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Formation and classification of vineyard soils from the Mediterranean Range System (NE Spain)

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Introduction

Nowadays, modern oenology is based on quality criteria. This quality is frequently associated to very especial conditions of soil, climate, management and others, which form the concept of *terroir* (Seguin, 1986). The knowledge of this *terroir* allows promoting high-quality wine market. Soil, considered either alone (Rodríguez & García-Rodeja, 1995) or with climate (Conradie, 1998), is the main factor of the *terroir* who affects the grape production. The most important soil properties are the physical ones, mainly the ones related to the water content (Oliveira, 2001). It is difficult to find specific works that analyse vineyard soils using micromorphology. However, this discipline could be useful to determine processes that influence the soil physical properties and specifically the water content, as clay formation (McKeague, 1983) or mineral weathering (Delvigne, 1994).

Nearly twenty representative soils from four main geological units of the Mediterranean Range System (NE Spain) have been selected. These soils are located in modern vineyards of high-quality production, propriety of Miguel Torres Winery, a winemaker of international prestige. The aim of this work is to determine the formation and classification of different vineyard soils, using micromorphological analysis, and discuss about the implications on vineyard management and wine quality.

Formation of Mediterranean vineyard soils

A wide variety of soil forming processes have taken place in the studied soils, due to the interaction of different factors: parent material, climate, time, topography, biota and man. The main identified processes are related to mixed silt and clay accumulations, clay accumulations, carbonate accumulations, hydromorphic features and anthropic and biologic activity.

Mixed silt and clay accumulations form whole-soil (hypo-)coatings, characteristic of cultivated clayey soils (Fitzpatrick, 1993). Clay accumulations may have either an illuvial origin, an *in situ* origin or both (McKeague, 1983). The features originated by *in situ* clay neoformation are coatings of sand grains, and coatings and infillings of pores and coarse components. The features related to clay illuviation are coatings and infillings of pores and cracks of coarse components. In some cases, degeneration of clay features have been observed, due to bioturbation, displacement and replacement by carbonates and expansion-retraction of clay (argilloturbation). Carbonate accumulations may have either an illuvial or a biological origin. The features of biological accumulations are quesparite infillings of pores (Boixadera *et al*. (eds.), 2000). The features of carbonate illuviation are representative of different degrees of calcification. First, a process of crystallization produces acicular crystals and few hypocoatings of micrite and microesparite. Then, a process of recrystallization produces abundant coatings and hypocoatings, nodules and infillings of esparite and microesparite. Finally, there are processes of displacement and replacement of grains, and carbonates (micrite) begin to occupy the micromass. Some polycyclic soils have been described, with processes of descarbonatation, clay illuviation and recarbonatation. In those cases, carbonates coat the clay coatings. In general, the hydromorphic features are impregnative Fe and Mn nodules, coatings and hypocoatings, showing incipient hydromorphy phases. In some cases, a palaeohydromorphy can be deduced from anorthic and very weathered Mn nodes. The hydromorphic features seem related to clay features, which are probably the responsible of changes in water regime. The main effects of the anthropic activity are the buried fertile horizons and the darker colour by organic matter accumulation. The main effect of the biological activity is bioturbation.

Classification of Mediterranean vineyard soils

In some cases, the soil classification does not reflect important pedogenic processes with remarkable implications on vineyard soil management: clay neoformation, silt and clay accumulation or incipient carbonate accumulation. Sometimes, these processes lead to cambic horizons, although it is not always possible.

For example, soils developed from granite of the Mediterranean Range System can treble their available water capacity (from 123 m^3/ha to 328 m^3/ha) thanks to a process of formation of clay coatings, and yet they are classified as entisols (SSS, 1999) / regosols (FAO/ISRIC/ISSS, 1998). These soils can not be classified as alfisols (SSS, 1999) / luvisols (FAO/ISRIC/ISSS, 1998) because the clay origin is biotite alteration and not clay illuviation; neither as inceptisols (SSS, 1999) / cambisols (FAO/ISRIC/ISSS,

1998) because the subsurface horizons maintain the rock structure. In this case, clay formation does not change classification in spite of having important management implications, as the possibility of water saving in irrigation.

Conclusions

The pedogenic processes that have been described using micromorphology affect directly the soil properties related to water regime, capacity of water retention and carbonate content, which have a direct influence on both vineyard management and wine quality. For example, the clay formation in very stony soils supposes a water reservoir that improves the crop quality. On the other hand, the processes of clay illuviation, typical of the red Mediterranean soils, allow the existence of localised soils that produce singular wines with a exclusive typicity. However, the current systems of soil classification (Soil Taxonomy and WRB) do not always reflect some of these important processes for the vineyard cropping system.

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