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THE SEMIAUTOMATED IDENTIFICATION OF THE PLANATION SURFACES ON THE BASIS OF THE DIGITAL TERRAIN MODEL. CASE STUDY: THE MEHEDINȚI MOUNTAINS (SOUTHERN CARPATHIANS)[1]

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Abstract: The paper presents a method for the semiautomated classification of the planation surfaces, using the Digital Terrain Model (DTM) and the object-oriented analysis. The effort undergone for developing such a method has a number of motivations. The first one is that these landforms are very important for *decoding* the geomorphologic evolution of the relief units. The second motivation concerns the fact that their identification and mapping, by using classical means, represents a difficult demarche, which requires a lot of time. Finally, the already-known limits of the relief analysis using the DTM at pixel level impose the testing of an object-oriented analysis, in which the area under study is divided into *objects* of various dimensions, as homogenous as possible from the viewpoint of one or more properties. The method that we propose supposes the following steps: the realisation of the slope model and of the flow model, starting from the DTM; the division, by segmentation into *objects* that are as homogenous as possible from the viewpoint of the slope; the classification of the *objects* into landforms (planation surfaces) by using the fuzzy functions and taking into account more factors simultaneously (the average slope value, the minimum slope value, the flow coefficient and the altitude), and the selection and grouping of the identified surfaces into sculptural complexes. The first stages represent the automated part of the method, while the last one requires a detailed geomorphologic analysis of the area, as well as the validation of the results on the field. The method was firstly developed for the Godeanu Mountains, the map of the levelled surfaces (Niculescu, 1965) being used for the identification of the parameters included in the algorithm, as well as for testing the results obtained in the view of the improvement of the method. Due to the good results thus obtained, the same method was also used for mapping the levelled surfaces in the Mehedinți Mountains, and, along with the field observations, there was realised the planation surfaces map for this relief unit.
Key words: planation surfaces, Geomorphometry, Digital Terrain Model (DTM), object-based image analysis (OBIA), Segmentation, The Mehedinți Mountains (Sothern Carpathians)

Rezumat: Identificarea semiautomată a suprafeţelor de nivelare pe baza modelului numeric al terenului. Studiu de caz: Munţii Mehedinţiului (Carpaţii Meridionali). Lucrarea prezintă o metodă de clasificare semiautomată a suprafeţelor de nivelare utilizând Modelul Numeric al Terenului (MNT) şi analiza orientată – obiect. Efortul depus pentru dezvoltarea unei astfel de metode are mai multe motivații. Prima ar fi aceea că aceste forme de relief au o importanţă deosebită în „descifrarea" evoluției geomorfologice a unităților de relief. A doua motivație este faptul că identificarea şi cartarea acestora prin mijloace clasice reprezintă un demers dificil, care necesită totodată foarte mult timp. In cele din urmă, limitele deja recunoscute ale analizei reliefului pe baza MNT la nivel de pixel impun şi încercarea unei analize orientate-obiect, în care arealul studiat este împărțit în „obiecte" de diferite dimensiuni, cât mai omogene în funcție de una sau mai multe proprietăți. Metoda propusă de noi presupune parcurgerea următoarelor etape: realizarea modelului pantelor şi a modelului scurgerii pornind de la MNT; separarea prin segmentare în „obiecte" cât mai omogene din punct de vedere al pantei; clasificarea „obiectelor" în forme de relief (suprafețe de nivelare) utilizând funcțiile fuzzy şi ţinând cont de mai mulţi factori simultan (valoarea medie a pantei, valoarea minimă a pantei, coeficientul de scurgere şi altitudinea) şi selectarea şi gruparea suprafeţelor astfel identificate în complexe sculpturale. Dacă primele etape reprezintă partea automată a metodei, cea din urmă necesită o analiză geomorfologică detaliată a arealului respectiv, precum şi validarea rezultatelor în teren. Metoda a fost dezvoltată prima dată pentru Munții Godeanu utilizându-se harta suprafeţelor de nivelare (Niculescu, 1965), atât pentru identificarea parametrilor incluşi în algoritm, cât şi pentru testarea rezultatelor obţinute în vederea îmbunătăţirii metodei. Datorită rezultatelor bune obţinute s-a utilizat aceeaşi metodă şi pentru cartarea suprafeţelor de nivelare din Munţii Mehedinţiului şi, împreună cu observaţiile din teren, s-a realizat harta suprafeţelor de nivelare din această unitate de relief.
Cuvinte cheie: suprafeţe de nivelare, geomorfometrie, model numeric al terenului (MNT), analiza imaginilor orientată-obiect, segmentare, Munţii Mehedinţiului (Carpaţii Meridionali)

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1. Introduction

Even though they occupy limited areas as compared to the slopes, the planation surfaces and levels have been in the attention of geomorphologists since the end of the 19th century, as these landforms give information concerning the relief genesis and age, being highly important reference points in the establishment of the stages and phases in the evolution of the relief units to which they belong (Posea, 1997).

Regardless of the genesis and of the type of the respective surface, the identification, the mapping and the achievement of the planation surfaces' maps at regional or local scale remains a laborious process, which requires much time and an impressing work volume, including the field activity, in direct proportion with the extension of the area under study. As the geomorphologic cartographic materials do not have national coverage and are not homogenous from the viewpoint of the legend and of the scale, it is very hard or even impossible to do the analysis of these forms for more extended areas, in order to decode the evolution or for practical reasons.

The method that we propose belongs to the area of the ***geomorphometry***, a new research direction among the Earth Sciences, which evolved at the meeting point of geomorphology, mathematics and informatics (Pike et all., 2009). Since the first attempts to digitally analyse the relief, there existed two approach tendencies, so that there can be distinguished a specific geomorphometry, which follows the analysis of the landforms, as discrete elements of topography, and a general geomorphometry, which analyses the relief as a continuous topographical surface (Evans, 1972). In the case of the specific geomorphometry, there were achieved methods for the identification of the linear or circular shapes (Parrot and Taud, 1992), of the narrow ridges (Chorowicz et al., 1995), of the slope types (Irvin et al., 1997; MacMillan et al., 2000; Burrough et al., 2000), or even for the automated extraction of some landforms (Graff and Usery, 1993).

During the last years, at national level, in the field of digital geomorphology, there were certain studies conducted for limited surfaces, but they mainly concerned the morphometric analysis of the relief or the identification of the occurrence areas of various present geomorphologic processes. In this respect, there are to be mentioned the permafrost modelling (Török-Oance, 2001, 2004), the analysis of the gravitational processes (Armaş et al, 2002, 2003), various GIS analyses of mountain geomorphology, including the analysis of the geomorphologic risk (Şandric, 2001; Mihai, 2003, 2004, 2007, Török-Oance, 2005). Few papers deal with the identification proper of certain landforms. There is to be mentioned the first attempt to identify the planation surfaces by using the DTM (Török-Oance, 2001[1]) and the automated classification of the relief elements by using object-oriented classification procedures (Draguț and Blaschke, 2006).

2. Material and methods

The present study comprises two parts: the first one presents the method proposed by us and compares the results obtained by using this method with the planation surfaces' map for Godeanu Mountains, which was realised through careful geomorphologic mapping (Niculescu, 1965); in the second part, there is obtained the planation surfaces map for Mehedinți Mountains – a relief unit for which such a geomorphologic map did not exist. Both areas belong to the Retezat – Godeanu Mountain Group, located in the western part of the Southern Carpathians, where *there appears the most typical and uniform scale concerning the order and number of the erosion steps and their grouping on complexes* (Posea, 2005) and where they were firstly identified by Emm. de Martonne, in 1907.

2.1. The morphometric analysis and the identification of the morphometric elements used in the classification

In order to establish the morphometric elements that best characterise these landforms, the general geomorphologic map of the Godeanu Mountains (Niculescu, 1965) was used as starting point. This was scanned and rectified by using as reference image the digital topographical map, scale 1:25,000, georeferenced in Stereo 1970 coordinates. There were used 34 reference points, mainly confluence points and elevation points (ArcGIS 9.2 soft). The map thus georeferenced was used for the digitizing of the planation surfaces and a vector layer, with polygons differentiated on the three sculptural complexes (Borăscu, Râu Şes and Gornovița), was obtained. This was used to extract and to statistically analyse the data in the morphometric models obtained from DTM.

A SPOT HRS digital terrain model with 30 meters spatial resolution was used in order to realize the morphometric models. The following morphometric models were obtained: the slope

[1] *Aplicații ale Sistemelor Informaționale Geografice în geomorfologie (II). Identificarea şi cartarea suprafețelor de nivelare cu ajutorul SIG*, paper presented at the Geographic Information Systems Symposium – 9th Edition, *Al. I. Cuza* University, Iaşi.

model, the aspect, the plan and profile terrain bending. Since the planation surfaces are relict forms, usually located on interfluves, on the surface of which there can be identified the remnants of slightly deepened relict valleys at the most, we considered that the mathematical model of the flow concentration can offer important information. The statistical interrogation of the morphometric data was realised for every polygon (planation surface). The descriptive statistical variables analysed for every morphometric index were the following: the minimum value, the maximum value, the average value and the standard deviation. Following this analysis, it was noticed the fact that the mild slope represents the essential feature of these forms, followed by the flow concentration, which displays minimum values of less than 80, and the altitude, the planation surfaces being grouped on different altitudinal steps. With respect to the aspect and the terrain bending, the values are very different from an area to the other, and, thus, they are not defining for these landforms.

2.2. Segmentation

The analysis of the relief, on the basis of the DTM at pixel level, has a series of already well-known limitations, such as the impossibility to include into analysis the topological relations (vicinity, connectivity, inclusion) or the form of the objects (Blasche and Strobl, 2002). The significant results obtained in the automated classification of the relief, through the object-oriented analysis (Drăguț and Blasche, 2006) proved the obvious superiority of this method as compared to the pixel level analysis.

The transformation from the pixel level to the *object* or *spatial primitives* level was realised by using the Definiens v.5 programme, through the image segmentation process, which requires the specification of the homogeneity rules by setting the size of a scale. This size is a no-dimension one and, at low values, enables the attainment of smaller objects with higher homogeneity degree, while at high values leads to the attainment of heterogeneous, large-sized objects. Since the slope of the terrain is the essential variable in the identification of these forms, the segmentation firstly regarded the realisation of certain areas (*objects*) as homogenous as possible from the viewpoint of the declivity and big enough to ensure a facile subsequent classification (Fig. 1). There were tested more segmentation variants, with scale values of 10, 20, 30, 50 and 100. The selection of the best segmentation was done through the visual analysis of the results that were overlapped on the DTM and were tridimentionally represented. The best result was obtained at a scale value of 20.

2.3. Classification

The classification process of the objects obtained through segmentation took into account more factors, among which the slope is the most important. Taking into account the values that we identified through morphometric analysis and the data collected from the field literature (according to Posea, 1997, S I has a declivity comprised between 5 and 7 ‰, S II = 20 – 30 ‰ and S III = 5 – 20 ‰), more classification variants were tried. The results were compared through the overlapping of the layer with the digitized planation surfaces over the result of the classification. The best result was obtained when the average slope value for each object was used, and not the maximum values. Other problems faced in the classification process regarded the elimination of the objects displaying the same morphometric features as the planation surfaces, i.e. the floodplains, the terraces and the lakes.

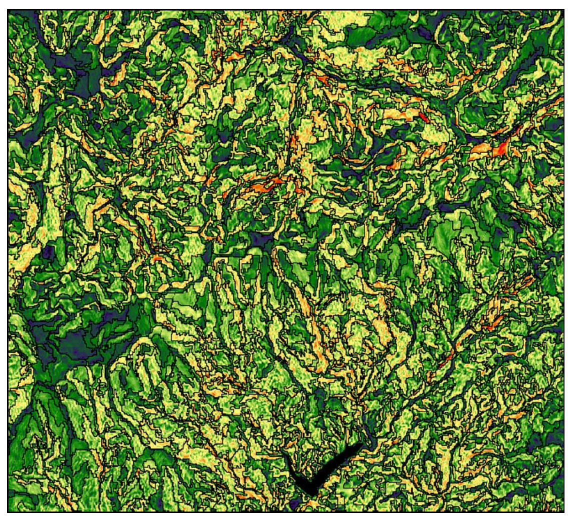

Fig. 1. The spatial primitives or the *objects* obtained through the image segmentation process

Finally, the conditions used in the classification process for the identification of the planation surfaces, were the following:

- the average slope value of under 14 degrees,
- the minimum slope value of less or equal to 2 degrees (in order to eliminate those objects that, although having an average slope value of less than 14 degrees, do not contain horizontal surfaces and, thus, are not planation surfaces),
- under 80 value of the concentrated flow. As previously mentioned, the planation surfaces are relict forms and they are not crossed by any

river. The consideration of this criterion enables a better identification of the planation surfaces, as well as the automated elimination of the flat areas, such as the terraces and floodplains along the rivers,

- an average value of the infrared reflectance of under 45 (there were used Landsat ETM satellite images – band 4). The inclusion of the satellite images in the classification algorithm was necessary in order to exclude the lakes (they can be well noticed in Fig. 1), which, following the *average slope* and *minimum slope* criteria, were classified as planation surfaces.

2.4. Results and discussions

In order to check the correctness of the classification result, this was compared with the map realised by Niculescu (1965) (Fig. 2) and it proved to be 91 percent accurate with respect to the location of these forms. The unidentified surfaces are generally smaller areas that belong to the Râu Șes sculptural complex and that probably have a more accentuated declivity. However, there are to be noticed differences with respect to their shape, as a rule being observed the fact that the proposed method leads to the achievement of slightly bigger surfaces than the real ones. It must be specified the fact that, in contradistinction to the planation surfaces' map realised by Niculescu (1965), in which these forms are strictly represented for the area of the Godeanu Mountains, the result that we obtained covers a much more extended surface, practically all the DTM surface, i.e. also parts of the neighbouring mountain units. These were not included in the evaluation of the method, because of the absence of appropriate geomorphologic cartographic materials.

Practically, following the algorithm, a digital map of the possible planation surfaces is obtained. However, in order to achieve the final map, it is mandatory to further use additional data, such as the field data, the geological data and the aerial photograph-based analysis. Moreover, it is necessary to group them on sculptural complexes, by taking into account the altitude. The method shortens very much the work time and the result is useful both for the field mapping and for subsequent geomorphologic analyses. The utility of the method also lays in the fact that the following elements are accurately known for each identified form:

- the mathematical position, the GPS being successfully used for the field mapping;
- the surface and the perimeter;
- the maximum, minimum and average values and the standard deviations for any morphometric element that is derived from the DTM;
- geological and tectonic data, when such information exist in digital format.

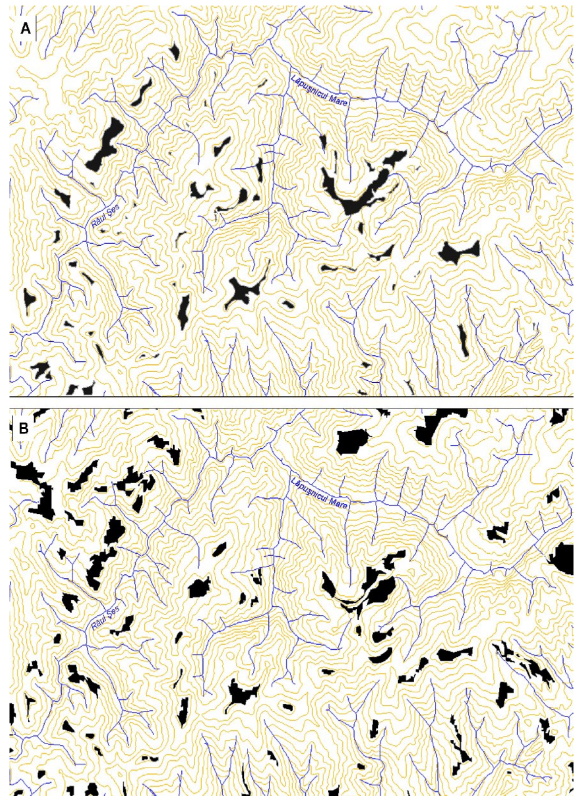

Fig. 2. Comparison between: A, the planation surfaces' map for the Godeanu Mountains (Niculescu, 1965) and B, the result obtained through the object-oriented analysis

The tridimensional visual analysis of the result obtained, or in combination with the anaglyph maps (Török – Oance, 2006), is also very useful in the identification of certain *problematic areas* or in the elimination of errors.

3. The achievement of the planation surfaces' map for the Mehedinți Mountains

In order to realise this map (fig. 3), in the first stage it was used the previously described methodology, including the same type of DTM, and in the second stage the results were validated on the basis of the field mapping, of the digital geological maps (Török – Oance, 2006), of the aerial photograph-based analysis and of the analysis of the DTM-based geomorphologic profiles. In addition to the previously described situation, in the case of the Mehedinți Mountains, the quasi-horizontal surfaces that represent the bottom of the extended karstic depressions were erroneously identified as levelled surfaces. The correction of this error was manually done for the time being, through reclassification; the automated elimination of these situations will be attempted in

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future studies, as this type of errors will probably be encountered in the analysis of any karstic region.

The final map (Fig. 3) was obtained in OCAD 9 programme, by integrating the digital data and the data obtained from field mapping. We chose this solution because in this program it could be built a digital library of conventional signs corresponding to the legend of the general geomorphologic map at big scale (1:25,000), proposed by the Institute of Geography (1993).

4. Considerations on the planation surfaces in the Mehedinți Mountains

4.1. The Borăscu sculptural complex

The presence of this sculptural complex is signalled in all neighbouring mountain units and it can be presumed that it also existed in the Mehedinți Mountains. At present, there can be noticed the existence of certain karst erosion outliers that surpass 1,300 meters altitude and are considered remnants of the Borăscu surface: Stan's Peak (1,466 meters), Piatra Mare a Cloşanilor (1,421 meters) and Pietrele Albe (1,335 meters), Culmea Bradului (1,331 meters) and Geanțul Ismenelor (1,343 meters) (Emm. de Martonne, 1907; I. Ilie, 1970; I. Povară, 1997) (Fig. 3).

4.2.The Râu Şes sculptural complex

It appears very well developed in the Mehedinți Mountains, on crystalline rocks in the northern sector, as well as on limestone, in the central and the southern sectors. It occupies a surface of 19.54 square kilometres, almost equal with that occupied by the Gornovița complex (Fig. 3, A). Two levels can be differentiated: the first one is not much extended, it lies at approximately 1,300 meters and it develops exclusively on limestone; the second one, with important extension, is comprised between 1,200 meters in the central part and 800 – 900 meters in the south.

The Râu Şes I level occupies a surface of 3.4 square kilometres, being mostly destroyed by erosion. It appears only on limestone and solely south of Arşasca (Fig. 3). Its greatest extension is in the area of the main ridge of the Mehedinți Mountains, in the central sector, between the Arşasca and the Țăsna valleys, where it also registers the highest altitudes, around 1,300 meters. It is dominated by some calcareous peaks that rise up to 150 meters above this level.

It has the shape of small karst plateaus or of planed ridges, which often have structural character, as in the case of those located east of the Pietrele Albe Peak. The great negative karstic forms located between Stan's Peak and Țăsna deepened in this level (I. Povară, 1997), which can be easily reconstituted; although the calcareous ridge situated westward of the karst depressions is narrow and strongly fragmented, it still remains at a relatively constant level of 1,200 – 1,250 meters of altitude (Photo 1).

South of the Țăsna valley, the appearance of this level is only exceptional (Fig. 3). It is to be noticed that the altitude of the outliers of this surface decreases towards south: Inălățu Mare (1,301 meters), which dominates Balta Cerbului karst depression, probably also deepened in this level, Colțu Pietrii (1,229 meters), Şuşcu (1,192 meters) Rudina Mare (1,177 meters) and Grăbănic (1,131 meters), the last one being also developed on the formations of the Severin Thrust-sheet.

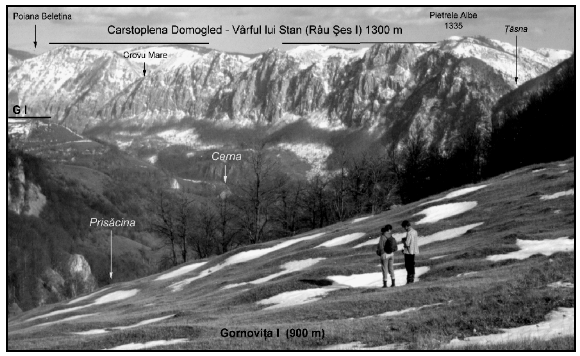

Photo 1 The Domogled – Stan's Peak old Karstplain, seen from the Cerna Mountains

The Râu Şes II level is much more extended than the previous one, covering 16.14 square kilometres (Fig. 3, A). It is present in the northern sector, as well as south of Arşasca. There are to be distinguished two different situations:

- *The Râu Şes II level developed on crystalline rocks* appears in the northern sector, on the Ridge of Cerna and in the southern sector, between Grăbănic Peak (1,131 meters) and Meteriz Peak (722 meters). Depending on the type of rock, there appear differences concerning the morphology and the extension of this level. Thus, in the Ridge of Cerna, where this level cuts off granitoids, it takes the shape if a rounded top, locally levelled into small plateaus, more developed south of Cioaca Înaltă Peak (1,137 meters), but without surpassing 300 meters breadth (L. Badea et al., 1981). The ridge maintains a relatively constant altitude of 1,000 – 1,100 meters and it is dominated by generally rounded peaks, genuine erosion outliers, among which the highest are Cioaca Înaltă and Ştevaru (1,212 meters). These peaks can be considered outliers of the Râu Şes I level. Because of the lower altitude at which the remnants of these surfaces appear, as compared to the central sector, some authors (I. Povară, 1997) consider that the Borăscu and the Râu Şes surfaces are missing in this sector, as a consequence of the total destruction through erosion and that the highest peaks on the Cerna Ridge are remnants of the Râu Şes II level. As previously shown, the absence of limestones, along with other factors, permitted the total destruction of the Borăscu surface. The lower altitudes at which the Râu Şes complex appears here, as compared to the karst regions, can be also explained by the petrography differences. From our viewpoint, the integration of these surfaces in the Gornovița sculptural complex would be erroneous for at least two reasons:

- the much higher altitude, of more than 1,000 meters, at which this surface would appear, as compared to the situation from Godeanu and Cerna Mountains, where the Gornovița level maintains an altitude with 100 – 200 meters lower (Gh. Niculescu, 1965 and D. Gureanu, 2004) on the right slope of the Cerna. Moreover, in the Vâlcan Mountains, the Gornovița surface is registered at a maximum altitude of 900 meters (L. Badea et al., 2001).
- if it is considered that this surface belongs to Gornovița, it appears impossible to correlate it with the other relief steps on the eastern side of the Mehedinți Mountains.

The integration of the surfaces on the Cerna Ridge in the Râu Şes sculptural complex appears, thus, as obvious. The same opinion appears in the chapter dedicated to the Mehedinți Mountains, in the Geography of Romania, volume III (1987). Furthermore, this level appears well represented south of the Milean valley, in Plaiul Păltinei (1,049 meters) and in Cioaca Frasinului, at about 1,100 – 1,150 meters of altitude. It takes the shape of rounded ridges, or even of small plateaus, elongated on the direction of the ridge, remarkably flat sometimes, as in the case of that located south of Cioaca Frasinului Peak, bearing the suggestive local name of Poiana Punții.

In the central sector, on the interfluves bordered by the Țăsna, the Coşuştea and the Carmazanu, this level is present and well represented. It cuts off the wildflysch formation, as well as the ophyolitic complex of the Severin Thrust-sheet and it can be radially followed around Ciolanu Mare Peak (1,135 meters) and up to 950 meters of altitude, on the ridge that starts from Ciolanu Mic Peak and heads towards north-east.

In the southern sector, the Râu Şes II level cuts off the crystalline rocks of the Getic Thrust-sheet. It has the appearance of broad, uniform bridges that level the main ridge and occupy rather important surfaces, such as the one in Poiana Rachelii, covering almost one square kilometre.

- *The Râu Şes II level carved in limestone*, has a different appearance:

- as a suspended old karstplain (M. Bleahu and T. Rusu, 1965), bordered by escarpments or steep slopes, in the central and southern sectors and it is characterised by a particular topography. The planation surface shape is to be found only in the central sector, eastwards of the main ridge, but even there it often has a structural character. South of the Țăsna valley, because of the stronger deepening of the valleys of the tributaries of the Cerna, the karst plateau is divided into small massifs (L. Badea el al., 1981), so that the Râu Şes II level is maintained on smaller surfaces. More extended surfaces are noticeable in the Cociu, the Hurcu and the Şuşcu massifs, where there appear karst plateaus at about 1,100 meters (Fig. 3). Some of these can be considered as relict, such as the one in Culmea Vârtoapelor (I. Povară, 1997). The structural plateau unfold southwards of the Domogled ridge probably also belongs to this level.
- as a flat and extended plateau in the Obârşia ridge, cutting limestone and other sedimentary rocks. It is the most representative area for this type of relief in the Mehedinți Mountains. The plateau, extended on a surface of more than 3 square kilometres, is mostly forested, it maintains 1,000 – 1,100 meters of altitude and is dominated by erosion outliers, probably remnants of the Râu Şes I level: Cioaca Lacului (1,150 meters) and Poiana Mică (1,180 meters).
- as calcareous shelves, with an obvious structural character, on the southern slope of the Piatra Cloşanilor, at 950 – 1,000 meters of altitude.

4. 3. The Gornovița sculptural complex

The surfaces that permitted the reconstitution of this sculptural complex occupy 19.43 square kilometres. The occurrence area of this complex is mainly the eastern slope of the mountains and the northern sector (Fig. 3). Only in rare cases does this surface develop on limestone, mainly appearing on other sedimentary rocks, as well as on metamorphic and eruptive rocks. Two altimetrically differentiated levels were identified:

Gornovița I level is the most extended level within this sculptural complex. It is found on the secondary ridges, under the form of rounded or levelled sectors. It is well represented in the northern sector, where there is to be noticed the hydrographical basin of the Dobrota, in which the secondary ridges leaving from the Cerna Ridge, as well as those leaving from Cioaca Frasinului are levelled at about 850 meters in the origin sector and at 750-800 meters near the confluence with the Capra river. The ridges that descend from the Cioaca Înaltă towards the Dobrota river are deforested and are occupied by numerous small shelters and isolated houses in the levelled sectors. Of these ridges, the longest one is Plaiul Cernei, over 6 kilometres long, descending in steps towards the confluence of the Dobrota with the Capra. It is almost entirely deforested and it is crossed by an old pastoral road that connects the Motru valley, the Cerna valley and, through the Oslea Table land, with the pastures from the Alpine level of the Godeanu Mountains. The southern part of the Cioaca Frasinului small crystalline massif , between the origin of the Iapa Mare gully and Cracu Pietrii, is also a representative area for the occurrence of this level. Because of the mild slope characteristic for the area, the forest was cut and replaced by pastures and numerous shelters.

The secondary elongated ridges that depart from the Obârşia Ridge towards east, formed in the crystallyne rocs of the Getic Thrust-sheet or of the Severin Thrust-sheet, as well as in the wildflysch sedimentary formations, bear the traces of the Pliocene modelling. Generally, the higher ridges, with east-west orientation, such as the Ridge of the Paharnic or the Măgura Ridge bear the traces of the Gornoviţa I level, the morphology of which is that of levelled ridge at about 750-850 meters, marked by the presence of erosion outliers with little altitude differences and with rounded, knolly aspect: Peak of the Paharnic (885 meters), Vârful Înalt (732 meters), Ochianu Peak (757 meters) and Măgura Peak (797 meters).

In the central and southern sectors, the Gornoviţa I level can be recognised on almost all secondary ridges that descend towards the Mehedinţi Tableland. It is to be noticed an altitudinal decrease of this level from the north to the south. Thus, in the Ciobanul, the Costeşti and the Camena river basins it maintains an altitude of about 800 meters, as in the case of the ridges Băia, Padina Turmei, Dealul la Şest and Comorîştea, while south of the Gherghenițu valley, this level appears only at 700 – 750 meters of altitude.

The ***Gornoviţa II level*** is rather characteristic to the Mehedinţi Tableland and especially to the Bahna basin. In the mountains, it appears especially in the northern sector, where it penetrates along the Motru, the Lupşa and the Brebina valleys. Southwards of the Coşuştea it has a discontinuous occurrence in the border sector between the mountains and the tableland. From the morphological viewpoint, it is similar to the previous level, the planed or rounded ridges that maintain 650 - 500 meters of altitude being dominant. This level, much extended on the interfluves between the Lupşa and the Motru Sec, is entirely developed in Cretaceous wildflysch and displays significant flatness and relatively constant altitudes of 600 – 650 meters. Near the Muchii Peak (661 meters), the ridge takes the aspect of a small plateau, with breadths that can surpass 500 meters (Fig. 3).

The Gornoviţa surface in the Cerna basin, on the slope corresponding to the Mehedinţi Mountains, appears under the form of valley replats levels. Gh. Niculescu (1965) is the one to notice the presence, in the upper course of the Cerna, of a number of replats levels that certify the rhythmic post-Miocene deepening of the valley. Among these, the 700 - 900 meters level is considered synchronic with the Gornoviţa level. The subsequent studies (L. Badea et al., 1981; I. Povară, 1997) support this presumption and underline the presence of the valley replats levels also in the middle Cerna basin. Trying to connect these levels, we consider that in the Băile Herculane region, the 750 meters replats level corresponds to the Gornoviţa I level, while the 600 meters one to the Gornoviţa II level. In most of the cases, on the slope of the Mehedinţi Mountains, these replats levels coincide with faulted compartments, lowered in steps towards the Cerna; thus, the integration of these levels in the Gornoviţa sculptural complex is possible but it must be regarded with a lot of reserves.

An interesting situation is that within the lower areas located eastwards of the line of the Geanţuri. In this area, the secondary ridges that descend from the Cerna Ridge are heavily levelled, representing small elongated plateaus that, in the near vicinity of the contact between the granitoides and the limestone, astonish through their horizontal character, strongly contrasting with the surrounding karst ridges. Their integration in the 700 – 800 meters altitudinal level, at which the Gornoviţa level appears on the opposite slope, in the Cerna Mountains (D. Gureanu, 2004), made us presume that these ridges would integrate in the Gornoviţa. Sculptural complex.

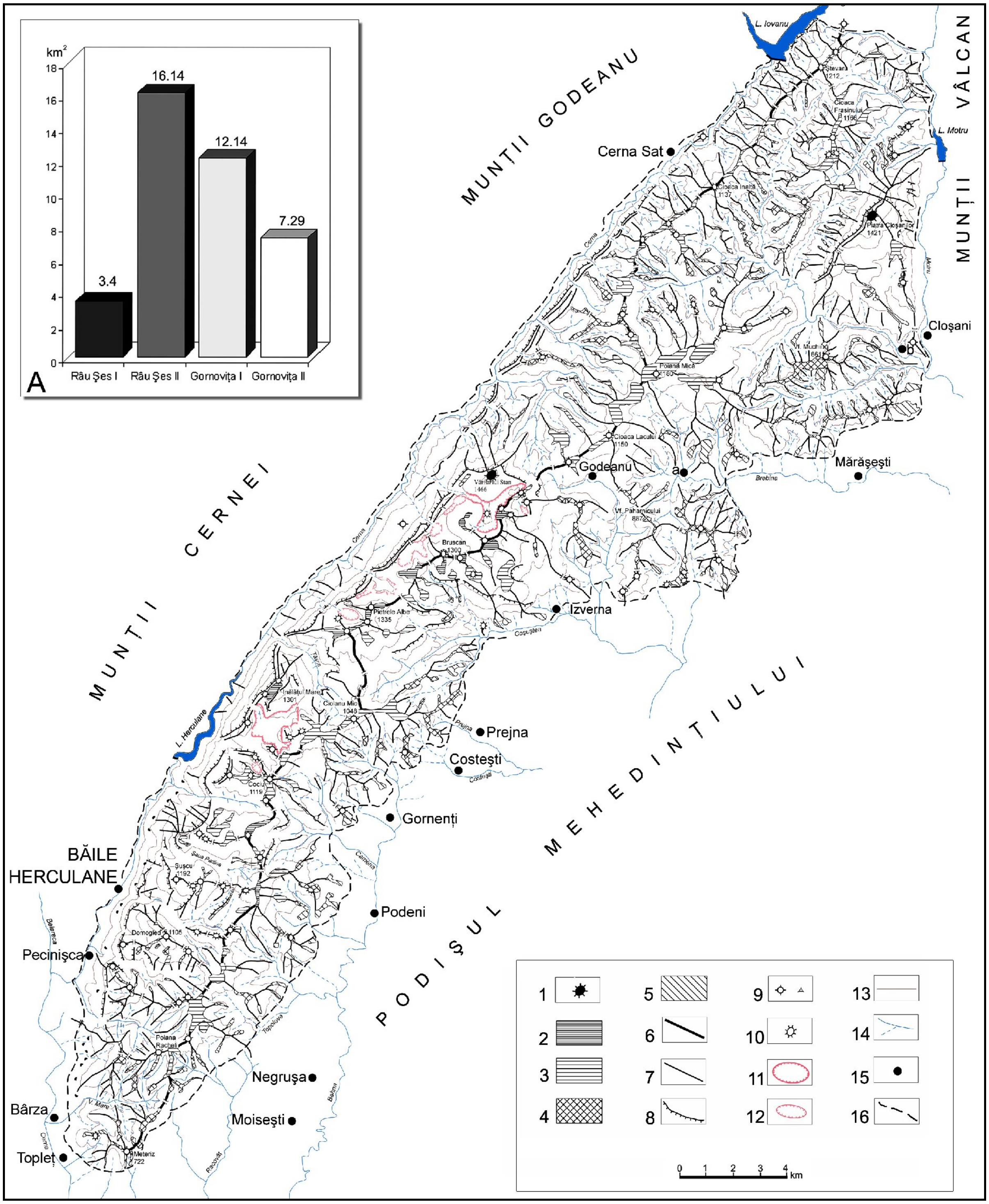

Fig. 3. Map of the sculptural complexes from the Mehedinţi Mountains:
1, outliers of the Borăscu level (over 1,300 meters); 2, Râu Şes I (1,100 – 1,300 meters); 3, Râu Şes II (850 – 1,100 meters); 4, Gornoviţa I (750 – 900 meters); 5, Gornoviţa II (500 – 650 meters); 6, main ridge; 7, secondary ridge; 8, calcareous escarpment; 9, rounded peak/pyramidal peak; 10, erosion outlier; 11, open karst depression; 12, uvala, doline; 13, contour lines equidistance of 200 meters; 14, rivers; 15, settlement; 16, limits of the Mehedinţi Mountains; a, Obârşia Cloşani; b, Motru Sec; A – The surface occupied by each level.

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