Geomorphological mapping of the Mazi-Oinoe area, Northwest Attica, Greece.

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Abstract

The Mazi basin (also called the Mazi Plain or Oinoe), located in the northwestern part of the prefecture of Attica, is complex terrain comprised of a wide range of landforms, due to various geomorphological processes. This paper presents the initial results and mapping of a study that aims to understand the natural processes which have contributed to the formation of its landscape. This research is conducted in collaborations with a wider program of research, the Mazi Archaeological Project, which aims to investigate human-environmental interaction in the very long term.

The Mazi basin is included in the topographic maps of the Hellenic Military Geographical Service scaled 1:5.000 and in the geological maps of the Institute of Geology and Mineral Exploration, scaled 1:50.000 (map sheets "Erythrai"-"Elefsis"). These maps constitute the primary data for the geomorphological mapping, which is supplemented by the available Orthophoto maps of the National Cadastral Survey, Google Earth imagery, and extensive field work. Thematic layers for the topography, hydrography and geology were constructed using GIS. A precise Digital Elevation Model was used for creating slope and aspect maps. Slopes and lithology were subsequently classified into categories, which were combined in order to render detection criteria of landforms. Finally, with the appropriate combination of colors and symbols, the geomorphological map of the study area was produced.

Keywords: *Oinoe, Northwest Attica, GIS, multi-component analysis, semi-automated Geomorphological mapping,*

1.1 Introduction

The Mazi basin in Northwest Attica (Fig. 1) -- named after the area's main village, later renamed Oinoe -- is bounded by the mountains of Parnes (to the East), Pateras-Makron (to the West) and Kithairon (in the North West). Situated on the main route between Eleusis and Thebes, it has long been an important thoroughfare for the greater region. Since the Classical period, the basin has been situated in the Attic-Boeotian borderlands (Chandler 1926, Ober 1985, Fachard 2013), and its agricultural attractiveness made it a matter of contention between Athens and its neighbors. In general terms, however, the occupational history of the plain remains poorly known. In Modern times, human exploitation and impact on the landscape have been severe. Large scale inhabitation and cultivation of the Mazi basin changed the rate of natural processes, as massive irrigation systems were built in order to irrigate the crops and supply the inhabitants with drinkable water. Therefore, the importance of the human impact in this area must be observed, analyzed and mapped along with the natural processes. In order to achieve this, a geomorphological survey was carried out during the winter and the spring of 2014. Most dramatic forms of human intervention in the landscape were identified and mapped, especially the irrigational trenches, which are shown as torrents in the topographic map of the HMGS (Hellenic Geographical Military Service). Following the survey, a detailed geomorphological map was created, representing the current landscape along with the natural processes and the main forms of human interference. A semi-automated method was used to draw landforms, the natural processes and the main human activities.

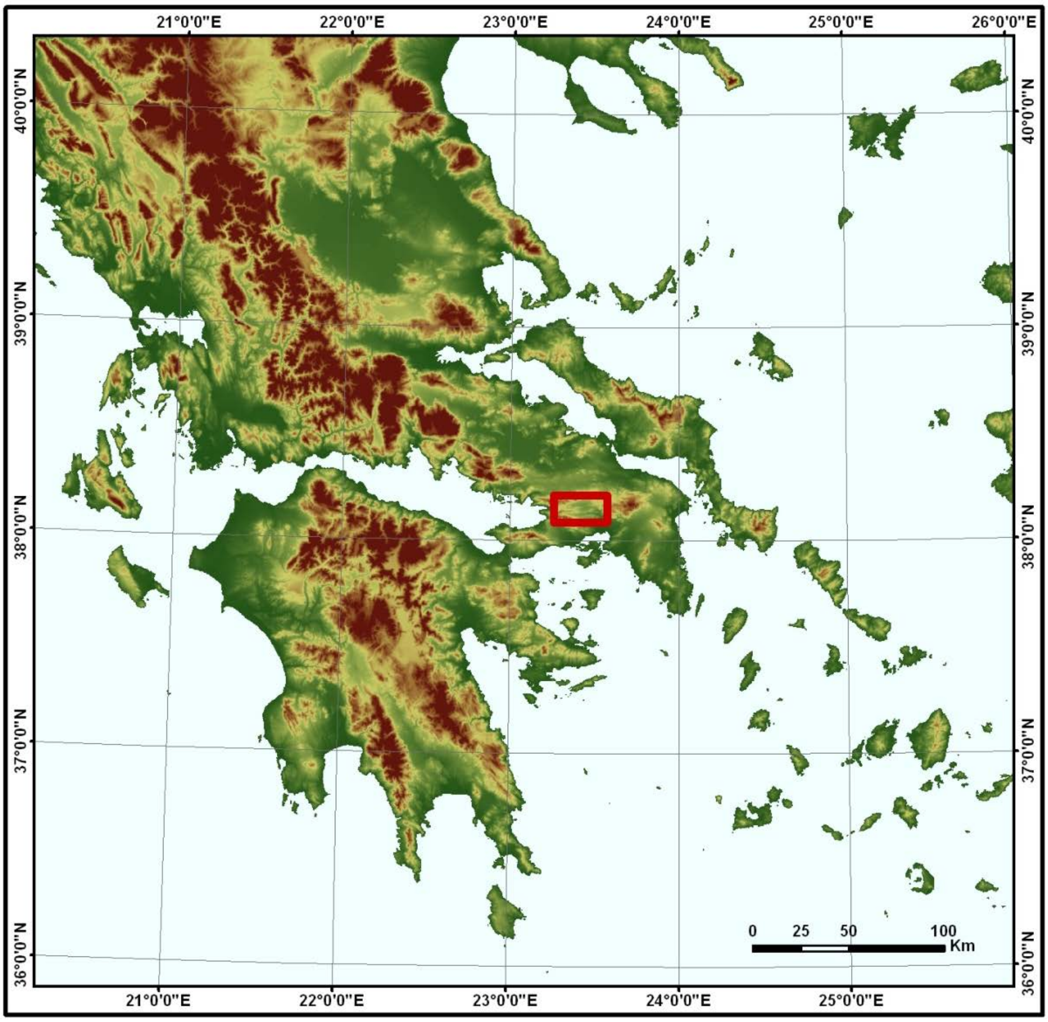

Fig.1: Map of mainland Greece showing the position of the study area.

2. Methodology

2.1. Data Used

The first stage of the research was the collection of maps and remote sensing data for the study area. The maps include the large (1:5.000 and 1:25.000) and medium scale (1:50.000) Hellenic Military Geographical Service's topographic sheets, as well as the geological maps produced by the Institute of Geology and Mineral Exploration ("Erithrai" and "Athinai-Elefsis", scaled 1:50.000). Remote sensing data include large-scale aerial photos taken by the National Cadastre (1:2.500) and the Hellenic Ministry of Agriculture (1:5.000), as well as WorldView-2 multispectral satellite imagery (courtesy of the DigitalGlobe Foundation). Furthermore, aerial photographs were acquired in analogue format for stereoscopic analysis.

The second stage of the geomorphological mapping consisted of fieldwork. Many landforms and their characteristics were identified, as well as a number of topographical and geological features which were not discernable in the maps and imagery. These features were recorded in order to be included in the final results of the research.

2.2. Features

The topographic maps provided the 20-meter contours, points of fixed altitude such as the triangulation points, and the torrents of the region. In many areas, especially where slopes range from 0 to 15^{o}, the 4-meter contours were also digitized in order to create a more detailed Digital Elevation Model, which will be used in the next stages of the geomorphological mapping and spatial analysis. The lithology and tectonics of the area proved more difficult to extrapolate from this dataset, since the scale of the geomorphological map was set to 1:25.000 while the geological maps are scaled 1:50.000. Last, the geological formations and faults were digitized from the map sheets. However, in many cases, these had to be corrected and verified with the use of the remote sensing data and ground-truthing in order to avoid errors and deviations in the final map.

3. Results

3.1. DEM & Slope Map

The Digital Elevation Model (DEM) is a three-dimensional representation of the terrain (Fig.2). It can be used to generate data useful in geomorphological mapping, such as slope maps, aspect maps, watersheds, river basins and drainage networks (only approximately in the last case). The DEM was produced from the digitized contours and the elevation points. The original format is a Triangular Irregular Network (TIN) that was transformed into a reticular layer (raster), with cell size set to 10 by 10 meters. The detail and accuracy of the landscape representation are characterized as an element of major importance in geomorphological research.

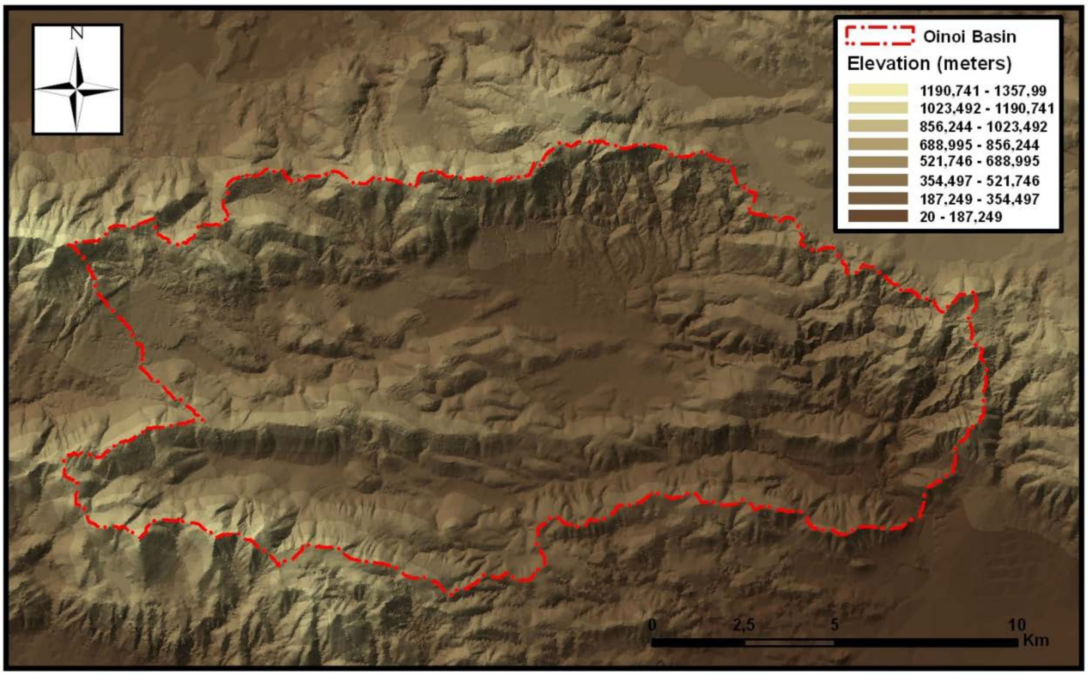

Fig.2: Digital Elevation Model of the study area

In geomorphological mapping, the slope map is among the most important types of data generated by a DEM (Gustavsson et al., 2009). It represents the relief inclination at every cell of the study area. Slope is one of the main features of geomorphological analysis, as different landforms occur in different inclinations. Here, the cell values were grouped into six categories, in accordance with the Unified Key mapping system established by the IGU Commission on Geomorphological Survey and Mapping during the 1960s – 1970s (Fig.3).

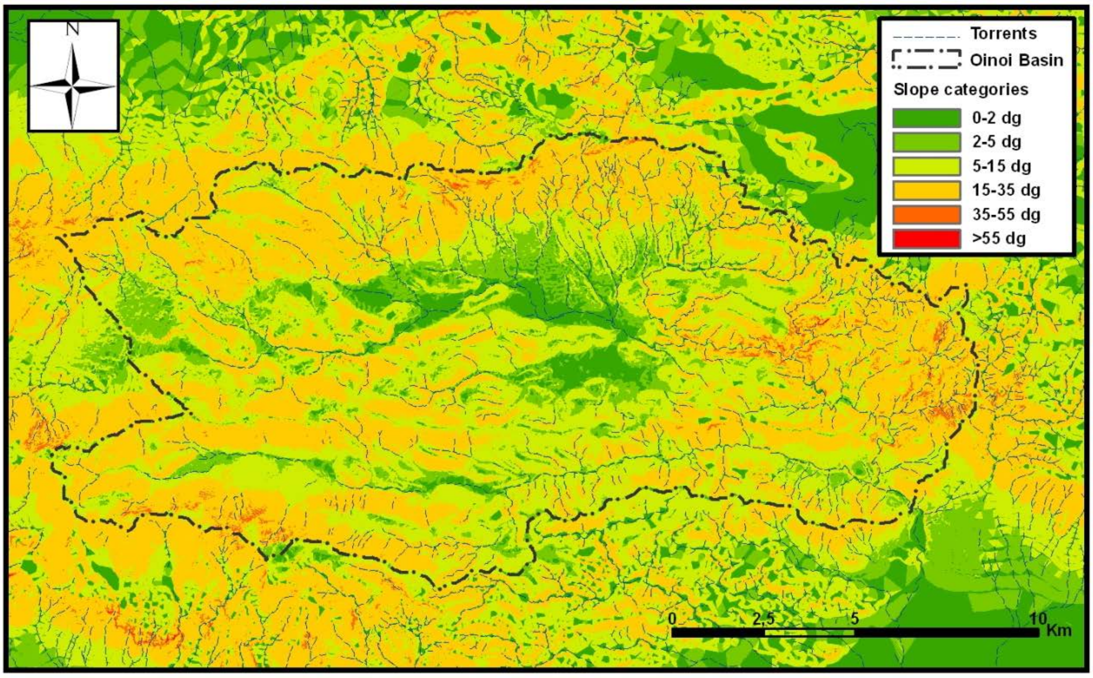

Fig.3: The classified slope map of the study area

The aspect map, generated by the DEM, displays the orientation (direction) of slope for a terrain in degrees. It was used, in some cases, for determining landform characteristics that are affected by the presence of elements such as wind or sunlight. (Fig.4)

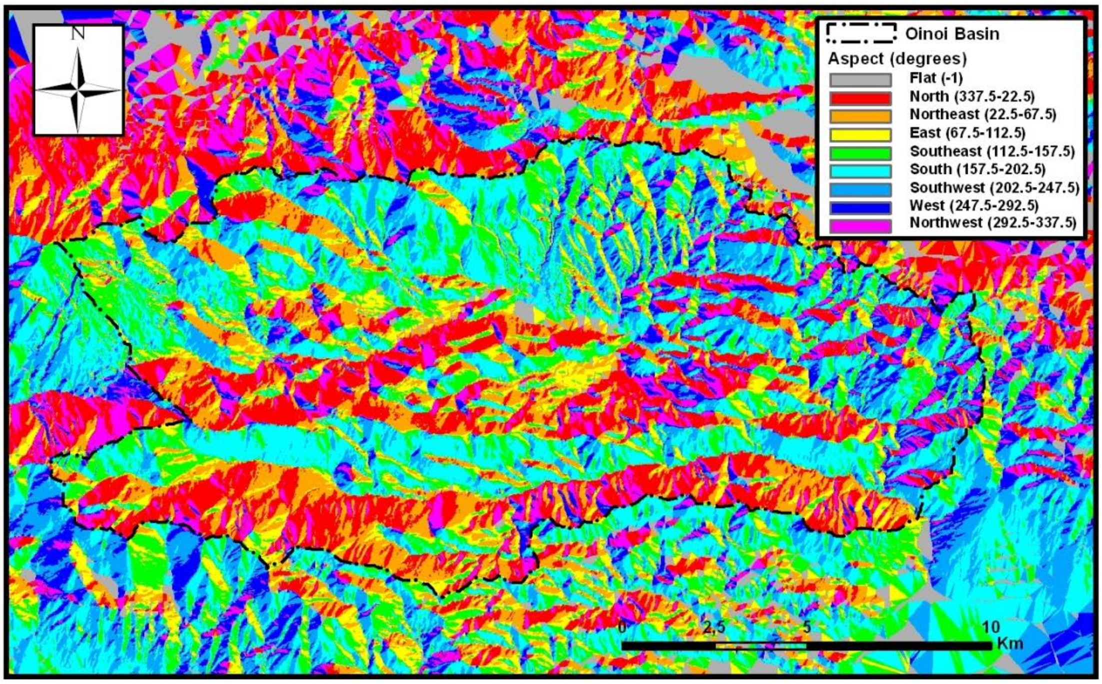

Fig.4: Aspect map of the study area.

3.2. Semi - Automated geomorphological mapping

Basic criteria used for the identification of the landforms were slope and lithology. Various combinations of the specific criteria were used as shown in Table 1.

Table 1 - Criteria for multi-variable analysis

Landforms	Criteria
Cliffs	• Slopes > 35^o • Alpine formations
Planation surfaces	• Slopes < 5^o • Alpine formations
Alluvial cones and debris	• 35^o > slopes > 5^o • Post alpine deposits
Gorges	• Slopes > 35^o • Buffer 50 m. from streams • Alpine formations

The primary criteria used for the identification of the region's cliffs were the high relief inclinations (> 35^o) combined with the presence of alpine formations. The areas selected by the automated process were verified by remote sensing and fieldwork (Van Asselen et al., 2006; Pavlopoulos et al., 2009).

Smooth relief slopes (<5^o) combined with the presence of alpine formations were used as criteria for determining planation surfaces. Furthermore, elevation was used to classify surface levels, while the aspect map determines the direction in which these surfaces slope.

The multivariable analysis used for the identification of the alluvial fans, the colluvial deposits, as well as the debris and screes, had satisfactory results. Qualitative interpretation of the remote sensing data and the topographic and geological maps was used to verify the presence of these landforms, to separate the alluvial from the colluvial deposits, as well as to determine how these landforms occurred in specific areas and assess the factors that contributed to their formation. The fieldwork observations and notes played a major role in this procedure. Finally, the shapes of the valleys, down-cutting erosion, gorges and knick points were identified by the combined study of the topographic maps, the slope map, and fieldwork.

3.3. Map Composition- The Geomorphological Map

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. Appropriate cartographic symbols for each geographical entity were used. For individual cases, new symbols were created for the accurate interpretation of the information.

The symbols and patterns used for the lithology, the tectonic and the geomorphological features are in accordance with most geological and geomorphological maps, as part of an effort to obtain a self-explanatory legend. Topographic and anthropogenic features use symbols displayed in many topographic maps of the region (Fig.5).

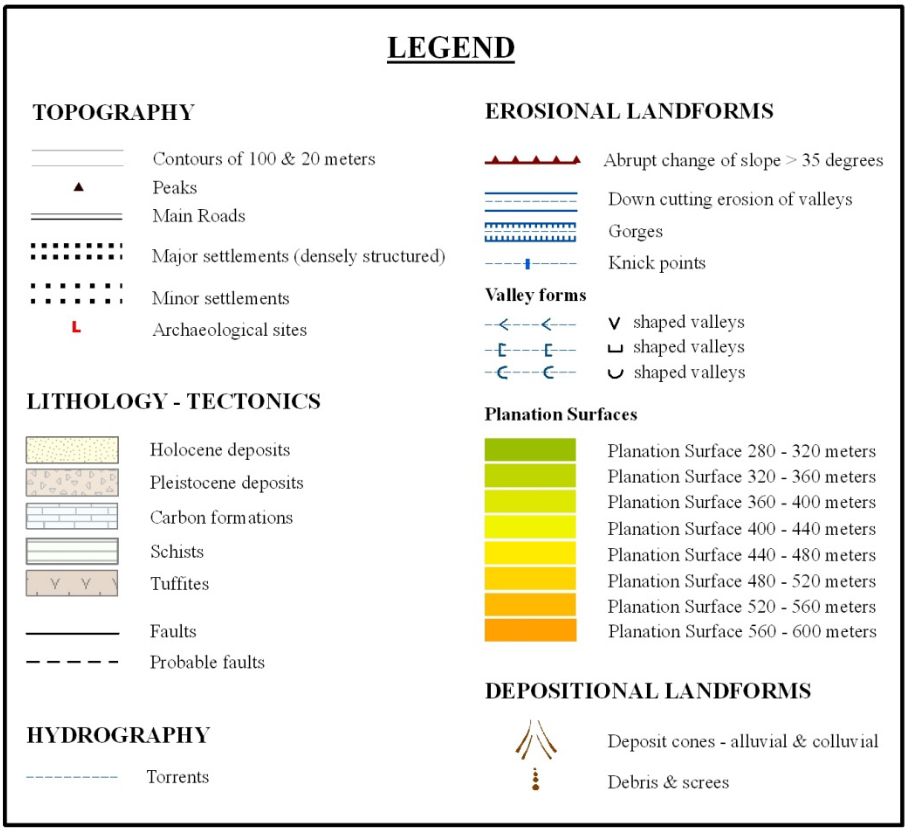

Fig.5: The legend of the geomorphological map

The geological formations are symbolized with light colors and fills, so as to be distinguished from the other features of the map. The planation surfaces are displayed with gradient colors that indicate their elevation, and the contours are displayed with light shades of grey. All features relative to fluvial erosional processes use blue color, while the alluvial deposits symbol is in brown color. Debris and screes use a symbol with circles of gradually increasing radius, which indicates the direction in which they fall downhill (to the side where the radius increases). Symbols for settlements vary according to their size and construction density.

Fig. 6: East side of the geomorphological map of the study area.

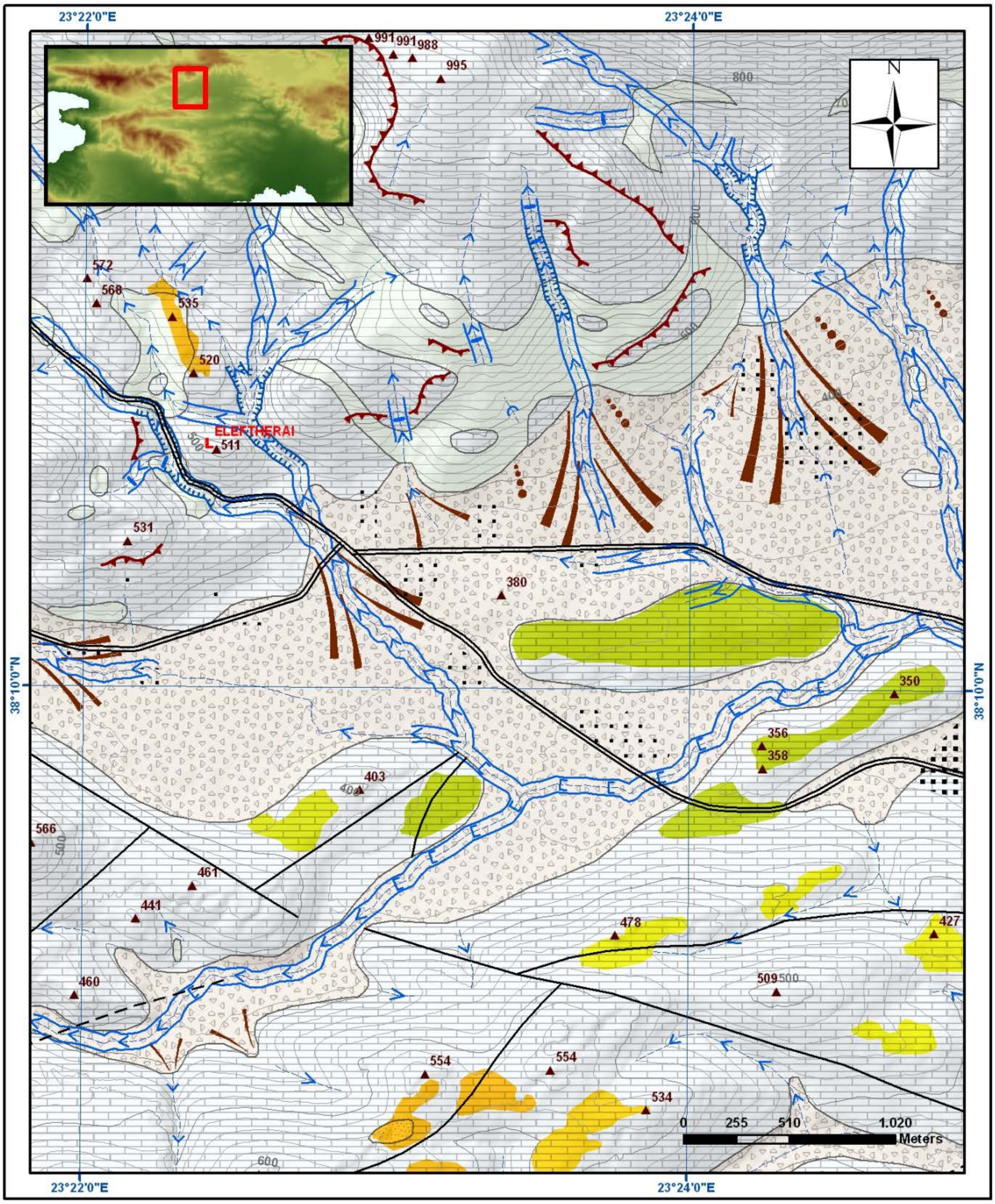

Fig. 7: West side of the Geomorphological map of the study area.

The substratum of this area consists mainly of carbon (limestone) formations and Schists in places (Fig. 5, 6,7). The substratum is filled with Pleistocene and Holocene sediments. The Pleistocene sediments are widespread in the area (Fig. 6,7), though mainly concentrated in the northern part, in the deposit cones, alluvial and colluvial fans. Here, debris and screes can be observed due to the gravitational activity and the steep relief (Fig. 6,7). Holocene sedimentation is found only in the eastern part of the basin -- west of the ancient site of Oinoe -- and to the south, near the village of Pournari (Fig. 6,7).

V-shaped valleys are observed mainly above 450m, near the mountainous areas where knick points and gorges are found. Most of them are located in the Eastern part of the study area, mainly in limestone formations. The U-shaped valleys are situated in the central part of the study area, along with the ⊔ shaped valleys, whose origin is mainly anthropogenic. The hydrographic network has seasonal runoff (Fig. 6,7).

Planation surfaces of different elevations (180m up to 600m) are also present in the carbon formatted mountains surrounding the study area (Fig. 6,7).

At high altitudes, above 500m, cliffs are concentrated in the mountainous areas of the Mazi basin (Fig. 6,7).

4. Discussion-Conclusion

The present research was concerned mainly with identifying and mapping the natural and anthropogenic processes which have transformed the landscape. In late geological times (Pliocene-Pleistocene), the area consisted of a basin-lake infilled by sediments derived from its hydrographic network. Subsequently, the water from the Mazi basin was drained in the Thriasian basin (to the South), leaving behind the sediments and consequently creating this fertile area. The central part of the basin consists mainly of Pleistocene deposits, while Holocene deposits are observed in the eastern part of the geomorphological map. The hydrographic network is mainly modified (especially in the central part of the basin) by human intervention, motivated by current demands for agriculture and settlement. On the other hand, the gorges and knick points testify to an older tectonic activity, whose role and importance have considerably decreased. As a result, the erosion-deposition processes, along with the geological substratum which form this basin, present a complex set of landforms which were exploited by humans since prehistory. The results of this geomorphological research will be combined with ongoing archaeological fieldwork to examine more precisely the nature of this human-environmental relationship over time.

5. References

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