

# Some contributions to the drawing of the general geomorphic map using GIS tools. An application to Timis Mountains (Curvature Carpathians)

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**Keywords:** geomorphic map, GIS, vectors, DEM, overlay, legend.

**Contribuții la întocmirea hărții geomorfologice generale cu ajutorul SIG. Aplicație la Munții Timișului (Carpații Curburii).** Harta geomorfologică a Munților Timișului (Postăvarul-Piatra Mare-Clăbucetele Predealului) a fost întocmită la scara 1:25000. Aceasta este o sinteză a tuturor temelor vector ale unei baze de date SIG, la nivel de tipuri genetice de relief, grupate în funcție de dimensiuni și particularități spațiale. Selecția simbolurilor cartografice a avut la bază structurile de legendă existente, adaptate la particularitățile terenului. Facilitățile oferite de pachetele software au permis alegerea simbolurilor din biblioteci precum și controlul pozițiilor reale prin tehnica overlay. Harta a fost corelată permanent cu harta geologică și imagini satelitare, ceea ce a permis un grad de acuratețe remarcabil, evaluat și cu ajutorul punctelor de control GPS în teren. Cu ajutorul datelor derivate din Modelul Numeric Altitudinal (declivitate, umbrire) a rezultat un grad de expresivitate considerabil.

## 1. Introduction

The general geomorphic map has proved, in time, its position as a key, synthetic map, that cartographically accomplishes any regional geomorphological study. In the past decades, through their contributions, geomorphologists had in view not only its scientific substantiation, but also an improvement of representation methods, by creating and adapting some of the map legends adequate to different scales and regional relief particularities. As a result, publications of theoretical and practical value appeared (Demek, 1972, Klimaszewski, 1963, 1982, 1990). The high interest shown in the field of geomorphic mapping stimulated, the creation, during the IGU congress in 1956, of a special commission of geomorphic cartography, which attempted a standardisation of map legends and representation methods at different scales, and tried to encourage the geomorphology schools to use, and thus to enrich representation methods, in order to offer more complete and complex information useful to theoreticians and especially to practitioners (Demek, 1972, Demek, Embleton, 1982, Grigore, 1972, 1979).

Romanian geomorphology adapted to this trend, successfully applying graphical representation methods to complex relief descriptions, in the context of the very first regional studies. Following the first simple, but suggestive maps, included in regional studies of great historic value, rendering mainly landforms types and levels (Tufescu, 1937, Vâlsan, 1939, Popp, 1939, Orghidan, 1969 etc.), a new phase was represented by the detailed maps at large and medium scale, with extended legend, drawn according to modern principles, sustained, as well, by the new editing technologies, and the black and white or colour printing (Posea, 1962, Niculescu, 1965, Badea, 1967, Roșu, 1967, Donisă, 1968, Mac, 1972, Grumăzescu, 1975, Ichim, 1981 etc.). Simultaneously with the international achievements, new map legends and drawing methodologies for the general geomorphic map were applied and permanently perfected by the Romanian scientists (Posea, Popescu, 1964, Martiniuc, 1971, Grigore 1973, Ungureanu, 1978, Badea, 1993, Ielenicz, 2000, Posea, Cioacă, 2005). Map legends have been drawn also within research projects, which implied mapping Romania's relief at medium and large scale (1:200,000, 1:50,000, 1:25,000); these projects were initiated but only the

representation methodology was completed. The project of creating the geomorphic map at 1:50,000 scale, for example, developed by the University of Bucharest within the Faculty of Geography with funds from the World Bank (1997-2002), allowed the editing of a new legend and, on its basis, the elaboration of Sinaia, Victoria and Măcin map sheets.

A new challenge in the field of relief cartography was the development of computerised techniques in the frame of Geographical Information System (GIS). Although a considerable regress is noticed in the preoccupation of drawing these thematic maps (Rădoane & Rădoane, 2007), some of the geomorphology schools continued the improvement of map legends and representation methods, and, more important, they moved forward by bringing the applications at GIS standards.

Here we remind the Swiss geomorphology school, where the tradition of terrain mapping has been continued by creating special legends (see Atlas der Schweiz - Atlas de la Suisse, the relief type sheet, red. E. Imhof). A notable contribution belongs to researchers in Lausanne, who, for over a decade have improved the large scale geomorphic map legend (Schoeneich, 1993, Reynard et al., 2005). This map legend has been widely applied in digital environment, in case studies on the Swiss Alps and Prealps (Schoeneich et al., 1998, Gentizon et al., 2001). The above-mentioned legend was first applied in Romania on the Geomorphic Map of the Bucegi Plateau (Werren, 2007, unpublished bachelor degree dissertation held at University of Lausanne). In the context of GIS applications, geomorphologic cartography has become a field of interest, considering especially the new algorithms that allow the modelling of topographical data, or the passing from classic 2D maps to the three-dimensional ones, to map-server applications that allow the user to design the map according to his own needs (Häberling, Hurni, 2002). Advanced researches are made by a group of scientists who work on mountainous cartography in Switzerland and the alpine states. Differences in elaborating the general geomorphic map in GIS imposed the use of standard methodologies for creating data bases and generating symbols, as a consequence of the problems encountered in redefining the cartographic language, because new possibilities of

combining and actualising information appeared for a more precise and suggestive representation of landforms (Gustavsson et al., 2006, Gustavsson et al. 2007).

For Romania, the procedure of elaborating the geomorphic map in GIS is recent, this achievement belonging to the last decade. Some of the studies include series of maps that used software programs able to recognise the topological proprieties of the spatial entities (Armaș, 1999, Armaș et al., 2004, B. Mihai, 2005, Condorachi, 2006 etc.). The present study analyses specific problems occurred in creating a GIS cartographic representation.

## 2. Methodology

Drawing the general geomorphic map in GIS is made according to the principles of the specific applications of this system (Bernardsen, 2001). Considering the consistence of literature in this scientific field, we insist on the actual problems occurred during the elaboration of Timis Mountains map, Curvature Carpathians (B.Mihai, 2005). The following steps were followed in editing this cartographic material:

- identifying and retrieving specific geographical information;
- converting the geographical information to a GIS format;
- selecting the map legend and its management;
- the actual editing.

*Identifying and collecting geographical information* (Table 1) proves necessary considering the fact that no large and medium scale maps were drawn for the mapped area before. Only restricted areas were, partially, subject for this type of representation (Oprea, 2005, for Prahova mountainous basin), like Sinaia map sheet at 1:50,000 scale, unpublished (Ielenicz, Popescu, 1999), which includes just the southern side of Clăbucetele Predealului. Geographical information is gathered from different sources, including topographic and geological maps, satellite imagery, aerial photogrammetry, and, also, field map-making.

The 1:25,000 scale topographic maps used state, first of all, the final map scale. Moreover, their scale influences field mapping quality. Data derived from these maps are connected to the topography (10 m interval contour lines, altitudes, steeps represented through symbols and dashes), and to the major drainage network. In this context there were used the only maps available, edited in

1982 at the mentioned scale. Data age is not a defining element in terrain map-making. After being converted in digital format, these 9 map sheets (in our case), allow drawing out the information with support value in relief graphical representation.

The only sources of geological information were the 1:50,000 scale available geological maps. These maps cover the entire mountain space mapped, and they give extremely necessary data, considering the great expand of lithologic and tectonically shaped relief-types. The stratigraphical and lithological information is richer than the structural-tectonic one, this imposing the data correlation with the isohypses and special field mapping. The fact that the scale of the topographic maps was twice smaller didn't induce major problems, because geo-correction permitted a nearly perfect superposition of the information layers.

A considerable advantage was the satellite images and the aerial photographs, taking note of the high fragmentation of this mountain space and the great accessibility problems of some of its sectors (B. Mihai, Şandric, 2004). Although their spatial resolution is limited (10 m at the Spot Panchromatic images, 30 m for Landsat TM, respectively), satellite images cover the whole studied mountain area in one scene. We selected images with a spectral resolution that superposed over the visible and infrared spectral intervals. The Spot 4 Panchromatic, from July 1997, offered very useful images, at 10 m resolution and an overcast of less than 2 % of the sub-scene, considering the high forest covering (about 75 % of the mapped surface). After being submitted to geometric corrections, this digital image was considered a reference informational layer. Because of the inconsistency of auxiliary information, aerial photographs couldn't be used in creating a digital mosaic. No for the less, they partially cover the whole area, spatially and temporally (1956, 1972, 1980, 1985, 1990 flights). Their resolution (0.5-1 m) is a remarkable advantage in localising small landforms from areas without forest.

Although an ancient method, field map-making was an important part of the study. Small landforms' diversity and great number, along with the necessity of correctly identifying the relations between terrain on one side and lithology and structure on the other, required systematic field campaigns, carried on from May 1997 to December 2003. These campaigns were conducted mainly within the areas where the morphological

problems were most complex (watersheds, imminent river catchments, erosion surfaces, small basins, river beds, structural ridges, subalpine barren lands etc.). The above mentioned topographic map and the geological map were the working basis, at which we added a great number of colour detailed and panoramic photos. After studying the maps and the aerial images, the planning of mapping campaigns was set on the selection of typical routes that would have permitted the gradual coverage of the whole mountain space in study. Typical landforms and wide land coverage points were taken in view.

*Converting the geographical information in GIS format* is the main element that underlines the passing from the classical format paper map to the digital map. Considering this fact, the lack of digital information led to the design of GIS applications meant to structure data sources and especially the information derived from their content into informational layers. An exception was the Spot Panchromatic digital satellite image, which still needed to be geometrically corrected.

The topographic map required several high resolution scanning (as much as over 300dpi), followed by geometric corrections, in order to associate the resulted pixels with their real position, reported to the Gauss-Krüger projection coordinates and to the 1942 Pulkovo Datum (ellipsoid). These procedures characterised the final map as well. The projection correction of the topographic maps was made considering the rectangular coordinates and allowed the set-together of a map mosaic that successfully covers the mapped area, with a field error of 10-20 m (for an area of over 370 km<sup>2</sup>). This mosaic of maps was used in the geometric correction of the geological maps and satellite images, which served to the indirect acquirement of other different information.

On the basis of this mosaic map, the topographic surface numerical model elaboration was initiated. Firstly, the 10 m interval contour lines (main and secondary) were entirely vectorized, including the auxiliary lines, the accidental ones, and the altitudes. This part occupied most of the geomorphic map editing time (over 50-60%). This solution was chosen given the circumstances of highly fragmented topography of the analysed mountain space (more than 10 km/km<sup>2</sup> in some sectors, according to the GIS analysis, B. Mihai, 2005) and the relief energy of over 1300 m, on a structurally and lithologically complex substratum (V. Velcea, 1970).

A distinct approach required the steep sectors. The presence of intense slope changes, represented on the topographic map by dashes and contour lines discontinuities imposed testing new representation methods. The contour lines' interruption was chosen, for the steep sectors, along with the automatic interpolation of existent points, without plotting new ones. This method was suitable especially where the slope surfaces were limited, so that interpolation errors of the triangulation model were punctual.

On the basis of the topographic maps, an Digital Elevation Model (DEM) was elaborated with a 10 m resolution, with a sufficient resolution to overlay the small landforms in the field as vector thematic layers. Most of the landforms in the Timiș Mountains are over 10 m in height (except for the small islands within the channel, gullies waned under the forest, steep river shores, isolated blocks of rock etc.).

The DEM was generated by interpolation of topographic data as a raster layer which generated a new thematic layer, that of slopes. As a characteristic of the topographic surface, declivity is used in the background of the geomorphic map, first to explain the localisation and association of the complexes of small landforms, and second, to offer a more expressive image of the map. The possibility of drawing the slope map from DEM is another great advantage of the GIS environment, because it allows a reclassification of the declivity thresholds, in accordance with the purpose and selection of the most adequate legend.

In our case colour shades were chosen (Fig. 1), for no difficulties in reading and interpretation after the overlaying of colour symbols. The 15 and 30° limits were selected to reset the declivity values, in agreement with the topographic characteristics, so that the valleys, steeps and interfluves could be identified without the need of any distinct symbols (dashes, colour trends). In addition to this, DEM allowed the derivation a new thematic layer, that of topographic surface aspect, which takes in consider its shading at certain values of solar elevation and azimuth (hillshade model). A selection was made for the values that show with the greatest accuracy structural asymmetries of interfluves, so that in combination with the slopes they would offer the map a higher expressivity and would facilitate its interpretation process. The two thematic layers (slopes and shading) were superposed in order to amplify shading transparency, and by that, to easily identify the declivity areas.

On this complex background the superposing of strictly geomorphologic information was initiated. These were the result of the centralisation of multiple digital mapping results, with the creation of new vector themes, conditioned by the specificity of conventional marks (Table 1, Figure 1). During the field campaigns, mappings were synthesised on areas from the topographic map and verified on SPOT satellite images, aerial photographs and geological maps. The thematic organisation of information was made in the same order, from major landform levels to widely extended genetic relief types, to the actual morphodynamics and the elements of cartographic base. As a synthetic terrain representation, map editing enforced the selection of only the most important elements of the concluded mappings. All the remained vectors were the object of different maps with geomorphologic thematic (morphostructure, morphopetrography, periglacial and morphodynamics maps) included in a distinct study (B. Mihai, 2005). Only a quarter of the vector themes created in agreement with field reality was, thus, selected.

*The map legend selection and its management.* Besides the carefully choosing of vectors themes that became spatial geomorphologic entities, the selection of the most adequate symbols was also a necessity, and their ordination for visualisation on thematic layers as well.

A total of 45 themes were selected for the Timiș Mountains General Geomorphic Map, of which 43 in vectorial format (shape files), two in raster format (slopes and shading), respectively. The selection considered choosing illustrative features of the terrain, which can be represented at 1: 25,000 scale. Because of this reason, certain elements gully thalwegs, microforms of small rivers floodplains, human induced depressions etc., were eliminated. More, the idea of considering the temporary hydrography part of the cartographic base was abandoned, because, viewed its high density and complexity, it would have complicated map reading and interpretation processes.

The chosen legend was based upon the many symbols used in local map legends published in time. The final choice was a more recent map legend (Ielenicz, Popescu, 2001), used in drafting the 1:50,000 scale geomorphic map, Sinaia sheet. Even if the scale was smaller, we adapted it to our demands, considering the possibilities of generating symbols in digital format.

Selected symbols were adapted to the field, scale and most of all to the digital and, afterwards, to printed representation possibilities. Relatively restricted symbol libraries enforced, in some cases,

a new adaptation of the legend to encountered problems. Some situations occurred when the symbol kept its colour but it was replaced, because some elements couldn't be represented at scale any more (e.g.: dolines-like microforms or more extended nival micro-depressions). Polygon themes generating was restricted to selecting colour shades attached to the configuration,

without describing the microforms in detail (e.g. dejection cones, local landslides, terrace bridges or erosion levels). In this case overlapping on the slope background offered more expressiveness. Some of the microforms were represented through vector associations, within the same theme (e.g. saddles systems) respecting map's scale.

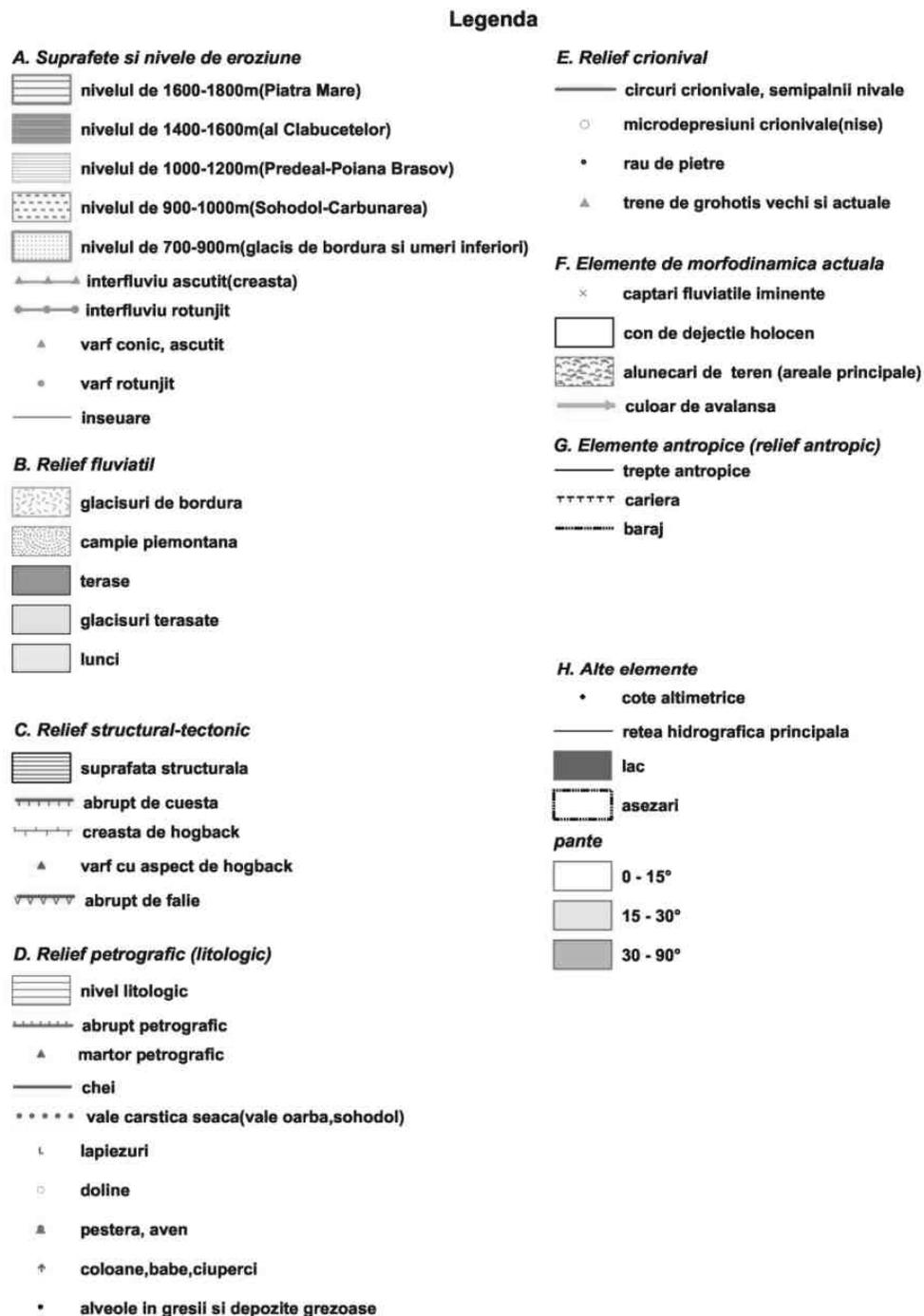


Fig. 1 Legend of Timis Mountains (Curvature Carpathians) Geomorphic Map

The degree of forest covering (about 75%) induced major difficulties in geomorphologic mapping. In this situation, microforms under the forest were less recorded, considering their dimensions and soil and trees coverage. These are mostly very dense thalwegs, fixed debris, isolated inactive steeps etc. They were chosen taking into account their dimensions and specific evolution. Considering the intense fragmentation, the interfluve networks were represented to explain this characteristic of mountain relief. Interfluves increase map expressiveness in combination with the relief levels areas (erosion levels, see Vâlsan, 1939, Ielenicz, 1972, Posea, 1999).

Legend organising or management implied gradual visualisation of informational layers. The main problem was setting the information in the final format, through a backward legend visualising. The point shaped themes (Table 1), representing punctual microforms (caves, dolines, peaks etc.), were overlapped first to the line-themes (cuestas, ridges, gorges, thalwegs etc.), and then to the polygon-themes (relief levels, landslides, dejection cones, settlements, slopes, shading). In this respect, we pass to legend's text drafting, in the classical order adopted by most of the authors. This imposes a permanent check of the symbols reporting to the map, and a correct ranging, from the smallest to the greatest forms, from the most evolved to the most recent ones,

from the erosive to the accumulative ones, concluding the cartographic base. The latter was simplified at the maximum level, the temporary streams and communication routes being eliminated. The only elements introduced, represented with contours for an easy interpretation, were the human settlements, derived from the separated land use vectorization (SPOT PAN 1997 image source).

*Editing.* The map comes along with the complete legend, the graphical scale (automatically generated and adapted, respectively, as a result of map projection recognition in digital environment), the title and orientation. Cartographic representation comprises all the elements of a general geomorphic map, although editing was made in digital environment only. Map printing can be made in any chosen format, but this requires the use of a high resolution plotter, connected to the computer on which the application was rolled.

Most of the times, printing induces difficulties, as the highest fidelity printing is made from the soft format that generated the map and large format printing equipment is rarely available. In our case, we exported the map in image format that can be opened and printed. This involves some resolution damages. Thus, exportation is made at great resolution values, even if it slows down the conversion process.

Table 1 Characteristics of digital themes composing the General Geomorphic Map

Landform	Topology	Information source	Validation
Erosion surfaces and levels	Polygon	Topographic map Geologic map Field mapping ANM	Geometric connection correlated with geologic data Checked on panoramic images
Interfluves	Line	Topographic map SPOT image Aerial photographs	Checked on panoramic images
Peaks	Point	Topographic map Aerial photographs Field mapping	Checked on panoramic images
Saddles	Line (association)	Topographic map Aerial photographs Field mapping	Checked on panoramic images
Border glacis, piedmont flats	Polygon	Topographic map Aerial photographs Field mapping	Checked on panoramic images
Terraces, terraced glacis, floodplains	Polygon	Topographic map Aerial photographs Field mapping	Checked on images, cards, field drafts
Structural surfaces	Polygon	Topographic map Geologic map Field mapping ANM SPOT satellite image	Checked on field
Cuesta, hogback cuesta, hogback crest, fault steep, petrographic steep	Line	Topographic map Geologic map	Checked on panoramic images and 3D models

		Field mapping ANM SPOT satellite image Aerial photographs	
Hogback-derived peak, lithologic outliers	Point	Topographic map Geologic map Field mapping ANM	Checked on panoramic images and 3D models
Lithologic levels	Polygon	Topographic map Geologic map Field mapping ANM	Checked on panoramic images and 3D models
Dry carstic valley	Line	Topographic map Geologic map Aerial photographs Field mapping	Checked on filed Photographs
Karstic microforms and other lithologic microforms (rom. babe, ciuperci, alveole)	Point	Topographic map Geologic map Field mapping	Checked on filed Photographs
Crionival cirques	Line	Topographic map Field mapping Aerial photographs SPOT satellite image	Checked on field Photographs
Crionival microforms (debris, niche etc.)	Point	Topographic map Field mapping Aerial photographs	Checked on filed Photographs
Imminent fluvial catches	Point	Topographic map Field mapping Aerial photographs	Checked on field
Alluvial fans	Polygon	Topographic map Geologic map Field mapping Aerial photographs	Checked on field
Landslide areas	Polygon	Topographic map Geologic map Field mapping Aerial photographs SPOT satellite image	Checked on field Panoramic images
Avalanche corridor	Line	Field mapping Aerial photographs SPOT satellite image	Checked on field Panoramic images
Dams, quarries, human induced steps	Line	Topographic map Field mapping Aerial photographs SPOT satellite image	Checked on field Panoramic images
Altitudes	Point	Topographic map	
Main fluvial network	Line	Topographic map	
Lakes	Polygon	Topographic map Field mapping Aerial photographs	Checked on field
Settlements	Polygon	SPOT satellite image Aerial photographs	Checked on field Panoramic images
Slope	raster (grid)	ANM	Checked on field

### 3. Interpretation elements

The edited geomorphic map provides synthetic information regarding the morphology of the mapped mountain area. Its drafting method and format impose some constraints in its interpretation, which will be further discussed.

The map selectively displays all the characteristic landforms of Postăvaru-Piatra Mare - Clăbucetele Predealului mountain area. These were selected from all the vector themes created for the geomorphological study of this region. Many landforms were eliminated due to their small size, and, moreover because of visualization and reading difficulties. Our intention was, thus, to design a

well-balanced relief representation that would include all relief levels and genetic types, and, especially to obtain a relative proportion between categories. The cartographic base was simplified, in order to eliminate any possible confusions in reading and interpretation.

Map analysis and interpretation can be performed on map sectors or function of relief genetic types. We used the second option, but also included two map patterns that comprise most of the symbols from the legend. The analysis according to the genetic types (Pecsi, 1977) offers the advantage of enclosing essential and complex features of the map's relief.

*Erosion surfaces and levels* were mapped on the basis of 1: 25,000 scale topographic map contour lines configuration. These have been generated as distinct themes, function of their age, after the critical interpretation of some pre-existent small scales cartographic documents (Ielenicz, 1972, Posea, 1998, 2002) and after confronting with field reality. A limitation of connecting sectors, function of map scale, was attempted, and, also, a delimitation of the structure and lithology influence on in their delineation (the most difficult problem). These trends with symbols that gradually show the trends' age are displayed in Figure 2. The lack of these trends in numerous sectors, as an effect of the Pliocene-Quaternary erosion (obvious especially in the Timiș basin), enforced a complete mapping of the crest and outliers (peak) residual relief, especially where structural and lithologic origin was not evident.

*Fluvial relief*, highly discontinuous, was generalized in the conditions in which the terraces have local features, they are mostly shaped in cones and glacises, and, moreover, they are covered with colluvial and proluvial materials. They differs from the other relief trends by chromatics, but interpretations are limited to locations, some genetic aspects (for example terraces - terraced glacis), and less to the connections between them. Frequently no more than one or two terrace steps with maximum 7-8 m level differences occur. In Predeal – Timișu de Sus area (Figure 3), these relief types, strongly affected by torrential processes, appear more evident. The most acute viewing problem is the overlapping of alluvial fans over the terrace surfaces, enforcing the diminution of terrace surface symbol and the extension of the alluvial fan ones. In this case, the issue of transparent alluvial fan symbol was abandoned, in order to explain this feature.

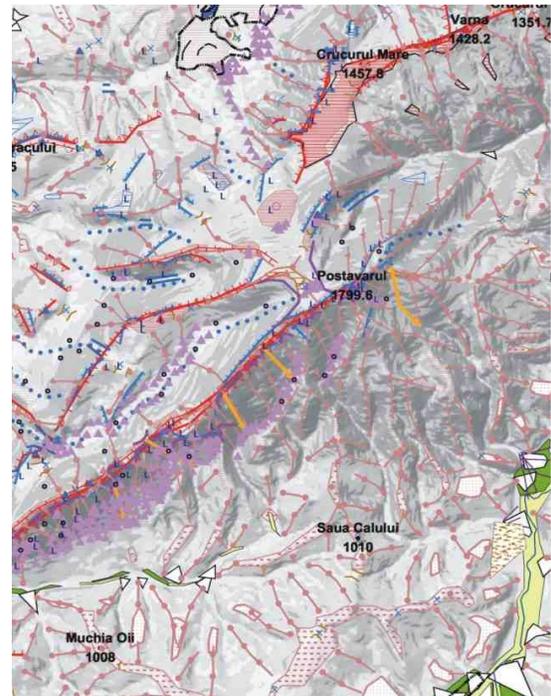


Fig. 2 A sector of the Timiș Mountains Geomorphic Map where erosion surfaces and levels, and other relief types can be distinguished. The map's legend is concordant with Fig. 1

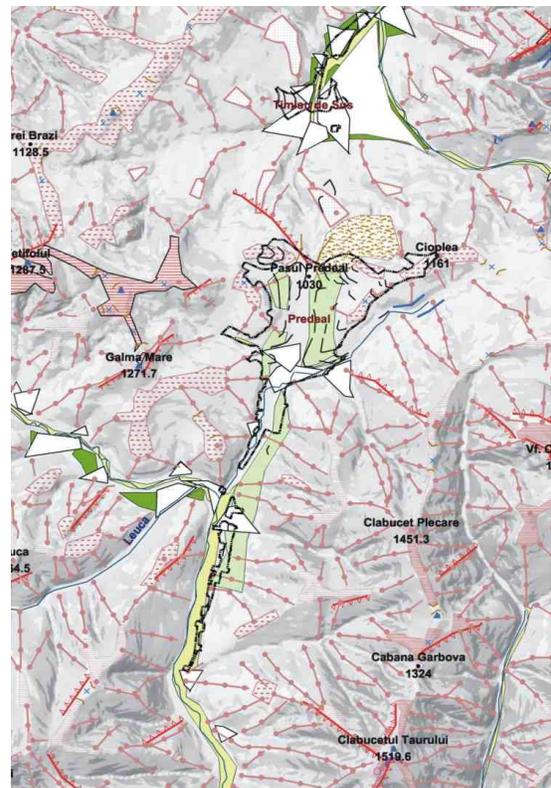


Fig. 3 A sector of Timiș Mountains Geomorphic Map, where the fluvial relief particularities and also other relief types can be distinguished. Map's legend is concordant with Fig. 1

The *tectonic-structural relief* forms were grouped so that to emphasize the complex character of mountain environment morphologic structure of Braşov tectonic depression boundary. There were generated 31 informational layers containing almost all form types (B. Mihai, 2005), so only the most important themes were selected (six). Their selection aimed the use of as few symbols as possible in representing the morpho-structural character, outlined in the whole region by cuesta abrupt, faults, hogback crests, opposite to the large erosion surfaces and levels with structural character. This last issue imposed the combination of first group's symbols in the legend with the symbols describing morphostructure elements. It is the status of the Poiana Braşov surface, which partly has structural character (Figure 4), or the case of some replats levels from the Timiş valley of the Piatra Mare Mountains.

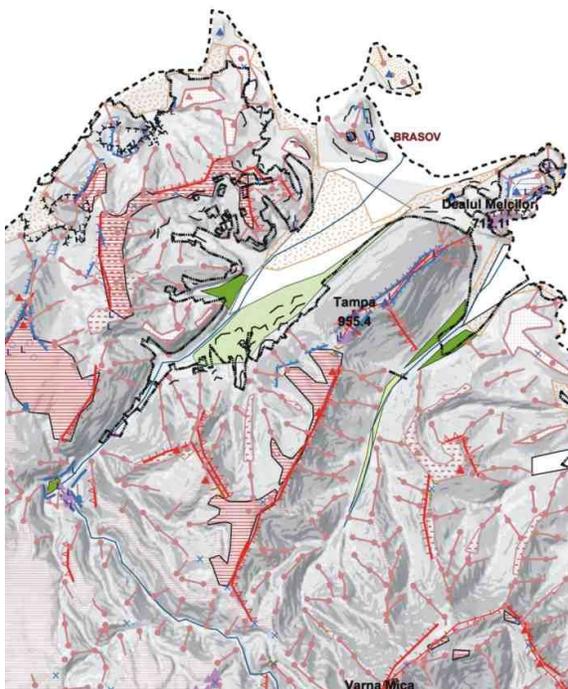


Fig. 4 A sector of the Timiș Mountains Geomorphologic Map distinguishing north-eastern Postăvaru Mountains structural relief features, as well as other relief types (approx. 1: 50000 map scale). Map's legend is concordant with Figure 1

The interpretation of the morphologic structure is considerably facilitated by the visualization of declivity values in the background, which emphasize the morphographic asymmetries, with important slope changes.

The *Petrographic relief* deals with the problem of great microform diversity and especially with their reduced dimensions. Similar to morphostructure, 18 layers have first been generated, of which only 10 were selected based on representativeness criteria. The morpholythologic map (B. Mihai, 2005) implies many reading difficulties because of the reduced detail dimensions (example: limestone pavement, alveolus, dolines, caves etc.). In this case (Figure 2), we opted for the balanced selection of the most representative microforms corresponding to all important rock types. On this reason, about half of the symbols belong to karstic landscapes, and the others are divided between base morpholythologic elements (steeps, levels) and sandstone modeled microforms, conglomerates, trahites etc. Landslides were included to the present morphodynamics. Very widespread in the forestlands, fossilized or partially covered by soil and vegetation microforms were removed. The map scale did not permit the observance of some microforms, of mostly few meters dimension contour (the largest dolines have 10 m in diameter and they are frequently covered by soil and vegetation).

The *cryonival relief* was limited only at the most representative aspects. From within the 13 vector and raster (accumulation of stagnant snow) themes, only 4 were selected, even though many lithologic and structural steeps have periglacial origin and cryonival evolution. All these tend to distinguish the existence of two relief generations. The detritus forms are the most representing for the present cryonival evolution. The use of point symbols succeeds in distinguishing the dimensions of these debris masses from the base of steep slopes and corresponding, also to some rock streams and thalwegs. The cryonival cirques, represented with the line symbol, are connected to the cryonival environment and especially to the altitudinal position, the exposition, local topography's configuration, and the superficial deposits, partially fossilized by soil and vegetation (Fig. 2).

The *elements of the present day morphodynamics* were rigorously selected, for an easily map reading. From among 34 themes created during the elaboration of the present morphodynamics map, only four were selected on the size and representativeness. Disputed in literature for a long time, fluvial catchments were kept especially where they occurred or will occur (important points, on main water ranges, Figure 3).

The symbol is reduced and marks especially the saddles. The (recent) alluvial fans define a highly intensive torrential erosion zone (the largest were selected, irrespective of the torrential activity profile). Thus, the torrential processes symbols specific to the morphodynamic map (Ielenicz, 1982, B. Mihai, 2005) were removed, because they would have overcharging the content of the cartographic material. Landslides have a discontinuous and local character being present inclusively on geologic maps (the large and old masses). The scale and especially the micro-scale morphology constrained the detailed representation of the component elements. There are widespread old deluvial deposits, the major landslides were afforested and the large landslides were replaced by superficial overburst landslide ridges, solifluction areas, alternating with gullies and rills, trees uproot micro depressions (especially beech). We introduced, in unmarked zones on the geological map, a set of similar areas, but we also applied generalizations in this case (for example into the built-up area of Predeal town, where many elements appears, as well as 4 slide masses). The avalanche corridors were limited to pronounced steps and torrent sources where the snow stagnates. Only the main ones were marked and verified on Landsat winter satellite images (January 1997, when, because of the local climate, snow melted here and there). The other morphodynamic elements are separately approached in a special map.

*The elements of anthropogenic relief* express the human induced impact on this mountain area by their number and diversity. Linear (road excavation, road mounds) or punctual (quarries), the elements were selected by their size and illustrative quality. From over 15 vector themes, only three elements were chosen. The human induced levels are represented by the habitat and its related settings (Brașov, Predeal, Poiana Brașov). The quarries are limestones related and they have a great influence in landscape shaping at the border section with Brasov Depression. The limestones likely modified some of the outliers' configuration (Dl. Sprengi, Dl. Melcilor at Brașov). Dams complete the anthropogenic micro-features of landscape and produce transformations within the fluvial morphodynamics.

*Elements of the cartographic base* were diminished to the minimum level, taking into account the fact that communication routes and other similar elements would have overcharged the

map. Main height points were kept with their exact values, based on analyses and interpretation. Settlements contours extracted from the interpretation of a 1997 SPOT satellite image are closer to the actual ones. These polygons' transparency allows a facile interpretation of each settlement geomorphologic base, and of the constructions' impact on relief (Fig. 3 and 4).

*Slopes function as visualisation base.* Processed to obtain a shading effect, this raster layer was reclassified in the three intervals, to rapidly distinguish valley, steep and interfluves areas and to correlate slope with different microforms. We no longer attributed steeps a chromatics, thus, reported to their surface, interpretation is facilitated, as the slope areas sequence (in this case pixel clusters) offer information on steeps' longitudinal section complexity.

*In conclusion,* creating the general geomorphic map in GIS is both advantageous, and disadvantageous. Firstly we can take into account: the unlimited possibilities of grouping and testing landforms association without scale limits; the precise microforms localisation by drawing them out from different information sources with the same geometric properties (the same projection); the possibility of building data bases with digital layers, selecting and generalising their content, and, finally, the possibility of verifying map's accuracy with GPS techniques (partially tested in our study as well). We may add rapid and facile editing of the material to be printed. One major disadvantage is the restriction in symbol editing, difficult visualisation of punctual information in case of large and complex legends, requiring a special attention and even eliminating some themes that can appear in the legend but not in the map, being covered by larger themes (e.g.: a doline covered by a karstic level's symbol). Printing in image format causes resolution reductions and geometric deformations that can affect precise measurements. Still, the method has the great advantage of reduced time of editing and the possibility of obtaining a superior expression level.

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