Considerations on Elaborating Medium-Scale Digital Geomorphologic Map of Romania

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Abstract: *Nowadays, the development of GIS together with the analysis of the digital terrain model (DTM) and the satellite imagery makes possible the improvement and the up-dating of the geomorphologic maps content. A geomorphologic map synthesizes the way the relief forms, the way surface or sub-surface deposits are distributed, as well as the processes that affect relief. This paper aims to reveal the practical importance and the necessity of the digital geomorphologic maps, maps that are essential in the field of environment and biodiversity protection and preservation, in drawing up the risk maps, impact studies, etc., and to present possible steps in creating this digital geomorphologic map. As support for creating it we will use the general geomorphic map at scale 1:200.000 achieved between 1977 and 1990 by the Geography Institute of the Romanian Academy. Also, based on different DTMs, a series of algorithms can interactively validate the map symbols' position, dimension and shape.*

Keywords: *GIS, digital terrain model, geomorphologic map, analysis.*

1. Introduction

As Romania became member of the European Union, it is compulsory to implement the European environmental directives (Nature 2000, INSPIRE), the technological programs (GMES – Global Monitoring for Environment and Security, etc.) as well as the recommendations of the International Geographical Union (IGU). It is therefore obvious the necessity of creating geospatial databases for the sustainable use of natural resources, biodiversity and security. This paper aims to present the importance of the digital geomorphologic map's existence as an indispensable element for disasters' management and prevention, for the drawing up of the risk and landslides maps, for natural resources and biodiversity management, etc. A geomorphologic map synthesizes the way the relief forms, the way the surface or near-surface deposits are distributed, and reveals as well the processes that affect relief. They are of interests for a series of experts interested in relief and landscape, activating in domains like geomorphology, pedology, forestry, agronomy, engineering etc.

At world scale, the first complete geomorphologic maps were elaborated at the beginning of the 20th century. These maps included representations of particular areas. At the International Geographical Union (IGU) congress in Rio de Janeiro (1965) some new ideas in approaching the geomorphologic maps' elaboration were presented, including: introducing of certain specific elaboration methods and adopting of a standard plotting system. In 1968 the International Institute for Aerial Survey and Earth Sciences (ITC) published a complete system of geomorphologic plotting for international use. In the last decades, together with the development of the Remote Sensing techniques and the Geographical Information Systems, the geomorphologic maps reached a new level, as the interpretation and representation of relief elements was eased by the possibility of comparing field data with data obtained from satellite imagery. Moreover, specific algorithms of automatic calculus and integration of morphometry, geodeclivity of slope's exposure data were

developed which helped even more in creating the geomorphologic maps. Despite the fact that geomorphologic maps continued to evolve, during the last century, an universally accepted mapping system was not yet defined, thus there are still differences regarding the form, the content and the cartographic symbols or generally speaking – the map legend. Presently, the International Association of Geomorphologists (IAG/AIG) is trying to unify the geomorphologic approaches. Thus, under the coordination of EC, a workgroup is developing a project that has as main objectives the following:

- Deepening the theoretical knowledge in the field of applied geomorphologic mapping;
- Creating standards, mapping procedures and legend-types for different applications and scales
- Disseminating and revealing the importance and efficiency of using digital geomorphologic maps as a basic instrument for the central and local authorities that deal with environmental problems, but also as a link among different scientific and professional communities.

Besides the IAG effort, we must also mention the work in the geomorphologic field of the USGS (United States Geodetic Surveys) and of other North American universities (Minnesota, North Carolina, etc). In Romania, a major achievement of geomorphologic mapping was the elaboration of the general geomorphologic map of Romania at a mean scale of 1:200.000 by the Geography Institute of the Romanian Academy. The drawing of the map at a scale of 1:200.000 started in 1977 and ended in 1990. The legend was elaborated according to the recommendations and the principles adopted by the Research and Geomorphologic Mapping Commission of IGU. The unique and universally valid legend cannot be applied at all the scales, which determined the replacement of generalized aspects, used in small-scale representations, with more and more detailed features of the forms, specific to large-scale representations. This is why legends were differentiated on categories of scales. Thus, the attention focused on establishing the principles for the elaboration of legends (Gr. Posea, Popescu and L. Badea, Niculescu – 1972) and for their application at different scales. The considerations presented in this paper are based on the above-mentioned general geomorphologic map of Romania at a scale of 1:200.000.

2. Methodology

The elaboration of a general geomorphologic map supposes the territory's investigation and knowledge display a uniform and detailed character in agreement with the map scale; moreover, it is necessary to make a geomorphologic analysis of the map, so that the fundamental morphometric elements (relief intensity and mean slopes) could be emphasized and adequately rendered. Mean declivity represents the colored background of the map. Relief intensity is a defining element in determining the classes of the relief forms, the main morphologic types – plains, hills, plateaus, and mountains, which represent, in fact, the association (assembly) of certain forms in their specific stages of evolution. Consequently, each trapeze has to be accompanied by a map rendering the classes of the relief forms or the relief units generically defined and hierarchically displayed by classes (as relief intensity and altitude), over which the lithological structure can be overlapped. This map has to render the orographic model or the orographic structure as a whole, the grouping or association of large forms, thus indicating the evolution of large relief forms.A very important element that has to be established for the development of the digital geomorphologic map is the legend. The drawing of the general geomorphologic map was based on a set of original principles:

- the groups or types of characteristic elements have to be rendered by symbols, hachure, or colors, according to the importance of the phenomenon.
- the legend has to correspond to a certain scale or, more precisely, to a certain group of scales: small (1:1,500,000 up to 1:1,000,000 or even 1:500,000), mean (1:400,000 up to 1:100,000) and large (more than 1:100,000 up to 1:20,000) and to the features of the

Romanian territory, which underlines the idea that the legend must not be universal. For example, the classes have to correspond to the relief forms and to the lithological features of Romania, not to that of Europe or of other continent.

- the possibility of including certain elements resulted from the elaboration of some special geomorphologic maps in the legend of the general geomorphologic map. For example, certain aspects, such as the fragmentation degree or declivity can be included in the legend, in order to increase the utility of the respective map.
- the legend has to display an open character, which means to allow the combination of certain morphological types selected for the representation and the adding of certain new elements resulted from future observation of the relief forms, without having an altered general structure

The elaboration of the legend respected the recommendations made by the Commission of Geomorphologic Supervision and Mapping of the International Geographical Union and the suggestions given for the legend of the Europe geomorphologic map at a scale of 1: 2.500.000 (1968,1971) and of the geomorphologic map at a mean scale (1973), obviously, by adapting it in order to better render the relief forms of Romania. The legend of the general geomorphologic map (scale 1:200.000) contains four parts (sections) and another fifth part overlapped on the general geomorphologic map. This last section was treated separately so that the clarity of the general geomorphologic was not to be affected. The classes and types of the relief forms are rendered by means of hachure of varied shapes and intensities.

The five parts of the legend are:

- the map of classes of landform
- the structural-lithological types and the cover deposits
- simple landforms and elements represented by symbols
- the genetic types of landforms (the most important section of the legend)
- declivity

This involves the classification of the map elements, and their separation to different types of vectors: polygon, line or point. Also, these types could have various types of hatches, colors and fonts. Once these are set, they should be integrated into a digital library of map symbols containing all necessary elements for the geomorphologic map. The validation of the present geomorphologic maps could be achieved by their correlation with the digital elevation models (DEM) at different resolutions and with high and very high-resolution satellite images.

From the geomorphologic point of view, a complete description of any relief forms can be achieved by using three elements: altitude, slope, and curvature. The slope is the most important element for describing the terrain surface. The determination of the slopes and of their exposure can be achieved by analyzing a digital terrain model. There could be used many types of digital terrain models, obtained from different data sources (topographical maps, satellite images undertaken by active and passive sensors, other data sources). For certain test zones, a digital terrain model can be generated by digitizing the contour lines from the topographical map at the scale of 1:25.000. The precision (accuracy) the relief forms are rendered within a topographical map is mainly determined by the density (equidistance) of the contour lines. The large- and mean-scale maps render, at high fidelity, the field elements, while the general topographical maps display an increased generalization level. Generally, the precision in altitude of a certain point determined by the interpolation of the contour lines is of 1/2-1/3 of the equidistance. In order to obtain certain results with a superior altimetric precision, a digital elevation model could be also generated on the basis of the topographical map at the scale of 1:5.000.

The processing of the satellite images overtaken by SPOT 5 HRS allowed obtaining a highly precision digital terrain model. This model can contain up-dated information referring to the relief elements. As supplementary data, there could be used other digital terrain models: SRTM

(generated through interferometry techniques) and DTED2 (informational content equivalent to the model generated by the digitization of the contour lines 1:50.000).

Fig. 1 Example of the General geomorphologic map of Romania, 1:200.000 scale

The precision of the digital terrain models could be evaluated by means of statistical methods that could include GPS measurements made in the field in the control points. Starting from these numerical models, there can be achieved a comparative study, the purpose of which is the identification of the most adequate model for the up-dating and editing of the geomorphologic map at a scale of 1:200.000. An extremely important scientific activity could be represented by the development and testing of the correlated algorithms for validating the map symbols' position, dimension, orientation and shape.

3. Final remarks

This paper aims to reveal the importance of a digital geomorphic map for Romania's territory in concordance with the necessity of implementing the European environmental directions, the technological programs and the recommendations of the International Geographical Union. It is more and more obvious that having a digital geomorphic map, together with a digital map symbols library, it is not only recommended but necessary in different projects and applications regarding the environment, such as territorial planning, drawing up the risk maps, sustainable use of natural resources, biodiversity, security, etc. Having the digital geomorphologic map as a support layer would help a lot of experts in different fields, from geomophologists to engineers, agronomists, etc.

The novelty revealed in this paper is the method of creating the digital geomorphologic map based on the analysis of different Digital Terrain Models and with the help of a series of interactive algorithms for validating the position, dimension, shape and orientation of the used map symbols, in correlation with the DTM.

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