation white and red wines, those same varieties and/or Chardonnay, Macabeo, Sauvignon blanc; and Syrah, Tempranillo, Cabernet sauvignon and Merlot, respectively.

The authors realize a study of zoning in order to provide information about the characteristics of the natural factors (geology, soils, climate) of the different sectors and wine-growing plots of the region for management purposes.

Materials and methods

The 1:50000 Geological Maps of Spain (IGME 1986 a, b), Topographic Maps (IGN, 1999, 2000 and 2001), and the 1:50000 Geomorphological Units Map and the 1:50000 orthophotographs (Consejería de Medio Ambiente, Junta de Andalucía) were used for the study and interpretation of the areas.

Those maps along with that of Crops (Consejería de Agricultura, Junta de Andalucía) were also used in diverse field trips to recognize the soils. In selected plots, soil profiles were opened for the description and sampling (soil, subsoil and geological material). The description was done according to FAO (1977) and soil analyses according to official methods (MAPA; 1994), except for the Chlorotic Power Index (MORLAT and CORUBE, 1981), organic carbon (SIMS and HABY, 1971) and microelements (PINTA, 1971). The WRBSR (FAO, ISRIC, SICS, 1999) was used for soil classification.

With data of 20 years (1983-2003) from five meteorological stations (Meteorological National Institute) next to the region, rainfall (mm), temperature and other climatic indeces (HIDALGO, 2002; TONIETTO and CARBONNEAU, 2004) tables were elaborated. The values were represented graphically on the area of study; isotherms and isoyetas correspond to four annual periods: C1 (2nd half of March and April), C2 (May, June and first half of July), C3 (2nd half of July to September) and C4

(October to first half of March) (PANEQUE et al., 2004). Finally, for the elaboration of the zoning maps, the ArcView v3.2 program (ESRI 1992-1999) was used.

Results and discussion

The geological factor determines important characteristics and processes in the region that finally have influenced the development of diverse geomorphological sites.

The formations of the Mid Subbetic -constituted by limy materials of different facies from the Jurassic (Lias) Period mainly- are the components of the mountainous zones, with altitudes superior to 500 m o.s.l., originated in the (Alpine) tectonic that occurred in the region.

The low zones, of altitudes less than 450 m, include areas of karstic origin –sink of the Fuente de Piedra Lagoon-; the Quaternary low areas associated to the lagoon- and those of the end of valley of the fluvial network(net) that feeds the mentioned Lagoon; and the southeastern sector suroriental of Molina, related to the hydrographic network that gathers waters of the oriental basin of the region and the partners to the Depression of Antequera and Guadalhorce River.

The medium zone, with altitudes between 450 and 500 m o.s.l. can be divided in several basins. Two of them are the most important and extensive: the oriental one, which corresponds principally to Molina term, and the western one that comprises terrains of Humilladero and Fuente de Piedra terms. In addition, a southern basin to the south of the *Sierra de Humilladero* and a northern one to the north of the Fuente de Piedra, Humilladero y Molina terms. In general, the Postorogenics Miocene Formations (Tortonense-Andalucense) are the geological base of the soils in the medium zone together with formatins from the undifferentiated Trias -marls, sandstones and gypsum-, the latter having a major superficial representation in the oriental sector of Molina term.

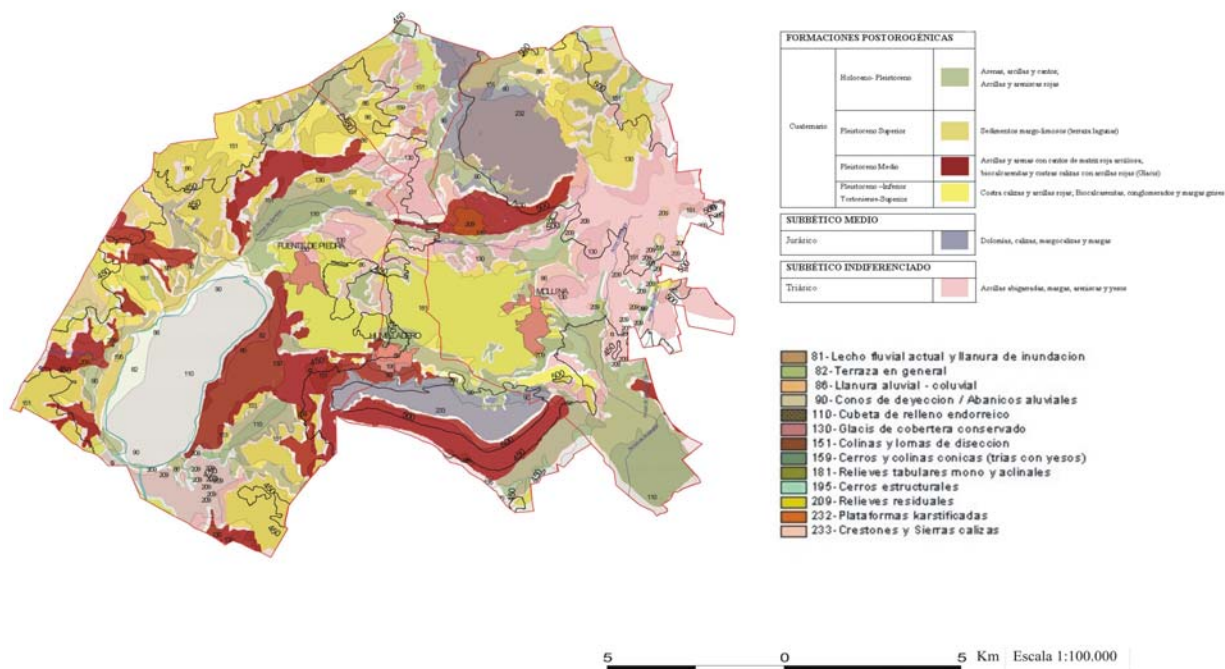


Figure 1 Geology and Geomorphology: Fuente de Piedra, Humilladero y Molina (Málaga, Spain)

Tectonic secondary, karstic and erosion-sedimentation finitertiary and quaternary processes are the cause of the final shaped of the three altitude and geological zones. For this reason the mountainous zone constitute the karstic platform of Molina and the mountain crests and limy saws of Humilladero, with some areas of glacis, debris cones and alluvial fans, and hills and dissected hills. The medium zones includes mono and acinal tabular reliefs around Fuente de Piedra, Humilladero and Molina terms; plains and hills of dissection in a border that surrounds practically to the region; glacises of cover that border on the mentioned mountainous formations and hills and Trias conical hills of the

northeastern sector of the region. Finally, the low zones are basins of endorreic landfill of Fuente de Piedra and of the south-oriental edge of Mollina term; alluvial-coluvial plains, mainly in Fuente de Piedra, and to the North-East and south-east of Mollina; and the current fluvial bed and plain of (temporary) flood of the south-east of Mollina. The figure 1 shows an altitude and geomorphological interpretation of the region.

The different Soil groups of wine-growing interest, with very degraded units, are principally on Tertiary and Quaternary materials, and in minor extension on oriental Trias material of the region.

Some soils are formed on Postorogenic Tertiary materials directly on calcarenite with more or less powdery limy crusts ("*blancales*"): Calcisols and Cambisols; while others appear on marls (gray, brown and dark soils): Regosols, Cambisols and Vertisols. In the quaternary sediments reclining on the previous geological materials and/or on marls and limy sandstones of the Trias, they also appear gray, brown and dark soils; and reddish-brown and red soils: Regosols, Calcisols, Cambisols, Vertisols and Luvisols; and in a quite minor extension some Fluvisols ("*vegas*", "*cabrijales*") hardly recognizable in the medium and high sections of the fluvial network the region. The figure 2 shows a geomorphological zoning map.

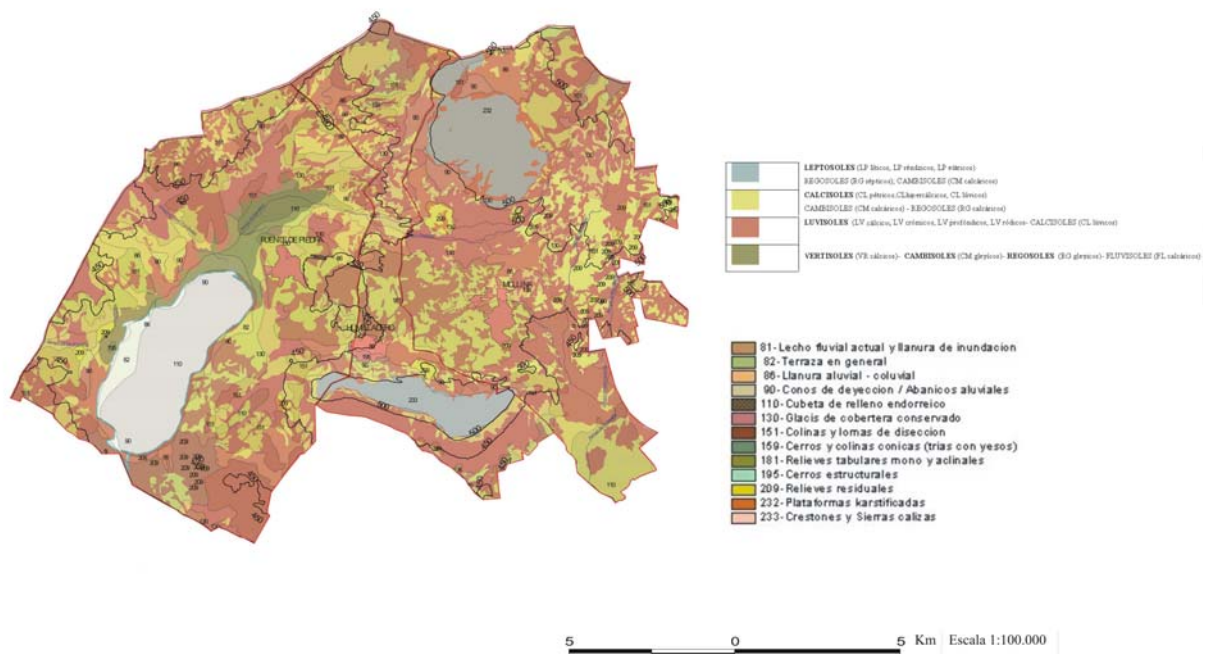


Figure 2 Soils Groups and Geomorphology

Finally, in the region four climatic zones have been delimited considering the values of rainfall and of temperature corresponding to the four established periods (C1, C2, C3, C4) (figure 3).

As result of the study of the geological areas and of the soils related to these, it turns out evident that those of major vine-growing suitability correspond to those of the Mid and Low Pleistocene (ancient Quaternary) and Andaluciense (Superior Tortoniense, Tertiary). The materials are constituted, respectively, by red clays and sands; limy crusts and limy stones; powdery and massive crusts, and red clays; and biocalcarenes and gray marls. Geomorphologically, they constitute glacises, tabular reliefs and hills (IGME, 1986 to, b, CMA,).

They are followed by the undifferentiated Trias terrains, with slightly less vine-growing suitability. Geomorphologically, those appears in hills and conical hills.

The third group of terrains belong to the Superior Pleistocene and Holocene. They are clays and dark sands, sandy slimes, marls and organic slimes and clays and red sands. They form some fluvial beds associated with creeks, plains of flood, lagunar terrace (of Fuente de Piedra) and endorreic landfill basins.

Finally, the Mesozoic terrains take part in the composition of the highest and strongest slopes reliefs. They are dolomites, limy and limy marls of the Mid Subbetic. They are represented – along with others - in the karstic platform of *Sierra de Mollina* and *Sierra de la Camorra*, and in the mountain crests and limy saws of *Sierra de Humilladero*.

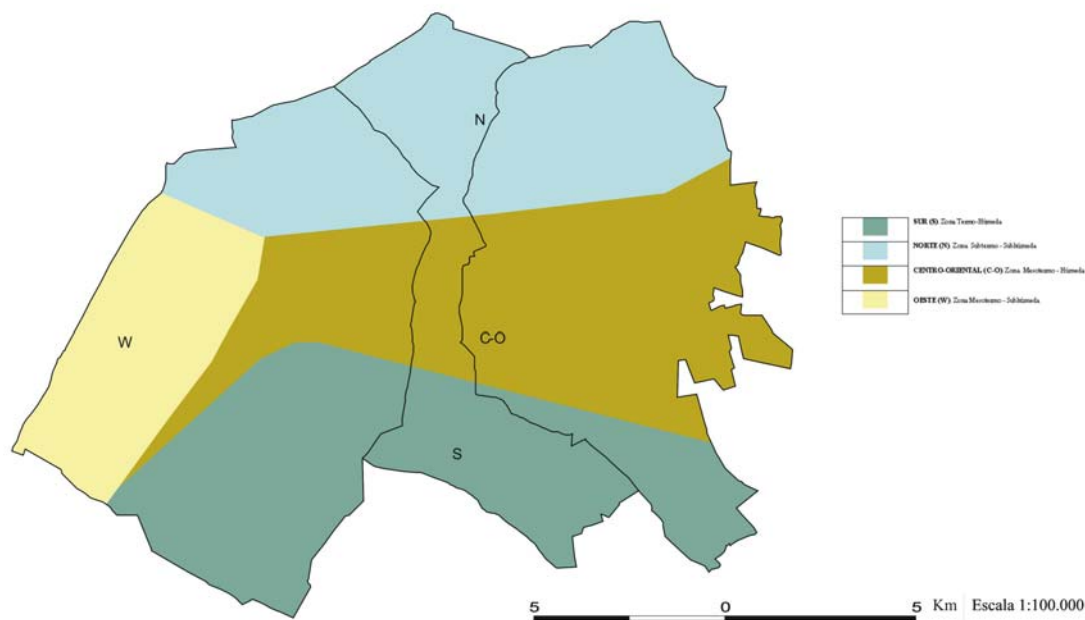


Figure 3 Climatic Zoning

From a pedological point of view –close to the previous geological and petrographical approach- Luvisols (LV), Calcisol (CL) and Cambisols (CM) are the Groups (FAO, ISRIC, SICS, 1998) of major spatial representation in the region and those of major use for the vineyard - specially in Mollina term- shared to a great extent with that of olive grove.

Some saturated chromic and profundic (rodic) Luvisols, on limy sediments (and sometimes on multicolored green clays) evolve to Calcisols (CL), for more or less ancient processes of degradation, in the same way that some calcareous Cambisols (CM) do it with major facility. In consequence calcareous Luvisols (LV), Calcisols (CL) and Cambisols (CM) are related in the regressive indicated sense and appear in the landscape very intermingled, since there shows the Soil Map of Soils.

Nevertheless, differences in the characteristics of the soil horizons (depth, texture, structure and composition, etc) and in the geological underlying material determine interesting shades in the vine-growing behavior of these soils and materials, especially as for the mineral nutrition and hydraulic properties, as the physical of profile samples analyses indicate.

Finally, the climatic study allowed to differentiate four zones; of them, the oriental center zone is defined like most adapted for the vineyard.

Conclusions

Using the experimental above mentioned methodology, diverse approximations have been realized to the zoning of Fuente de Piedra, Humilladero y Mollina municipal terms, wine-growing North zone of the Malaga, included in the Denominations of Origin of "Málaga" and "Sierras de Málaga".

The digitalization of cartographic documents along with the use of ArcView program have allowed to integrate the morphological, statigraphical and petrographical information of the terrains; that of soil (physiography, morphology soil profiles and physical and chemical analyses of horizons) and that of

the climate (temperature, rainfall, and bioclimatic indexes). Some of the results are summarized in thematic maps and zoning maps.

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