

GEOLOGY AND LANDSCAPE AS DETERMINING FACTORS IN MICROFIELDS AND DEVELOPMENT OF THE DIFFERENT SPANISH APPELLATION OF ORIGEN

Vicente GOMEZ-MIGUEL¹ & Vicente SOTES¹

(1) *Universidad Politécnica de Madrid (UPM)*. Avda Complutense s/n. 28040-Madrid, Spain.

vicente.gomez@upm.es & vicente.sotes@upm.es

Abstract

Dividing agrarian exploitations into microfields is a problem that influences the modern viticulture in a very important way. The aim of this work is the study of the influence of Geology and Geomorphology in agricultural structures, and more exactly applied to viticulture microfields, as determining factors in evolution and development of certain Appellation of Origin (AO). The field division of three AO in the Northwest of Spain (Toro, Bierzo, Arribes) is compared. These three regions were chosen because they have similar influence elements.

The Toro AO (total area 76.076,43 ha; vineyard area 4.887,12 ha) is located to the West of Duero river basin and it is formed with limestone and carbonated detritic materials from the tertiary series and with the materials from the glacia and the medium and low terraces of the own river. In this context the altitude difference is small (650-825 m) and the shapes are flat and smooth in the quaternary relieve and undulating in the link tertiary surfaces with slopes under 20 %. There are neither rocky outcrops nor stoniness to block the crop technical development.

The Bierzo AO (total area 142.672,08 ha; vineyard area 3.785,33 ha) is located in a sinking intermontane depression basin that is filled up with terraces materials, plioquaternary piedmont which are locally linked through tertiary detritical series with quartzite and schist materials that end in the primary mountainous edges due to basin close. The difference among cotes is important (525-1100 m) and the slopes are very changeable; flat in the alluvials, medium and high in the tertiary relieves and very high in the mountainous ones. Only in the mountainous basin edges there are some zones with rocky outcrops that block the crop technical development.

The Arribes AO (total area 101.969,94 Ha, vineyard area 1.66679 Ha) is located in an erosive surface that includes a whole of deep incisions and canyons of the Duero and its associated systems. In this surface the granite materials and schist, gneiss and quartzite paleozoic materials are predominant. These materials are locally covered with rests of glacia and quaternary materials and these filled up some depressions. The relief is very varied, from soft undulating surfaces in the erosive zone to vertical walls related to the incisions. In the whole AO the rocky outcrops and the stoniness make up or have made up an obstacle to the crop technical development.

Even though in the three AO a selection of the medium size is appreciated, the vineyard medium size is more than two times smaller in Toro AO (2.84) and in Bierzo AO (2.84), but more than five times smaller (5.54) in Arribes AO. On the other hand, while in the Toro AO, the wine-grower can select the better quality zones and zones with a proper structure and a independent of the considered elements, in Bierzo AO and in Arribes AO the vine-growers election possibilities are much lower or there are problems with the slopes which are often in relationships to the soil small effective depth, or if these problems have been eliminated by the effort through centuries the microfields division impede the vineyard crop technical development; the vineyard medium size is more than ten times higher in Toro AO, than in Bierzo AO and Arribes AO.

Key words : terroir, zoning, landscape, geology, microfield, Appellations of Origin, Spain

1. Introduction

Agrarian exploitations that are divided into micro-fields are a problem that influences the modern viticulture in a very important way. The aim of this work is the study of the influence of Geology and Geomorphology in agricultural structures and more exactly applied to viticulture micro fields as determining factors in evolution and development of certain Appellation of Origin (A O). The field division of three AO in the Northwest of Spain (Toro, Bierzo, Arribes) is analyzed. These three regions were chosen because they have similar influence elements (figure 1).



Figure 1. Location of the study area: Arribes AO, Bierzo AO and Toro AO

2. Methodology

The reasons that influence the choice of a particular field into an AO to plant vineyard are in relationship with very different elements such as socioeconomic and family situation, nearness to town centre, crops competitiveness, local valuation and tradition vine-growing and the special features of the own field structures. The present situation of the field structures is the result of their adaptation during hundreds of years to very different conditions of agricultural exploitation. The environment conditions influence very deeply this adaptation.

The previous realization of *terroir* zoning in the Toro AO, Bierzo AO and Arribes AO (Gómez-Miguel & Sotés, 1998-2010) allows us to make use of data in relationship with different media variables that directly influence vine exploitation conditions in the production zones under their influence.

The cartography of litho-stratigraphic units of landscape, soil and climate that characterizes the Medioambiental Homogenous Units (UHM) and the field information from the vine registration (Comunidad Autónoma de Castilla y León, 1998-2008) being suitably managed, allow us to analyze the vine distribution and fielding according to every of these compounds.

3. Results

The Arribes AO occupies an area of 101.969,94 ha and is located at the west of the Duero River, the Bierzo AO occupies an area of 140.672,08 ha and is located at the Sil basin and finally the Toro AO occupies an area of 76.076,43 ha and is located at the Duero basin (table 1).

Table 1. Surfaces and fields in the AO Toro, AO Bierzo y AO Arribes

CONCEPT	TORO	BIERZO	ARRIBES
Total number of the fields	30360.00	532173.00	137561.00
Total surface (ha)	76076.43	140672.08	101969.94
Vineyard fields number	3778.00	38717.00	11598.00
Vineyard surface (ha)	4887.12	3785.33	1666.79
Total number of the fields (no vineyard)	26582.00	493456.00	125963.00
Total surface for field (ha)	2.50	0.26	0.74
Surface for field of the vineyard (ha)	1.29	0.10	0.14
No vineyard surface (ha)	71189.32	136886.15	100303.15
No vineyard surface for field (ha)	2.68	0.28	0.80
Surface for no vineyard field/Surface for vineyard field	2.07	2.84	5.54

The vine distribution standards in the three AO follow different patterns: in Arribes AO there are 1.666,79 ha of vineyard that are mainly located at the central zone and they spread to the north and the south in a quite dispersed way; in Bierzo AO there are 3.785,33 ha of vineyard and the vine is mainly located at the fringe that goes along the central nucleus of the cavity with a bigger development to the north; and in Toro AO there are 4.887,12 ha of vineyard that spread in a quite homogenous way along the region (figure 2).

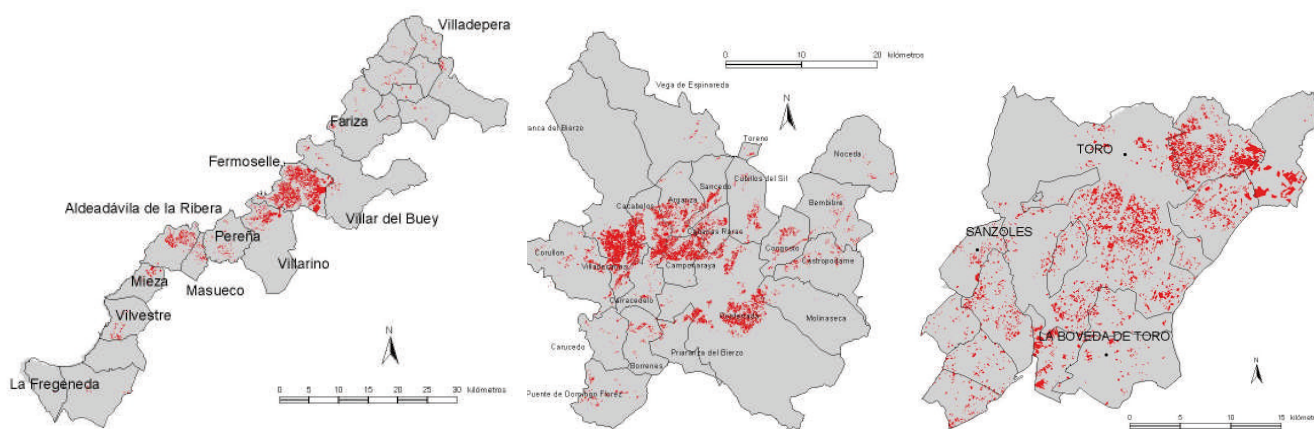


Figure 2. Different forms of vineyard occupation (red) in the protection zones of the Arribes AO (left) Bierzo AO (centre) and Toro AO (right).

The fields' average size is ten times bigger in Toro AO than in Bierzo AO and in this one it is three times lower than in Arribes AO. The average size of the vine fields is nearly thirteen times bigger in Toro AO than in Bierzo and Arribes AO. Definitely, a selection of the field size in favour of other uses is appreciated in the three AO: the average surface of the fields without vine is more than twice bigger in Toro (2,07) and in Bierzo (2,84), but it is more than five times bigger (5,54) in Arribes than in the vine fields.

The decision factors that have been considered to the election of the place to plant the vineyard are: the geological material (lithostratigraphy), the altitude and the landscape (geoforme, slope and position) as they are very interrelated and difficult to segregate. The rock

typology including their stratigraphic specificities (lithostratigraphy), is one of elements that conditions the vine cultivation in the three zones..

The Arribes AO is constituted by a flattering surface that includes a whole of deep incisions and canyons in relationship with the Duero River and its associated system. In this surface the granite materials and schist, gneiss, and quartzite Palaeozoic materials are predominant. These materials are locally covered with rests of glacia and quaternary materials and these ones filled up some depressions. The vineyards are concentrated in the most altered zones and in those with the most intense accumulations especially in relationship with the schistose and granite zones (fig 7).

The Bierzo AO is located in a sinking inter-mountainous depression basin that is filled up with terrace materials, plio-quaternary piedmonts which are locally linked through tertiary detrital series with quartzite and schist materials that end in the primary mountainous edges due to basin close. Certain tertiary units, mainly lutitic sands and siliceous conglomerates of the red series, and sands, lutites and magnesia clays of the conglomeratic polygenic Miocene series are the most important and together with the glacia bear more than the 85% of the vineyard and give specificity to the Bierzo AO wine (figure 3).

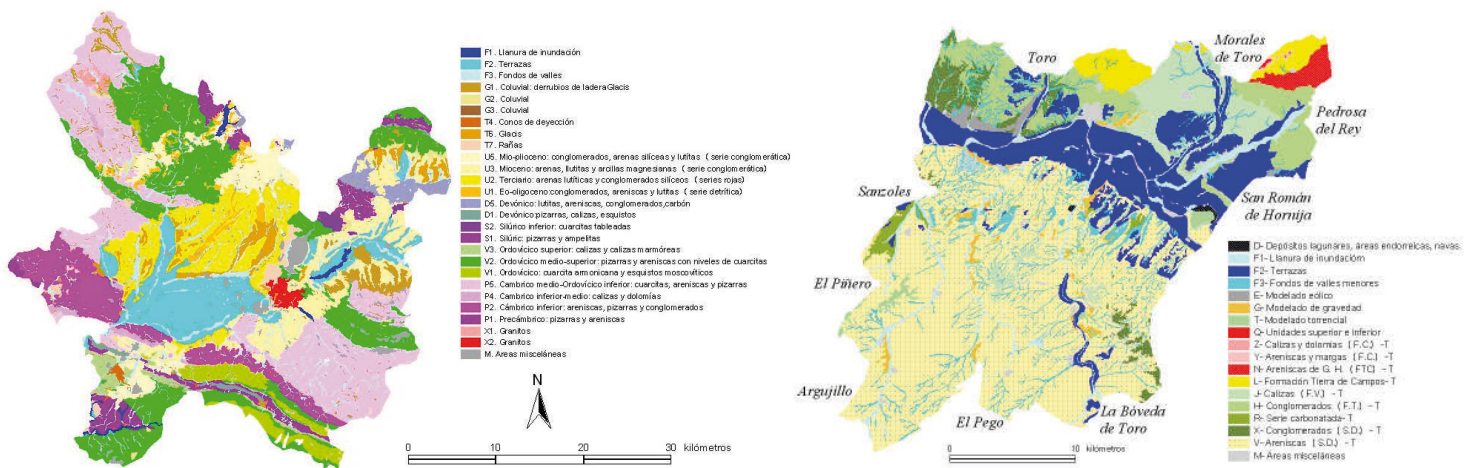


Figure 3 Litho-stratigraphic setting of the Bierzo AO (left) and the Toro AO (right).

The Toro AO is formed with limestone and carbonated detritic materials from the tertiary series and with the materials from the glacia and the medium and low terraces of the Duero River. The 78,3% of the vineyard is mainly concentrated in the terrace materials of the Duero River and in the sandstones of the detritics tertiary series, mainly due to its high surface extension.

The landscape elements are quite complex and differentiated in the three AO. In this section we are expressly referring to geomorphologic units (geofomes), height (figure 4) and slope. The information is taken from a detailed aerial photo interpretation (API) with a key formed by some digits (lithology, geoforme, slope, orientation, erosion...). The importance of these cartographic units lies on the fact that the mentioned attributes are assigned to every one of them. In Bierzo AO, for example, (figure 3) the general vineyard arrangement by lithologic groups (mentioned above) and API units allows us to carry out four big groups of lithography/landscape: in the first place, the geofomes, that were shaped in the Precambrian and Paleozoic periods (D, S, V, P, X) and occupy an important surface scarcely with vineyard, are of no viticulture interest; in the second place, fluvial modelling (F) with a special interest in the medium terraces of the main river (F 21 & F 22) with a 7,3% of vineyard and the secondary valleys (F 31 & F 32) with a 5,2%. (These units are in a very crucial moment as the vineyard is

competing with the fruits trees, figure 7); in the third place, the units in relationship with dejection cones, glacia and raña type (T) in which the interest for the T6 with a 9,3% of vineyard stands out; finally, the Tertiary units (U2 & U3) group more than the 75% of the vineyard.

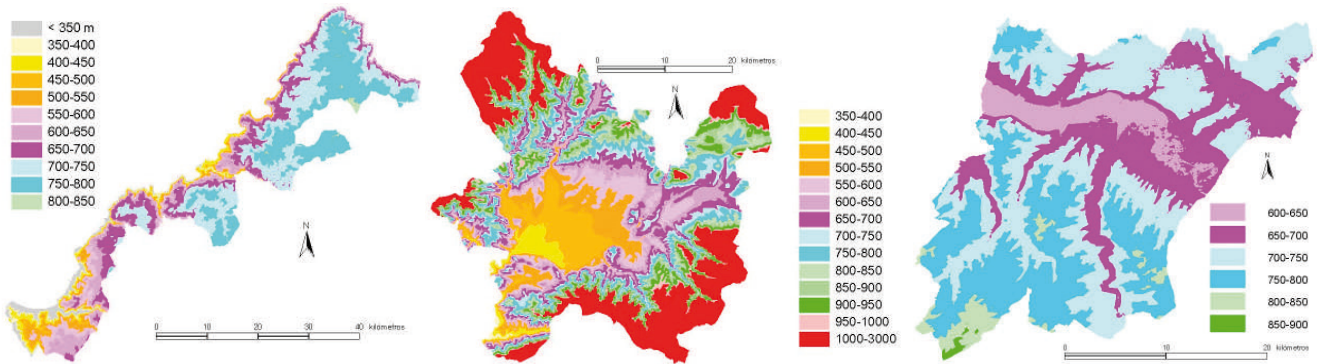


Figure 4 Altimetry in the Arribes AO (left), in the Bierzo AO (centre) and in the Toro AO (right): identical colours represent the same height interval.

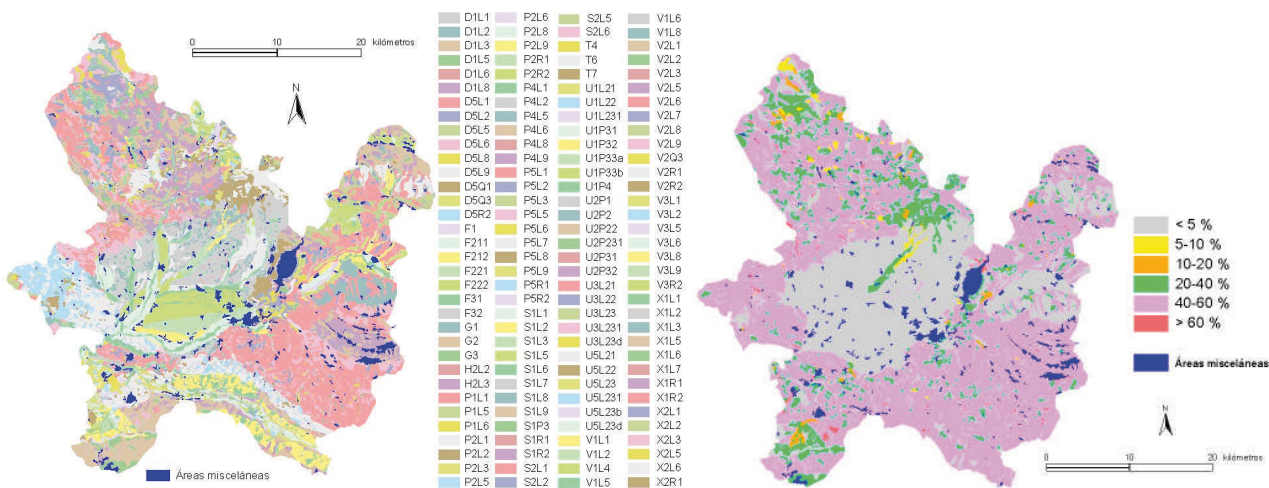


Figure 5 Landscape (Geoformas) and slopes in the Bierzo AO.

The relief of the Arribes AO is very varied, from soft undulating surfaces in the erosive zone to vertical walls related to the incisions and between them transitions with intermediate forms (figure 6). The height varies from less than 350m to more than 800m and the vineyard is mainly located in the interval between 650-700m with average percentages between 600 and 650m and between 700 and 750m and minimum percentages in the highest cotes or the too low ones (figure 4). The rocky outcrops and the stoniness are the protagonists in the whole AO. Precisely the withdrawal of stone blocks has caused the formation of fenced fields (“cortinas”) with relatively contradictory consequences: on the one hand, they form an exceptionally beautiful landscape (enotourism) and on the other hand, they make difficult to increase the fields size (field concentration) and they are a handicap to the crop technification (figure 7).

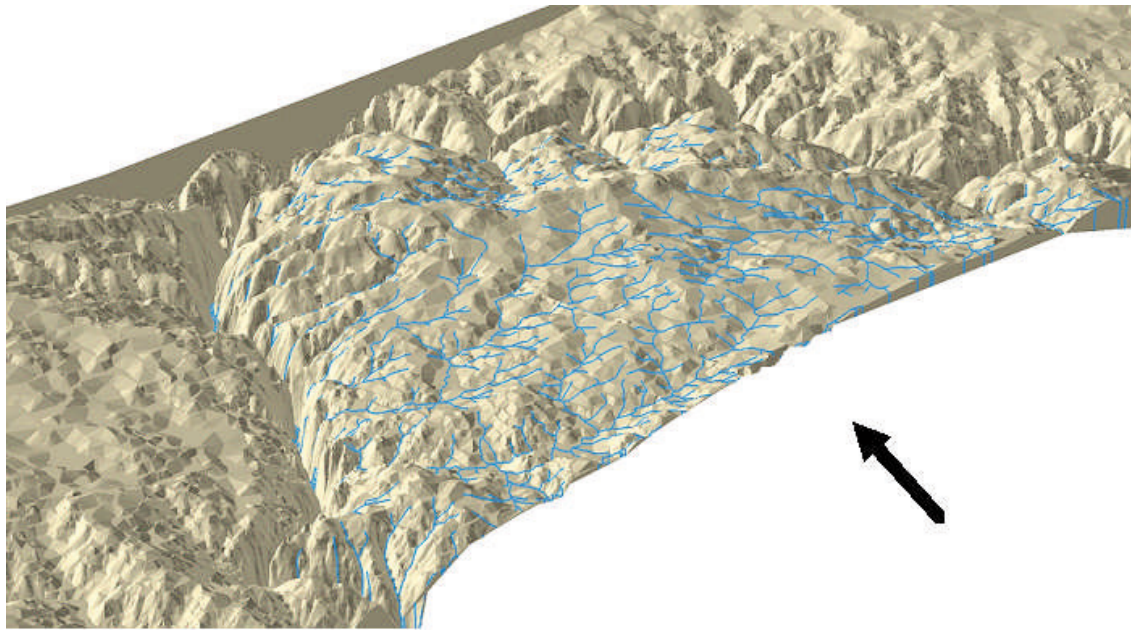


Figure 6. Drainage net (blue) on a digital model soil fragment superpose the ortophoto that stands out the canyon formed by the Duero River in the north of the Arribes AO.

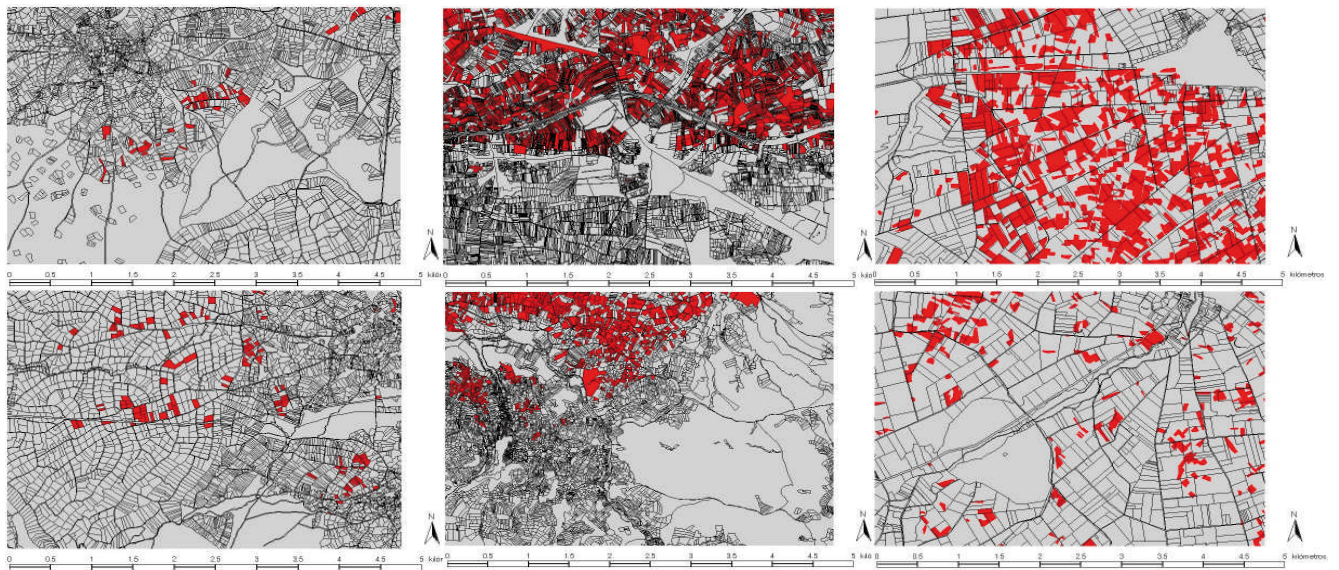


Figure 7. Examples of micro-fields patterns: a) left, in the Arribes AO (on top: competitiveness north-south for the lithology; down: positive evolution in the concentrated left zone); b) center, in the Bierzo AO (on top: competitiveness vineyard-fruit trees for the geomorphology; down: competitiveness vineyard-forest for the lithoforms); c) right, in the Toro AO (on top: Duero River terraces; down: detritic tertiary series).
 Details at the same scale (the vineyard in deep red).

In the Bierzo AO, the isohipses form concentric bounds that start at the Sil River exit, to the west of the AO, and they go up to the exterior from 300m to more than 1000m with very variable slopes: flat in the alluvials and medium or high in the tertiary relieves. The vineyard is concentrated mainly in southern positions between 450 and 650m (85,5%) and there are rocky outcrops and stoniness that block the crop technification only in the mountainous edges of the basin (figure 4).

In the Toro AO, the difference among altitude is quite small (650-825m) and the forms are flat and soft in the quaternary relief and undulating in the link tertiary surfaces with lower than 20% slopes (figure 4). There are neither rocky outcrops nor stoniness that block the crop technification. Thus, the vineyard goes along in a very homogenous way through the whole AO, even though, the light undulating relieves from the tertiary sandy and the medium Duero River terraces are preferred (figure 7).

4. Conclusions

In the three AO, a selection of the average size of the fields in favour of other uses is appreciated: the average size of the fields without vineyard is more than twice bigger in Toro (2,7) and in Bierzo (2,84) but it is five times bigger (5,54) in Arribes than the vineyard fields:

- In the Toro AO, the lithostratigraphic units and the most interesting geoformas are spread in a quite homogenous way through the whole AO. These units are quite flat and soft from the undulating surfaces of the detritus series and from the Duero River terraces and they have a very interesting and slight altitude difference, 650-825m, besides they don't have specific handicaps to produce quality wines and the fields are quite big so the vine-grower can chose those with the best quality and with a proper structure without any problems.
- In the Bierzo AO, their choice possibilities are quite less. The lithostratigraphic units and more interesting goformas are concentrated in specific places bordering the Sil River terraces in the centre of the basin. These units are tertiary slopes of red series and conglomeratic polygenic series with a southern ex position, between 450 & 560m and with media and high slope. Besides they have some specific handicaps (exposition, height, slope ...) to produce high quality wines and the fields have a medium size and thus, the vine-grower must choice the best quality, between 450 & 560m and with media and high slope. Besides they have some specific handicaps (exposition, height, slope ...) to produce high quality wines and the fields have a medium size and thus, the vine-grower must choice the best quality ones and those with a proper structure only in this zone.
- In Arribes AO, their choice possibilities are even lower. The lithostratigraphic units and the most interesting geoformas (zones between 650-700m that are more altered and with more intense accumulations mainly in relationship with the schistous and granite area) coexist with slope problems that are often associated to the very slight soil depth and/or rocky outcrops or stoniness which are very often insuperable or if those problems have been avoided by an effort along the centuries, then, the micro-fielding avoids the vine-growing technification.

5. Referencias

Comunidad Autónoma de Castilla y León (1998-2008). Registros Vitícola de la DO Arribes, DO Bierzo y DO Toro. Valladolid
 Gómez-Miguel, V. & V. Sotés (1998-2010). Delimitación de zonas vitícolas en la D.O. Toro, en la D O Bierzo y en la DO Arribes. ETSIA. Universidad Politécnica de Madrid.