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GEOMORPHOLOGICAL MAPPING OF MESSOGIA PLAIN (EAST ATTICA, GREECE)

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Abstract

This study concerns the geomorphological mapping of the area included in the map sheets Koropi and Plaka of the Hellenic Military Geographical Service map distribution in scale 1:50.000. This is an extensive area of East Attica which presents a complex terrain and a wide variety of landforms, due to its intense tectonism and the natural processes that shaped its morphology. The primary data that were used in the creation of the map mainly included geological and topographic maps, from which thematic layers of the topography, hydrography and geology were constructed through GIS processes. A Digital Elevation Model was also constructed, from which the slope and aspect maps were created. The thematic maps of slope and lithology were classified into categories, which were combined to constitute detection criteria of landforms. Decisive contribution in mapping was provided by the available orthophotomaps and aerial photographs, as well as the field work. Finally, with the appropriate combination of colors and symbols the geomorphological map of the study area was produced.

Key words: *GIS, multi-component analysis, semi automated, Geomorphological mapping.*

Περίληψη

Η παρούσα μελέτη αφορά τη γεωμορφολογική χαρτογράφηση της περιοχής που περιλαμβάνεται στα φύλλα χάρτη Κορωπί και Πλάκα της διανομής της Γ.Υ.Σ. σε κλίμακα 1:50.000 . Πρόκειται για μια εκτεταμένη περιοχή της Ανατολικής Αττικής η οποία παρουσιάζει σύνθετο ανάγλυφο και μεγάλη ποικιλία γεωμορφών, λόγω του έντονου τεκτονισμού της και των φυσικών διεργασιών που διαμόρφωσαν τη μορφολογία της. Για τη δημιουργία του χάρτη χρησιμοποιήθηκαν κυρίως γεωλογικοί και τοπογραφικοί χάρτες, από τους οποίους κατασκευάστηκαν μέσω Γεωγραφικών Συστημάτων Πληροφοριών τα θεματικά επίπεδα της τοπογραφίας, της υδρογραφίας και της γεωλογίας, ενώ κατασκευάστηκε επίσης και το Ψηφιακό Μοντέλο Εδάφους, από το οποίο προέκυψαν οι χάρτες κλίσεων και έκθεσης. Οι θεματικοί χάρτες των κλίσεων και της λιθολογίας ταξινομήθηκαν σε κατηγορίες οι οποίες συνδυάστηκαν αποτελώντας κριτήρια εντοπισμού γεωμορφών. Στη χαρτογράφηση συνέβαλλαν καθοριστικά οι διαθέσιμοι ορθοφωτοχάρτες και αεροφωτογραφίες, όπως επίσης η εργασία πεδίου. Στη συνέχεια, με τον κατάλληλο συνδυασμό χρωμάτων και συμβολισμών δημιουργήθηκε ο γεωμορφολογικός χάρτης της περιοχής μελέτης, η οποία αποτελείται από τμήματα διαφοροποιημένων μορφολογικών χαρακτηριστικών του αναγλύφου.

Λέξεις κλειδιά: *ΓΣΠ, πολυ-κριτηριακή ανάλυση, Ημι-αυτοματοποιημένες μέθοδοι γεωμορφολογικής χαρτογράφησης.*

1. Introduction

The study area is located at the central part of eastern Attica (Figure 1). Specifically, the area includes the northern part of Lavrion, Messogia plain, the mountains of Hymettus, Paneion and Merenda, the central part of the eastern coast of Attica and part of the coast of the Saronic Gulf. At the East the area is bordering to the South Evian Gulf while at the southwest it ends to the Saronic Gulf.

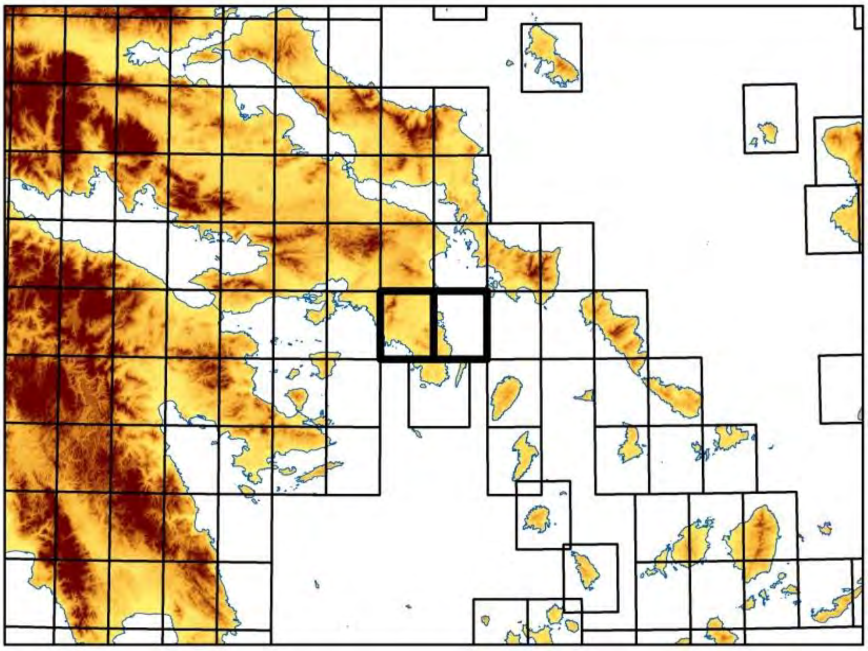

Figure 1 - Map location of the study area.

The study area consists of alpine and post alpine geological formations. The alpine rocks occur mainly in the mountains and hills and they are consisted of limestones, marbles, schists, phyllites, dolomites and ophiolites (Latsoudas, 2003; Papanikolaou et al., 2004). The post alpine geological formations include Neogene and Quaternary deposits.
The intense tectonic activity of the area defines the configuration of the folds of the relief, settles the mountains and the plains bordering basins, such as the main Messogia basin.
The climate of the region of Attica belongs to the dry Mediterranean type. During the winter season it appears characteristics of the temperate climate zone, with mild, wet winters, and during the summer season characteristics of subtropical climate zones of high pressure, with hot and dry summers.

2. Methodology

2.1. Data Used

The first stage of the research was the collection of analogue maps and remote sensing data of the study area. The analogue maps include large scale (1/5.000) and medium scale (1/50.000) topographic sheets that were gathered by the Hellenic Military Geographical Service as well as the geological map of the region from the Institute of Geology and Mineral Exploration. Remote sensing data include large scale aerial photos that were taken by the National Cadastre and the Ministry of Agriculture. Furthermore, specific aerial photographs were acquired in analogue format for stereoscopic analysis.

2.2. Dem and Slope Map

The Digital Terrain Model (DTM) was created from all the digitized contours and the elevation points. The original format was a Triangular Irregular Network (TIN) that was transformed into a reticular layer (raster), with cell size 25m.

The slope map is considered as one of the most important data generated by the DTM concerning geomorphological mapping (Gustavsson et al., 2009). Slope is one of the main features of geomorphological analysis, as different landforms occur in different inclinations. The cell values were grouped into 6 categories (Figure 2) in accordance with the uniform system of symbolism («Unified Key») which was established by the IGU Commission on Geomorphological Survey and Mapping during the 1960s – 1970s (Gustavsson et al., 2006).

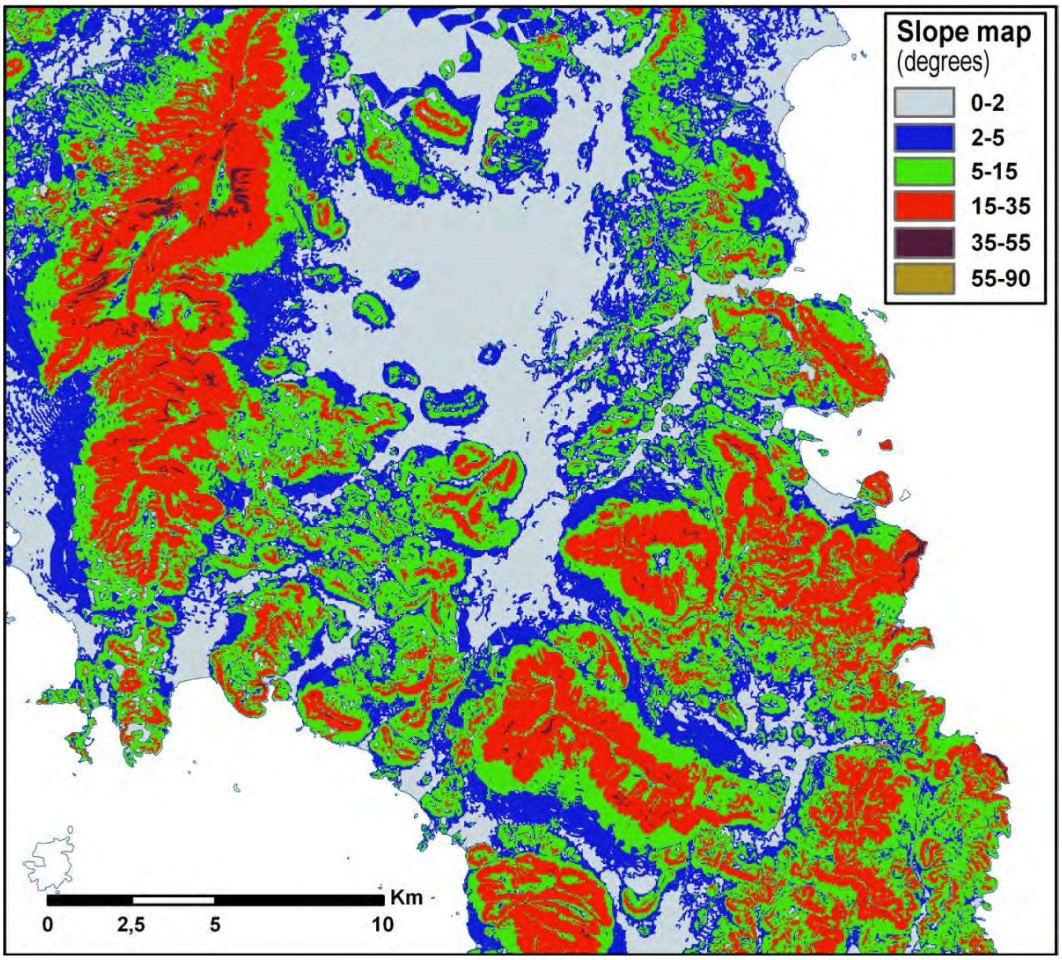

Figure 2 - Slope map of the study area.

2.3. Semi - Automated Geomorphological Mapping

Basic criteria for the identification of the landforms were slope and lithology. Various combinations of the specific criteria were used as shown in Table 1 (Van Asselen et al., 2006).

For the identification of the cliffs of the region were used as primary criteria high ground slope (> 35°) in combination with the presence of alpine formations. The areas that were marked by the automated process were verified by aerial photos and fieldwork (Pavlopoulos et al., 2009).

Table 1 - Criteria for multi-variable analysis

Landforms	Criteria	Success
Cliffs	• Slopes > 35^o • Alpine formations	Great
Planation surfaces	• Slopes < 5^o • Alpine formations	Great
Alluvial cones and side debris	• 35^o > slopes > 5^o • Pleistocene deposits	Medium
Terraces	• Slopes < 5^o • Post alpine formations • Buffer 100 m. from streams	Medium
Deep erosion	• Slopes > 35^o • Buffer 50 m. from streams	Low

To determine the planation surfaces were used as criteria smooth relief slopes (<5^o) combined with the presence of alpine formations. The application of this combination was very successful as it revealed most of the planation surfaces. Furthermore, classes of elevation of DTM were used to classify surfaces levelling depending on the altitude, as also the layer of the aspect map, generated by the DTM to determine the direction in which they creep.

The multivariable analysis to identify alluvial cones and side debris had less successful but still satisfactory results. Further classification of Quaternary deposits depending on the grade of coherence of the sediment may give better results. In this paper, for the identification of specific landforms, analogue methods were used which include qualitative interpretation of aerial photos and field work.

Regarding the detection of Inselbergs were used as primary criteria alpine formations that are surrounded by post alpine sediments. After identifying these regions, the elevation criterion was used to determine whether they are hills or not.

The coastal landforms were determined by the combined study of topography, geological structure and remote sensing data. The steep slopes of the shores were already recognized during the multivariable analysis for the identification of the cliffs.

The automated methods for the identification of the shape of the valleys and the terraces had low degree of successful determination.

All the multi-criteria determinations of landforms, verified by field work and remote sensing methods.

2.4. Map Compilation

The geographical entities were classified according their characteristics following the rules of cartographic generalization, abstraction and simplification (Gustavsson, 2005). Specifically, discrete levels of information were generated concerning topographic, hydrographic, geological, geomorphological and anthropogenic elements (Figure 3). For each geographical entity were used appropriate cartographic symbols. In individual cases were created new symbols for the accurate interpretation of the information (Figure 3).

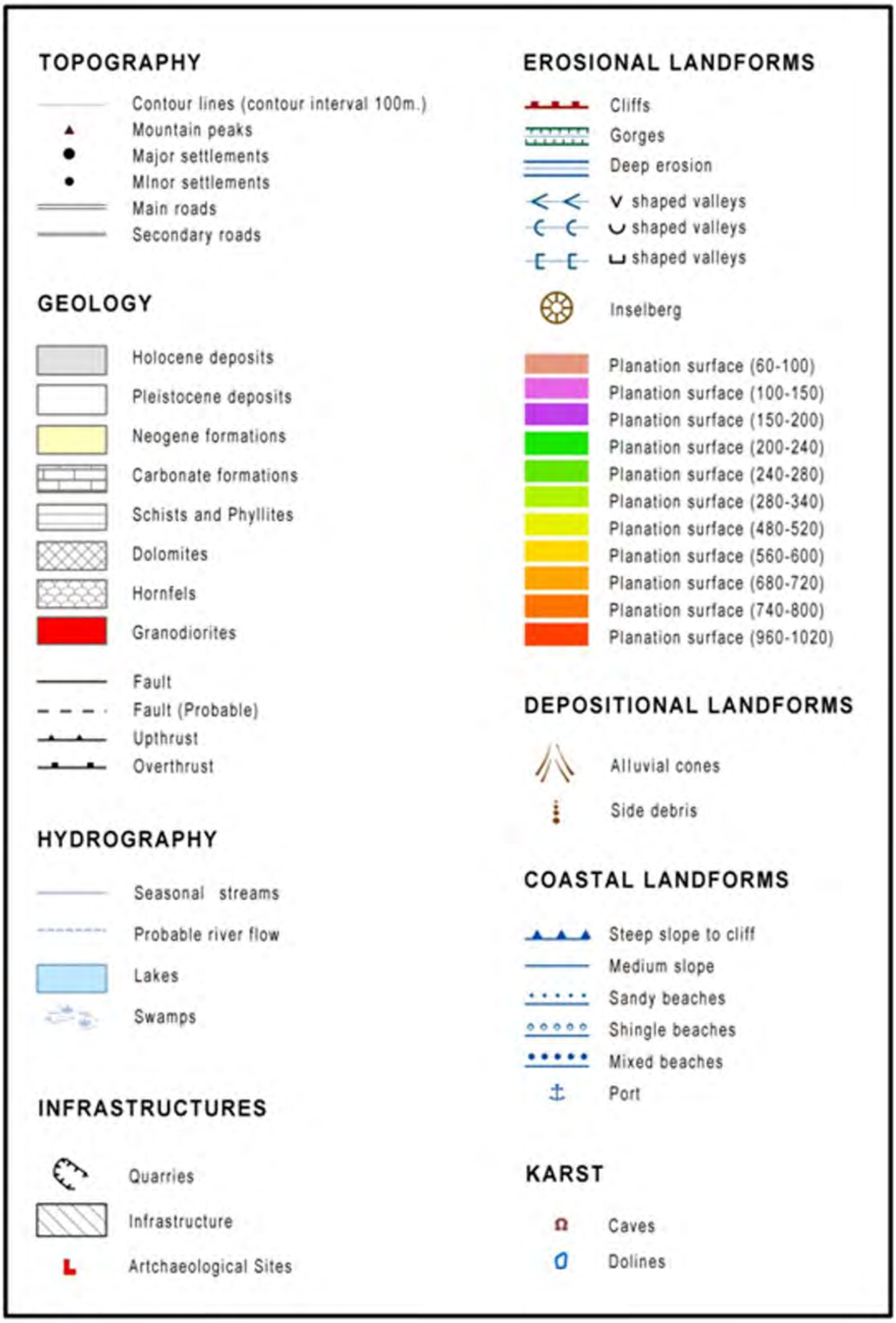

Figure 3 - Map Legend.

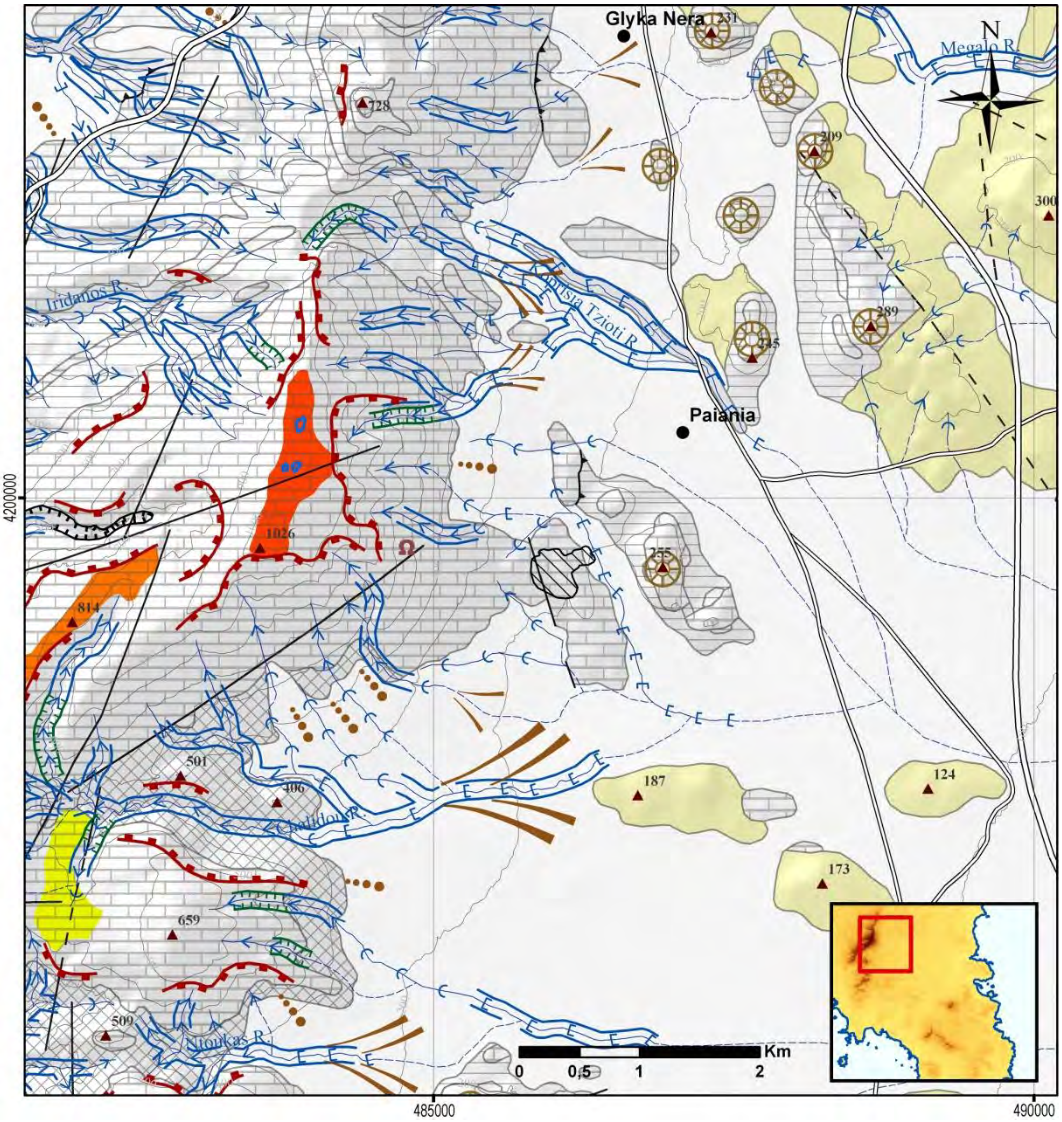

Figure 4 - Hymettus and the western plain of Mesogia - Part of the geomorphological map of Messogia plain, scale 1/50.000.

3. Results

Messogia plain outlines the characteristics of a mild terrain traversed by stage of maturity and characterized by smooth slopes, extensive alluvial areas and inselbergs (Figure 4). Messogia basin owes its genesis to the intensive tectonic movements that took place during the Alpine orogenesis and completed during the Upper Pliocene - Lower Pleistocene with the lifting of the surrounding mountains (Boskos, 2008).

During the Upper Miocene, seasonal lakes were located in the northern part of the main basins as documented by the lacustrine deposits of the specific period. Those lakes were either covered by sediment deposits from the neighboring mountains or dried after periods of intense drought. Moreover, marine transgression did not cover the entire area of Messogia (Papachatzis, 1953).

The Pleistocene deposits of the plain indicate the active tectonism and the intense processes of erosion and deposition of that period where the uplift of the surrounding mountains was still going on. The Holocene deposits are less extensive, due to limited runoff. The intense, deep erosion of Megalo Rema and Erasinos River that appear during the Upper Pleistocene is probably due to tectonic causes or to sea level changes (Figure 5).

The asymmetric morphology of Hymettus, where the eastern slopes appear steeper than the west is due to the intense tectonic activity of the region after the Lower Pliocene (Figure 4) (Krohe et al., 2010). From this period onwards was intensified the deep erosion of the valleys and gorges were created as their relative uplift was accompanied by the lowering of the hydrographic network. The erosional landforms took their present shape as the processes that created them continued along the tectonic and climatic changes of the Pleistocene (Pavlopoulos et al., 2005).

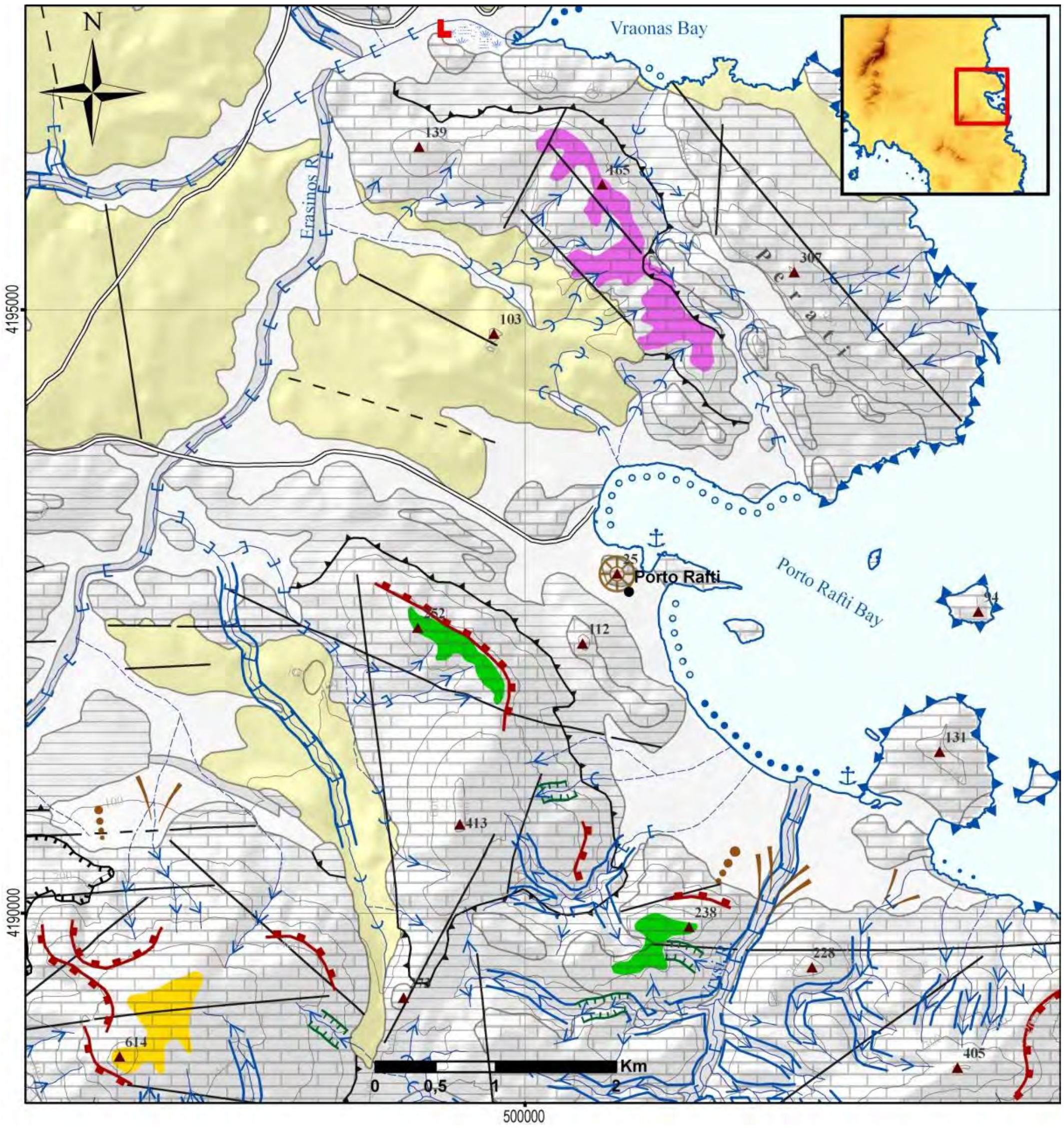

Figure 5 - Porto Rafti region - Part of the geomorphological map of Messogia plain, scale 1/50.000.

The planation surfaces of Hymettus at altitudes from 500 to 800 meters were formed probably during Miocene while the planation surfaces from 940 to 1000 meters can be considered older, and are correlated by lithology and altitude with the planation surfaces of Penteli Mountain (Pavlopoulos et al, 2005).

The planation surfaces of the lower elevations of Hymettus present south and west exposure and represent subsequent evolutions of the landscape (Figure 4). The planation surfaces from 200 to 240 m. and 240 to 280 m. are likely to be associated with the inselbergs of the basin, whose creation is associated with different susceptibility to corrosion of the lithological formations of the pre-Neogene relief.

Similar aspect present the planation surfaces of the central eastern coastal region at altitudes greater than 150 m. The planation surfaces identified in the southeast present aspect and morphological slope to the northeast, which means that this part behaves differently as documented by the differentiated morphology of the river networks (Figure 5) (Pavlopoulos, 1992).

The geomorphological evolution of the area is mainly controlled by the tectonic evolution and the climate change of the Pleistocene, while the upper part of the Holocene is also influenced by human interventions. The alluvial deposits show slow progress or stagnation, as the artificial arrangement of the streams and the anthropogenic formation of the surrounding areas impedes the natural deposition processes.

4. Discussion

The geomorphological map of Messogia plain presents the main landforms of the study area, showing clearly the characteristics of the relief to the extent permitted by the scale study. Recognition of landforms through modern methods of mapping provided by GIS was performed primarily by analyzing the morphological characteristics of the relief. The semi-automated identification techniques of the major landforms through multi-component analysis provided very satisfactory results which were verified by the study of cartographic data, remote sensing data and field work. For the attribution of geomorphology at larger scales the range of values of the criteria should be broaden. These values include quantitative parameters, such as distances and slopes, or qualitative parameters such as classification of the geological formations. In conclusion, automated analysis methods in geomorphological mapping are an important tool where output data should be verified in any case.

The analysis of the geomorphological map shows that Messogia plain is a basin which owes its genesis to the intensive tectonic movements that took place during the Alpine orogenesis and completed during the Upper Pliocene - Lower Pleistocene with the uplift of the surrounding mountains. The Quaternary climate changes have resulted to the accumulation of sediment within the basin and the creation of side debris and alluvial fans on the slopes of the surrounding mountains. Finally, the current status of the morphology of the area is due to the human factor.

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