PEDO-GEOMORPHOLOGICAL RELATIONS IN THE BOHOTIN CATCHMENT

Daniel Curea[1], Ion Ionita[2]

Abstract: The Bohotin catchment is related to a right-bank tributary of the Middle Prut and is located in the eastern border of the Central Moldavian Plateau, occupying a surface of 6.107 ha. From the range of sedimentary formations specific to the Moldavian Platform, erosion revealed clayey–sandy Bessarabian (Middle Sarmatian), Chersonian (Upper Sarmatian) and Meotian in age layers, arranged in monocline structure. The subsequent valley of the Bohotin, through its almost cross orientation towards the SSE dipping of geological formations, clearly emphasizes the first-rank structural asymmetry. In this hilly frame, the predominant genetic relief type is represented by the sculptural (fluvio –denudational) one, followed by the structural – lithological and accumulation landforms. In the context of a temperate continental climate and of the zonal vegetation of sylvosteppe and woods, there were formed mainly soils from the Cernisols and Luvisols classes and the impact of anthropic activities is revealed by the appreciable extension of Anthrosoils. On the one hand, this paper treats the connection between the genetic relief types and landforms and the distribution of soil cover. On the other hand, the present-day geomorphological processes, analyzed as restrictive factors of the fertility potential of soils in relation to their physical and chemical properties, are partially responsible for the quality classes and soil pretability.

Keywords*:* cuesta, structural plateaus, cernisols, luvosol, anthrosols, soil pretability.

1. Introduction

The Bohotin catchment is located in the eastern border of the Central Moldavian Plateau, within the "*Comarna - Raducaneni Hills*" subunit (Bacauanu V. et. al., 1980), previously known as "*Fata Prutului*" (Gh. Nastase, 1945). The Bohotin River represents a right-bank tributary of the Middle Prut, whose hydrographic basin occupies 6.107 ha, with a length of 17 km and the average width of 3.6 km. Northwards, it is confined by the Cozia catchment. Eastwards, it is bounded by the Prut floodplain, southwards by the Mosna catchment, westwards by the Crasna catchment, and north-westwards by Covasna catchment (Figure 1).

Bessarabian prevails in the studied area, being represented by clayey deposits with sandy seams, deposited in the marine, brackish facies, mostly located in the lower and middle reach of slopes. Jeanrenaud P. (1961, 1965, 1971) determined that these layers underlain more coarse formations, deposited in neritic (coastal) facies, of which detaches the reference horizon of the Repedea oolitic limestone and the Scheia sandstone (Figure no. 2).

The Chersonian deltaic facies, with its clayey-sandy deposits, outcrops in a more restricted area. It surrounds as a frame the upper catchment upstream of Raducaneni or

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develops as erosion remnants, to the east, on the main hilltops, such as the one situated south of the Isaiia village.

The Meotian is being preserved isolated, at over 380 m height, under the form of two erosion remnants on the Crasna-Bohotin hilltop. In its frame, Jeanrenaud P. (1961, 1965, 1971) separated two horizons, namely: the lower, reference horizon, *Nutasca-Ruseni*, consisting of andesitic cinerites with sandy concretions, separated by sands and clays and the upper horizon, consisting of a succession of sands, clayey sands and clays, in cross stratification.

Fig. 1. Bohotin Valley downstream of Răducăneni (25 June 2008).

Fig.2. Calcareous-sandstonic plate on the right valley-side of Bohotin in the Pârâul Pietrei – Bazga, Răducăneni geological and paleontological reservation (14 August 2012).

The most recent formations from the Bohotin catchment belong to the Quaternary, when the current aspect of the relief defines. They are represented by eluvia, diluvia, colluvia, proluvia, and alluvia (fluvial terraces, floodplains).

The continental temperate climate is characterized by the value of the annual average temperature of about 9.4 ºC at Raducaneni and an annual average quantity of atmospheric precipitations of 568.3 m in the same locality for the period 1961-2008.

The natural vegetation was significantly changed by anthropic activities, but we mention that initially two specific areas of zonal vegetation were identified, namely: silvo-steppe in the lower area and deciduous forest (durmast and mixture of durmast and beech) in the greatest heights.

2. Materials and methods

In order to reveal the geomorphological features from the Bohotin catchment, there were used both traditional research methods (observations and land measurements, geomorphological mapping, statistical-mathematical processing, analysis, synthesis) and modern methods based on GIS softs. Cartographic materials were obtained by means of the program TNTmips v.6.9., and the statistical processing was realized by Microsoft Office Excel 2007. An important step in the spatial modeling consisted in the achievement of the Didital Elevation Model (DEM), by vectorizing the contours lines and the heights from the topographic plans at scale 1:5,000. Then, on this base, thematic maps referring to hypsometry, slope and exposition of land, shading, etc. were compiled.

For the characterization of the soils cover, the pedological studies released by O.S.P.A. Iasi were consulted and processed by a unitary approach, at the scales 1:5,000 and 1:10,000. Soil maps from these studies were scanned and georeferenced. Subsequently, the soil units were vectorized, corrected and completed with new data, so that, in the end, 215 polygons were delimited. In the case of older pedagogical studies, it was necessary the equivalence of soil types, from the Romanian System of Soil Classification realized in the year 1980 and the Romanian System of Soil Taxonomy from 2003 in the Romanian System of Soil Taxonomy, published in 2012.

Land assessment and grouping on quality classes in respect of the arable (cropland) and pretability for vineyard was achieved according to the "Methodology of elaboration of the pedological studies", part II, I.C.P.A., Bucharest, 1987, using the soft BDUST ver. 9.5. Cadastral maps elaborated by ANCPI Bucharest and orthophotoplans from 2005 edition represented the base of compiling the present-day land use map.

3. Results and discussions

The local relief is a typically hilly one, with the average height of 250 m, strongly related to the formation and development of the subsequent valley, slightly diagonal (oblique) of the Bohotin in the generally monocline structure of the Moldavian Plateau. The height decreases progressively on the WNW-ESE direction, from the maximum value of 417 m in the Fagul lui Budacu Hill, in the Crasna-Bohotin hilltop at the minimum value of 30 m in the Prut floodplain (Figure no. 3). Most of the land, respectively 90%% of the studied area has the altitude below 300 m (Figure no. 4).

The map of slopes from Figure 5 reveals the presence of two strips with high value of slope, of greater than 25º. Therefore, the first strip, although more sinuous, reveals well contoured inside the catchment, especially on the right valley-side, at south of Raducaneni, Bohotin and Isaiia localities. In the upper catchment, it becomes slightly faint and continues on the left valley-side until the north of Raducaneni. This strip actually superposes the edge of the Bessarabian calcareous-sandstonic plate. The second strip, slightly sinuous but towering, has a restrained development on the W-SW part of the studied catchment, under the form of a border of the Bohotin- Upper Crasna hilltop, being grafted by Meotian cineritic sandstone. On the other hand, 83% of the land in the Bohotin catchment has the slope value between 3-15º or 5-27% (Figure no. 6).

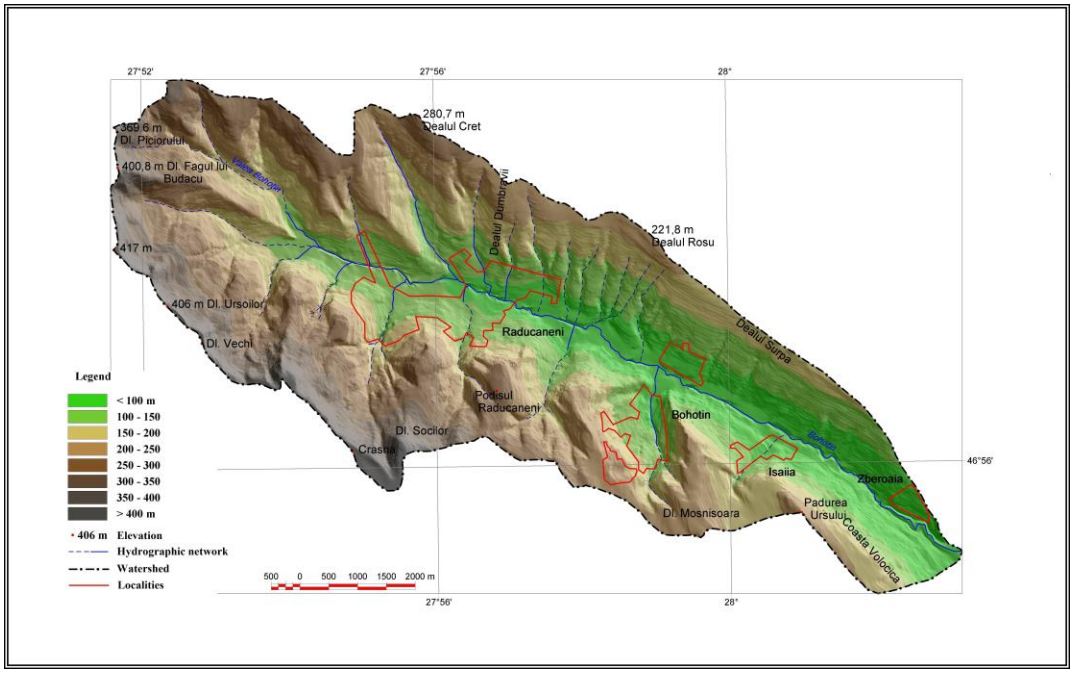

Fig. 3. Hypsometric map of the Bohotin catchment.

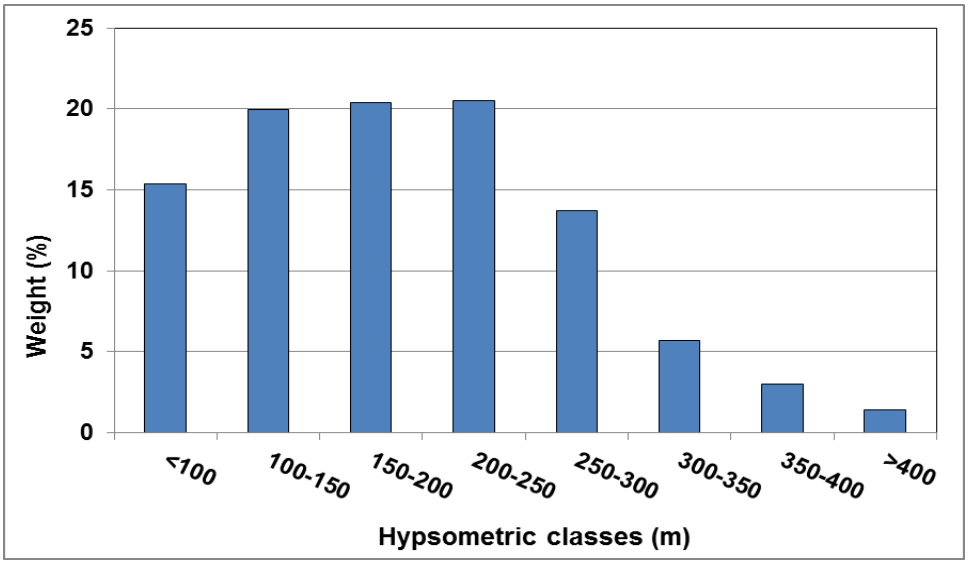

Fig. 4. Histogram of the heights in the Bohotin catchment.

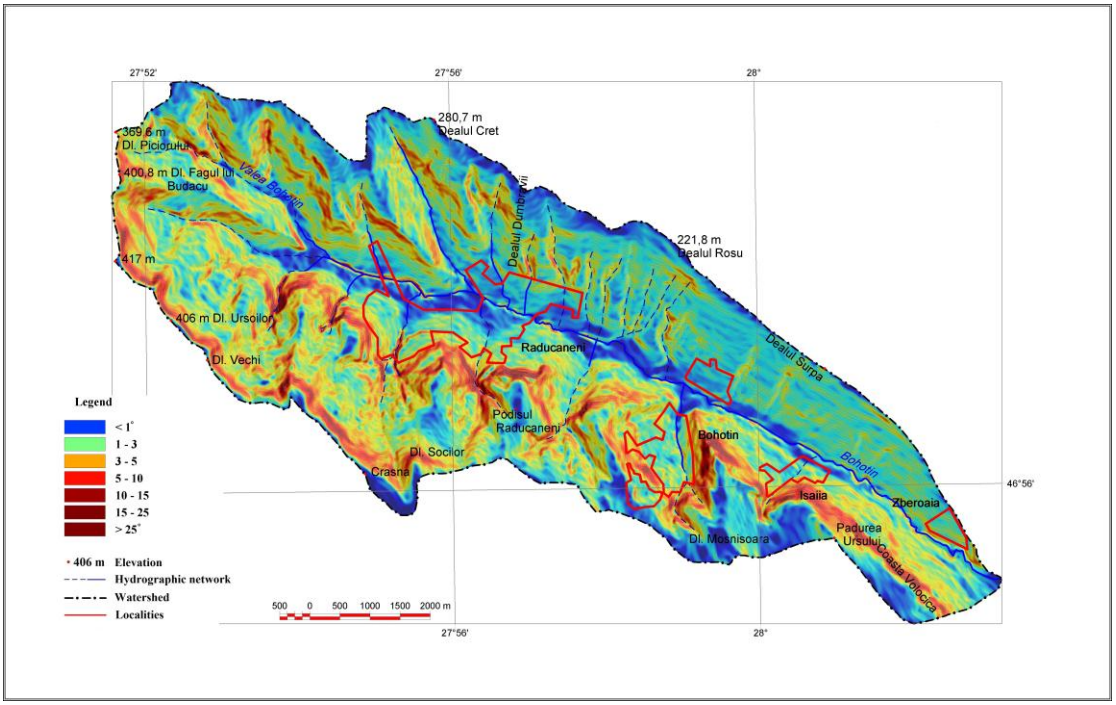

Fig. 5. Map of slopes (degrees) in the Bohotin catchment.

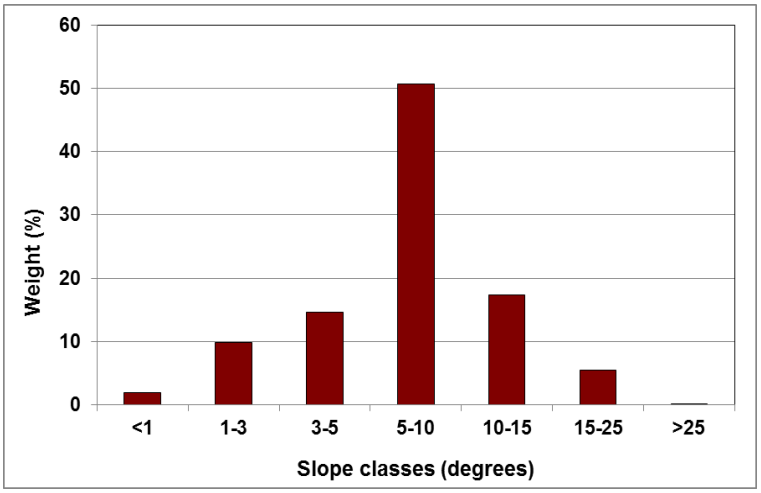

Fig. 6. Slopes distribution within the Bohotin catchment.

The main genetic relief types in the studied area are the ones specific to the Central Moldavian Plateau, namely: the structural relief, the sculptural (fluvio-denudational) relief in generally monocline and the fluvial accumulation relief (Figure no. 7).

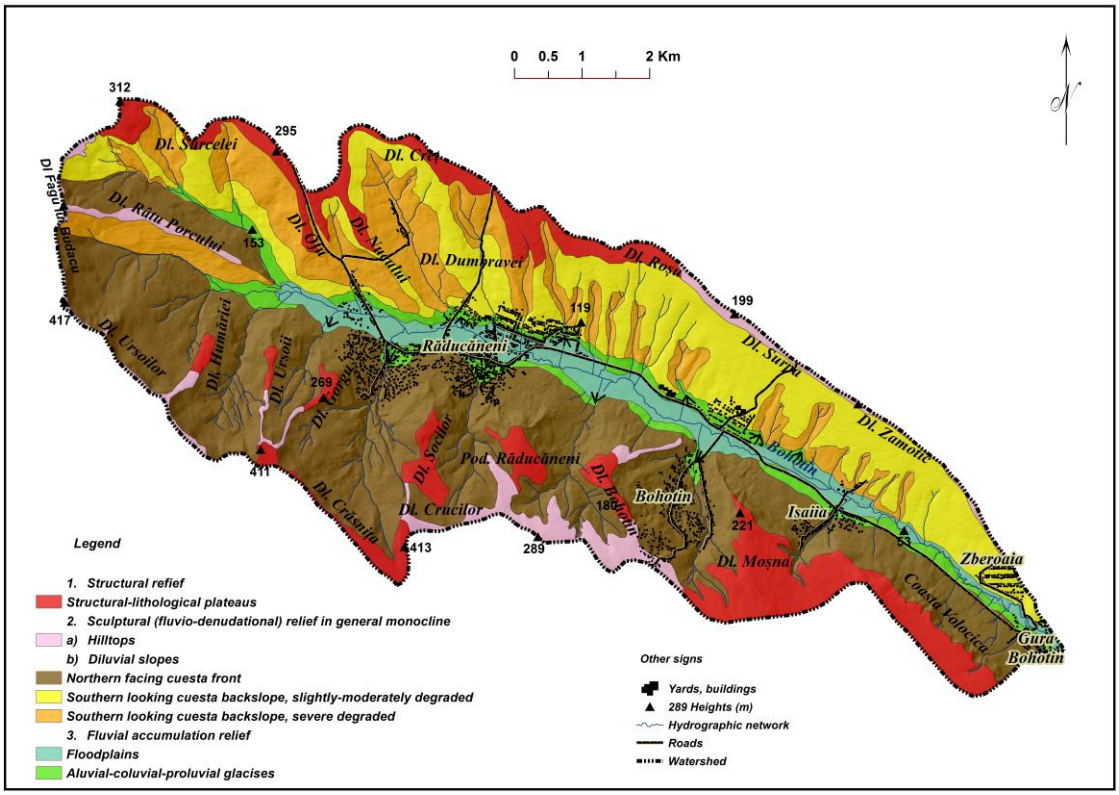

Fig.7. Geomorphological map of the Bohotin catchment.

The structural relief imposes through structural – lithological plateaus (platforms), in the meaning given by David M. (1922), which detains a marked weight, namely 14% of the total area. These plateau maintain in the relief under the form of more restrained erosion remnants, shoulders usually situated at 255-275 m (Nucul, Raducaneni Plateau, Soci, Gorgu, Ursoi) or more extended (the Mosna-Volocica-Unsu Plateau, in the SE part), grafted by the Bessarabian calcareous-sandstonic plate. Furthermore, here is also included the high plateau in the Crasnita Hill, developed on the Meotian cineritic sandstone.

The sculptural (fluvio-denudational) relief within monocline represents the prevailing genetic type as distribution, since it occupies 4,597 ha, which represents 75% of the total catchment area. It imposes in the relief by two specific landforms, namely: the sculptural hilltops and the diluvial slopes. The hilltops have a reduced weight (4% of the total sculptural relief), the main ones delimiting the studied area in the north and south. Alternatively, slopes are extending on 4,410 ha, so detain the most significant weight, namely 72% of the surface of the Bohotin catchment, and has the role of cuesta front (the right valley-side) and cuesta backslope (the left valley-side). The slopes' potential to reveal the preponderance of the cuesta relief is determined by the subsequent character, slightly diagonal (oblique) of the Bohotin Valley (Figure no. 8).

Fig.8. Asymmetrical Bohotin valley downstream of Pietraria Bohotin. The right side, northern facing cuesta front is in the foreground and the left side, southern looking cuesta backslope appears in the background (25 June 2008)

In this context, the following important features of the local cuesta relief are emphasized:

- The larger development of the Bohotin catchment on the right side (60% of the total) by outlining an ample cuesta front, strongly fragmented by obsequent tributaries, which shows quite an extended and advanced evolution of the valley of Bohotin.
- The double-storied character of the northern looking cuesta front of the Bohotin upstream of Raducaneni, where the first and ampler section is located in the lower half of the right valley-side, and the second section is grafted on Meotian formations in the area of the Bohotin – Upper Crasna hilltop. The level of structural-lithological shoulders is inserted between the two sections (stories) of cuesta front, being associated with the Bessarabian calcareous-sandstonic plate.
- The more restrained, apparently abnormal extension of the Bohotin catchment on the left side (40% of the total) is associated with the reduced length of the cuesta backslope. Therefrom, only three types of sub-asymmetries (land slope, present-day geomorphological processes and land use) are signaled of those mentioned by Ionita I. (2000) as typical to the cuesta relief in the Moldavian Plateau. This feature, the absence of length sub-asymmetry, resulted from the evolution of the Prut valley within the subsequent section downstream of Tutora. More precisely, we refer to its deepening and displacement towards the right, to SSW, which triggered either the lateral capture of lower catchment of subsequent tributaries Tatarca, Comarna, Covasna, Cozia and Ochiul, or the significant restriction of the left side of the Bohotin Valley.

The accumulation relief occupies the third position as percentage (11%) and is represented by the narrow floodplain of Bohotin and the alluvio-colluvial-proluvial glacises.

The most important geomorphological processes in the study area are the soil erosion, gullying, mass movements and aggradation of the valley bottom.

The surface of agricultural land pedologically surveyed is of 4,176 ha (68% of the total area of the catchment), of which 3,168 are distributed on simple soil units and 1,008 ha on complex soil units. Four soil classes and seven soil types were also identified, distributed on 48 simple soil units (SU). Moreover, in areas affected by landslides or gullying, seven complex soil units were obtained (Figure no. 9).

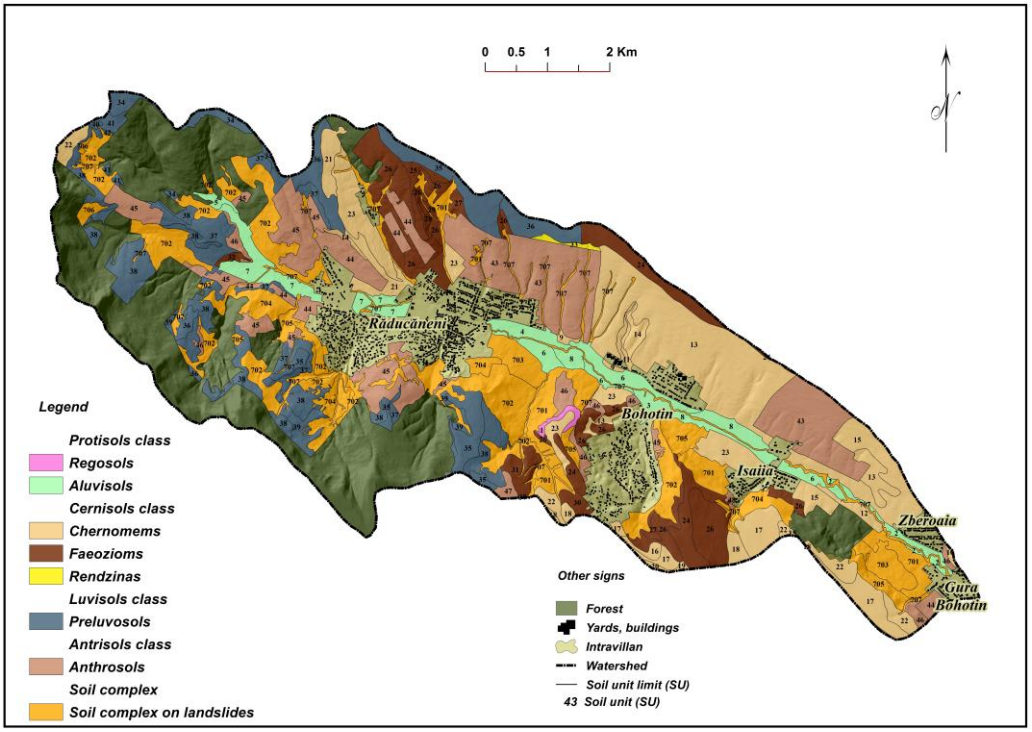

Fig. 9. Soils map of the Bohotin catchment.

The **cernisols class**, with the occupied surface of 1.817 ha, is the most extended (44% of the surveyed total) and occurring mainly on the left valley-side, southern looking cuesta backslope. In this class, chernozems (CZ) detain the main weight of 67% (1,218 ha), followed by faeozioms (FZ) with 32% (585 ha) and rendzinas (RZ) with 1% (7 ha).

Typical (CZ ti) and calcareous (ka) chernozems prevail (40% of the cernisols area), have neutral – slightly alkaline reaction (pH = 6.9–8.4), medium loamy texture due to 21.6 – 30.0% clay content and low-medium organic matter content (1.8–3.9%). Although calcareous chernozems are widely spread in the cuesta backslope (reverse), usually characterized by favorable conditions for vineyard, these soils present at the same time several chemical features which are not in the favor to this use.

Cambic chernomems (CZ cb) generally have an even development, occupy 494 ha (27% of the cernisols area), being met in the western and higher part of the cuesta backslope (the left valley-side), on the structural-lithological plateaus and in the soil complexes located on the cuesta front (the right valley-side). They are typified by a slightly acid – neutral reaction (pH = 6.3–7.2) and a low-medium organic matter content (2.1–5.1%). Their texture differentiates as follows: 62% medium loamy, 20% medium clayey-loamy and 18% loamy-clayey.

Cambic-greic faeozioms (FZ b-gr) occur in 410 ha (23% of cernisols), the argic-greic (ar-gr) ones in 2 ha, cambic-pararendzinic (cb-pa) in 40 ha (2%) and cambic-pararendzinic-stagnic (cb-pa-st) in 5 ha. These are spread on structural-lithological plateaus and in the higher areas of the cuesta backslope in the Ofu Hill, Nucului Hill, Surcelei Hill.

The framing of soil types from the chernisols class in quality classes for arable land shows us that 57% of these soils area included in the third class, 22% in the fourth and fifth classes, and 21% in the second quality class.

The **luvisols class** is represented by preluvosols (EL) only, occupying 24% (1,009 ha) of the pedological surveyed surface. The presence of the parental material with a medium,

loamy - clayey-loamy texture found up to the top horizons (23-39% clay, 22-30% s and 33-49% sand) together with the relatively high depth of carbonates explain the presence in a percentage of 98% of typical (ti) and only 2% stagnic (st) subtypes. Soil reaction is slightly-moderate acid (pH = 5.7–6.8), and the organic matter content (1.8–2.1%) is low. The absence of an impermeable horizon which might result in stagno-gleization on a larger surface, the predominantly medium texture, the moderate value of slopes of up to 5-8º (9-14%) and the depth of the ground water over 10 m caused the comprising of over a half of the surface (57%) with this soil type in the third quality class for cropland.

The **antrisols class** also imposes by a single soil type, the anthrosol (AT), which extends on 1,048 ha (25% of the surveyed surface), where two main subtypes distinguish: aric (ad) in two thirds of the area of the class and erodic (er). The aric subtype has an even spatial distribution on the landforms. Therefore, the cernic aric subtype (ad-cz) occupies 387 ha on the cuesta front (55% of aric anthrosols), the cerno-cambic aric subtype (ad-cc) occurs in the higher area of both the cuesta backslope and front, extending on 105 ha (15%), and the proluvic aric subtype (ad-el) with its 216 ha (30%) prevails in the cuesta front. Erodic (cernic or cerno-cambic) anthrosols have formed on the steep slopes (exceeding 20%), especially on the cuesta front and are enclosed in the fourth and fifth soil quality classes for arable.

The **protisols class** occupies 289 ha, representing 7% of the surveyed area and contains regosols (RS) on 9 ha (3%) and especially aluviosols (AS) on 280 ha (97%). Soil reaction is slightly acid to moderate alkaline (pH = 6.7 – 9.0), the organic matter content is moderate (3.48%) in the case of the molic subtype and extremely low to low (0.3-0.9) at the entic and calcareous subtypes. The texture of aluvisols is very varied. Therefore, on 30% of their surface, the texture is moderate sandy-loamy (with 86-90% fine sand). Then, a quarter of aluvisols have medium sandy-loamy texture (with 75-84% fine sand), 8% of aluvisols have medium loamy texture and 37% clay-loamy texture. Aluvisols typifies the Bohotin floodplain, and regosols occupy in particular the cuesta front.

The low-depth of the phreatic water table, mineralized in certain places, the extremely low organic matter content, the moderate alkaline soil reaction, due to the presence of the Na ion in the complex represent limitative factors of soil quality in this class. That is why, 58% of aluvisols are included in the fourth and fifth quality classes for arable.

By analyzing 18 eco-pedological indicators involved in establishing the mark of land evaluation through a rate varying between 0 and 1, as the feature is unfavorable or optimal, a number of four soil quality classes resulted in Bohotin catchment for arable land: the second class on 414 ha (10% of the agricultural total), third class on 2460 ha (59%), the fourth class on 605 ha (14%) and the fifth class on 697 ha (17%) (Figure no. 10).

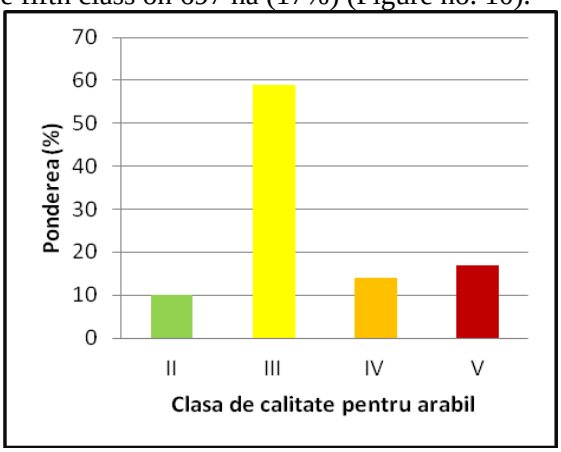

Fig. 10. Weight of the soil quality classes for arable land.

As to the vineyard, six classes of pretability were identified (Figure no. 11). An area of 490 ha (12% of the agricultural total), which contains the structural-lithological plateauss developed on the Bessarabian formations, several reaches of the hilltops and cuts of slightly inclined slopes offer the best conditions for the vineyard and are included in the first class.

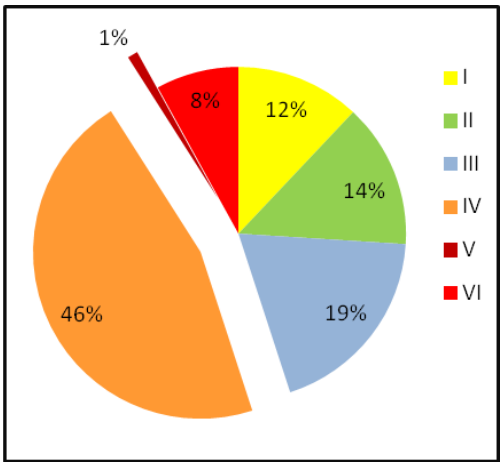

Fig. 11. Weight of the pretability classes for vineyard in the Bohotin catchment.

Most of the slightly inclined land (with slope of 2-5º or 4-9%), situated in particular on the left side of the valley of Bohotin, southern looking cuesta backslope, is included in the second class of pretability and occupies 564 ha (14% of the agricultural total). Moderately inclined land, with the slope of 5-8º (9-14%) and the loamy-clayey texture extend on 803 ha (19% of the agricultural total) and are comprised in the third class of pretability. In the fourth class 1,936 ha are enclosed (46% of the agricultural total), which especially include soils such as the calcareous chernozem and cernic aric anthrosol. The main limitative factors determining the inclusion of soils in this class with serious limitations concerning the vineyard are the slightly-moderate alkaline reaction (pH 7.9-8.7) and the presence of the carbonate-accumulative horizon (Cca), with 13-16% $CaCO_3$ in the top 60 cm.

4. Conclusions

Main genetic relief types within the Bohotin catchment are the structural relief (14%), the sculptural (fluvio-denudational) relief in general monocline (75%) and the fluvial accumulation relief (11%). The slopes are prevailing among the landforms (72% of the total area) and they usually exhibit both the cuesta front and backslope.

The subsequent Bohotin Valley, typical to the first order structural asymmetry, shows two important features, namely: the limited development of the left side (south looking cuesta backslope) triggered by lateral movement of the Prut Valley downstream of Tutora and the marked extension of the northern facing cuesta front, double-storied upstream of Raducaneni.

Under conditions of temperate climate, silvo-steppe and deciduous forest and the influence of human activity, four soil classes and seven soil types were identified. The Cernisols class is stretching on 1,817 ha (44% of the agricultural surveyed area) and it is followed by Luvisols (24%), Antrisols (25%) and Protisols (7%).

A number of four soil quality classes have been identified based on land evaluation marks. By far, the third class is the most significant and covers 2,460 ha representing 59% weight. In return, almost half of the agricultural land (46% or 1,936 ha) is included in the fourth class of pretability.

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