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DISSERTATION

"Revealing the Geoheritage of Attica and Eastern Peloponnese through geotouristic routes"

ODYSSEAS A. ARCHONTIKIS

R.N: 1114201300007

SUPERVISOR: PROFESSOR MARIA V. TRIANTAPHYLLOU

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ΤΜΗΜΑ ΓΕΩΛΟΓΙΑΣ ΚΑΙ ΓΕΩΠΕΡΙΒΑΛΛΟΝΤΟΣ

ΤΟΜΕΑΣ ΙΣΤΟΡΙΚΗΣ ΓΕΩΛΟΓΙΑΣ-ΠΑΛΑΙΟΝΤΟΛΟΓΙΑΣ

ΔΙΠΛΩΜΑΤΙΚΗ ΕΡΓΑΣΙΑ

«Ανακαλύπτοντας τη Γεωκληρονομιά της Αττικής και Ανατολικής Πελοποννήσου μέσω γεωτουριστικών διαδρομών»

ΟΔΥΣΣΕΑΣ Α. ΑΡΧΟΝΤΙΚΗΣ

Α.Μ: 1114201300007

ΕΠΙΒΛΕΠΟΥΣΑ: ΚΑΘΗΓΗΤΡΙΑ ΜΑΡΙΑ Β. ΤΡΙΑΝΤΑΦΥΛΛΟΥ

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PROLOGUE

The following thesis entitled “Revealing the Geoheritage of Attica and Eastern Peloponnese through geotouristic routes” has taken place at the Department of Historical Geology and Paleontology, Faculty of Geology and Geoenvironment, National and Kapodistrian University of Athens.

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ABSTRACT

Greece is a natural geological laboratory, which encloses knowledge for the current geodynamic processes of the Hellenic arc that took place through a series of earthquakes, volcanoes, intense sediment transports and depositions, coastal movements and other geological processes. It represents at the same time, a greatest geological museum with many significant positions that reveal the complex history of the region during the last 300 million years of our planet's existence. These positions known as Geosites represent geological places containing a great and large history of both the environment and the humanity. The purpose of this thesis is to outline the geotouristic value of geosites in Attica and Eastern Peloponnese, thus proposing a geotouristic route that can be used as a product for promoting the idea of geoenvironment and geoheritage. The methodology we used is based on the calibration of series of criteria, through which the assessment of all selected geosites is attempted. Criteria cover the topics of geology, ecology, culture, tourism and aesthetics, while each criterion is evaluated on a scale ranging from 1 (low significance) to 5 (high significance). The average number represents the total score of the geosite, which is indicative for their final evaluation. The quantitive assessment of all selected geosites can promote a feasible georoute as a process of education and love for the nature. In that way, sustainable tourism can be attempted, always relying on the adoption of a geo-consciousness. In other words, geotouristic routes for the sake of the preservation of such geological monuments can evidently be emerged as a new perspective of the geoenvironment and geological heritage, which after all, is what will lead to a sustainable geo-future and a better quality of life.

KEY WORDS: Geosites, Georoutes, Attica, Eastern Peloponnese, Geoheritage

SUMMARY IN GREEK

Η Ελλάδα είναι ένα φυσικό γεωλογικό εργαστήριο, το οποίο περικλείει γνώση για τις τρέχουσες γεωδυναμικές διεργασίες του ελληνικού τόξου που εκδηλώνεται μέσα από σεισμούς, ηφαίστεια, έντονες μεταφορές και αποθέσεις ιζημάτων, παράκτιες μετακινήσεις και άλλες γεωλογικές διαδικασίες. Αντιπροσωπεύει ταυτόχρονα ένα τεράστιο γεωλογικό μουσείο με πολλές σημαντικές θέσεις που αποκαλύπτουν την πολύπλοκη ιστορία της περιοχής στα τελευταία 300 εκατομμύρια χρόνια της ύπαρξης του πλανήτη μας. Αυτές οι θέσεις, γνωστές ως Γεώτοποι αντιπροσωπεύουν γεωλογικούς χώρους που περιέχουν πολυποίκιλη και σημαντική ιστορία τόσο του περιβάλλοντος όσο και της ανθρωπότητας. Σκοπός της παρούσας εργασίας είναι να σκιαγραφήσει την γεωτουριστική αξία επιλεγμένων γεωτόπων στην Αττική και την Ανατολική Πελοπόννησο, προτείνοντας μια γεωτουριστική διαδρομή που δύναται να χρησιμοποιηθεί ως προϊόν για την προώθηση της ιδέας του γεωπεριβάλλοντος και της γεωλογικής κληρονομιάς. Η μεθοδολογία που χρησιμοποιήθηκε βασίζεται στη βαθμονόμηση μίας σειράς κριτηρίων μέσω των οποίων επιχειρείται η αξιολόγηση των γεωτόπων αυτών. Τα κριτήρια καλύπτουν θέματα γεωλογίας, οικολογίας, πολιτισμού, τουρισμού και αισθητικής, ενώ κάθε κριτήριο αξιολογείται σε κλίμακα που κυμαίνεται από 1 (χαμηλή σημασία) έως 5 (υψηλή σημασία). Ο μέσος αριθμός αντιπροσωπεύει το συνολικό αποτέλεσμα του γεώτοπου, το οποίο είναι ενδεικτικό για την τελική του αξιολόγηση. Η ποσοτική εκτίμηση όλων των επιλεγμένων γεωτόπων μπορεί να οδηγήσει στην υλοποίηση μία εφικτής γεωδιαδρομής ως διαδικασίας εκπαίδευσης και αγάπης για τη φύση. Με τον τρόπο αυτό, ο βιώσιμος τουρισμός μπορεί να επιχειρηθεί, βασιζόμενος πάντα στην υιοθέτηση μίας γεω-συνείδησης. Με άλλα λόγια, οι γεωτουριστικές διαδρομές για τη διατήρηση τέτοιων γεωλογικών μνημείων μπορούν προφανώς να εμφανιστούν ως μια νέα προοπτική του γεωπεριβάλλοντος και της γεωλογικής κληρονομιάς, η οποία και τελικά θα οδηγήσει σε ένα βιώσιμο γεω-μέλλον και σε μία καλύτερη ποιότητα ζωής.

ΛΕΞΕΙΣ ΚΛΕΙΔΙΑ: Γεώτοποι, Γεωδιαδρομές, Αττική, Ανατολική Πελοπόννησος, Γεωκληρονομιά

INTRODUCTION

Environment was and remains along with the antiquities, the main developmental pillars of Greece (Damianos, 2013) for decades. In modern times, due to the constant growing cultural and environmental crisis, the lack of interdisciplinary knowledge leads to irreparable natural and moral disasters. Exploiting the history, the economy and the geostrategic position of a region is emerging as the ultimate goal, ignoring any need to preserve the environment and to ensure sustainable development. In recent years, however, the espousal of a new eco-consciousness worldwide, dictates that the segment of geo-protection and geo-conservation should be presented as ever again, most crucial and necessary. The charm of a place that exists, the geological monuments and phenomena reflect an important parameter of reality. In other words, we speak for geo-environment and geotourism as two interconnected links of a single chain. In addition to ensuring the contribution of geo-environmental sciences to developmental action over the time, it becomes now possible to adopt a new lifestyle, purely supportive for all the aspects of the environment. Therefore, the value, the dynamics and the role that the geo-environment ought to play for humans and the humans for it, is now of the utmost importance as it is directly linked to the maintenance and promotion of every society as a stronge and single system.

In this context, the active action of geoscientists along with the activation of governments is necessary in order for a strong effort to take place. Such an effort can seriously boost some geological positions in Greece and assist in their conservation. These places, which are particularly important, must be safeguarded and preserved, as they represent the key to the past and the continuation of the future. Thus, focusing on such forms of geotourism, the possibility of great acceptance by the public is becoming larger and larger, since spherical information on the value, uniqueness and status of these geological positions was largely limited. The major problem of society's failure to protect and geoconserve these monuments can ultimately be overturned, only through a process of interactive education and contact that aims to adoption of authentic and genuine geoprotective consciousness.

Briefly, the aim of the present paper is the multifaceted boost of a number of geotopes and the formation of a geotouristic route by studying their geological, historical, cultural, touristic, ecological and archaeological background. The process of assessing the selected geotopes will yield the usefulness of the geotouristic route that we will propose. The primary step is to process the information of each geotope, which will be based on generic information and knowledge for better understanding. The outline of their value based on selection criteria will eventually lead to the categorization of the geotopes, covering the need of engraving georoutes and revealing the role of geoheritage and along with its contents.

CHAPTER 1: «INTRODUCTION TO THE CONCEPT OF GEOTOPES»

The concept of geotopes and the need to protect the geoenvironment were not sufficiently understood and widespread throughout the world. In the Greek society, intensive efforts and long periods have been required in order for the institutional framework of the past decade to be modified, as it was mainly linked to the living environment. Luckily, in the last decades it includes a more holistic picture. The pedestal of all ecosystems, which is soil and geology, has come forward in recent years through the adoption of new laws; despite the fact that they were primarily concerned with protecting biodiversity, nevertheless are a huge step towards the clarification of geo-environmental concepts and the decoupling of the value of the geotopes from hosted biodiversity. The integrated protection of the geological heritage existed only for the archaeological caves, while for the other categories such as palaeontological remains and other geomorphological forms, it was and still remains incomplete, as both citizens and the State (i.e Public Services, Ministries) do not focus on what should be preserved. The ever-increasing social interest in preserving the environment along with the need of achieving a better quality of life, necessarily implies that we should now revise attitudes and policies upon nature. With the evolution of geosciences and the occupation of geoscientists, we are now able to realize that the concept of geotopes, geoconservation and geoenvironment ought to exist, as geotopes and geoenvironment are a timeless natural resource and at the same time the witness of human civilization and geological phenomena. The key for the future and the shield against modern environmental problems is now geoheritage, through which we are now able to understand concepts that will therefore lead to the creation of a workable policy. The combination of that policy and eco-geo-conciousness can lead to geological heritage and by extension to geoconservation, which after all is what sustainable development is all about.

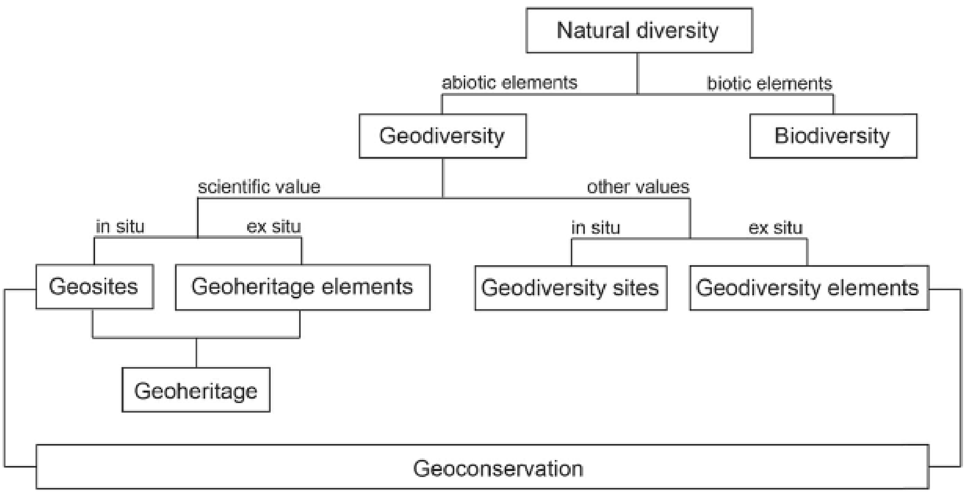


Figure 1: Conceptual framework of geodiversity, geoheritage, and geoconservation, according to (Brilha, 2015).

BASIC CONCEPTS-KEY DEFINITIONS

Geotopes: Geotopes, according to the "Atlas of Geological Monuments of the Aegean Sea 2002" (Velitzelos *et al*., 2002) are characterized by significant geological structures, typical or rare rendering, rare mineralogical occurrences, significant petrological occurrences, particular sedimentary structures, rare or characteristic fossils, tectonic structures, places of modern geomorphological and geological processes, particular geomorphological formations and landscapes of special natural beauty". The term geotope was legally defined as "Geographical Geomorphological structures that constitute natural formations and represent important moments of its geological history (V.3937 / GG 60, item A / 31-3-11 paragraph 2, second paragraph) of the land that are significant witnesses to its long evolution or show modern natural, geological processes that continue to evolve on the surface of the Earth".

Natural Geotopes*:* The creations of the forces of nature and the processes between them, which we immediately perceive, are minerals, deposits, fossils or geological interests such as ruptures and volcanoes that are irrefutable witnesses and testimonies of the processes of the forces of nature.

Anthropogenic Geotopes*:* It includes all geotopes that occur after human activity.

Geoenvironment: Geological environment or Geo-environment, we call the physical set of elements with dynamic constituent elements, the soil, the subsoil and the status of the waters (surface and underground) as it is shaped by the action of natural phenomena and functions as a system of multiple components for human socio-economic activities (Faltseta S., 1997).

Geological Conservation: We define geological conservation as the prudent use of mineral raw materials, which is a concept associated with sustainable development. Raw materials are essentially geological formations that took millions of years and special conditions to create. Therefore, their use should be limited to what is absolutely necessary, as it is an important loss and a change irreversible (Theodosiou-Drandaki, 1997).

Geographical diversity: Large number of different occurrences of geotopes that capture geological time and all geological phenomena along with their processes.

Geological-Geomorphological Heritage: Geological heritage is defined as the set of geological locations (geotopes and geological natural monuments) that are worth preserving for scientific, didactic, historical, cultural and aesthetic reasons (UNESCO, 1999). The geographic level of geological heritage is usually national.

Natural Monument: A geotope with a unique or prominent appearance of a geo-environment at a global level is called a geological natural monument and is of intense tourist or scientific interest (Triantaphyllou, 1992).

Geopark: Geopark is called a geographic area that contains a sufficient number of geotopes that can serve for research, educational, developmental, tourist purposes (Theodosiou, 2011). Geoparks have a defined geographic area (usually a prefecture level in Greek territory) and subjects that allow the development of economic/touristic activities.

Categories of Geotopes

- ***Tectonic Structures:*** are geotopes that have originated mainly from endogenous processes. In this category are mirrored fracture surfaces, tectonic horns, tectonic windows, sections of highly folded layers, sediments.
- ***Palaeontological sites:*** are locations that are rich in fossils and provide important information about paleoenvironment, paleoid and various ancestral forms of man.
- ***Locations of economic exploitation and mining***: All locations, which have been mining in the past and are now abandoned.
- ***Geomorphological sites:*** In this category are classified the karst geomorphs (caves, poles, sinks etc.), the residual forms of erosion (flags, gorges, ravines), the wind forms (dunes, deserts, beaches etc.) As well as depot forms.
- ***Hydrological sites:*** geotopes characterized by the wet element and at institutional level are defined as wetland-wetlands. They include lakes, lagoons, rivers, waterfalls and springs.
- ***Volcanic Forms:*** The most impressive geotopes created at the rise points of the Earth's mantle material. They include volcanic craters, creepers, fjords, volcanic rocks, and hot springs.
- ***Geohistoric Positions***: In this class the basic classification factor does not define the geological feature but the human activities that have developed over time on the geological feature. They are combinational or non-geological long-range locations because of human presence. Here you can find citadels, caves of historical interest, historical and archaeological sites with geological interest.
- ***Stratigraphic Positions:*** Sites of stratigraphic interest (intersection of layers of different age, stratigraphic incisions, invasions).
- ***Geotechnical Sites:*** This category includes artificial geotopes (canals, ponds, lakes drainage).

Criteria for Choosing Geotopes

In 1977, at the 2nd International Symposium on the Monuments of Nature and Geological Heritage, held in Molyvos, Lesvos, the criteria for the selection of scientific and research geotopes were recorded, and more fully formulated in Theodosiou-Fermeli-Koutsouvelou (2006).

The criteria are as follows:

- ***Representativeness:*** Refers to a comparison of other similar occurrences at different locations on the planet. That is, whether a geotope represents an important moment in the history of the Earth or has features and representative elements of wider processes to be a key location for research, interpretation or misinterpretation of geological events and processes.
- ***Rarity***: Refers to the number of corresponding locations that exist globally or to their limited geographic spread.
- ***Naturalness:*** It reflects a truly natural character, how much it has not been influenced by human energies so that it is closer to its primary state.
- ***Completeness and diversity of features***: They refer to extensive geological recordings and sequencing of geological data.
- ***Uniqueness-Particularity:*** This criterion refers to the aesthetic aspect of the landscape as beauty, charm, atextension and impressiveness can be considered as basic reasons for exploiting the geotope.

Cultural Geotope Criteria

Linking or identifying with cultural monuments. Geotope is linked to or identified with a cultural or archaeological monument, as well as with myths or traditions.

Criteria for the Selection of Ecological Monuments

The geotope is the background of a habitat or is the same habitat. By habitat, we mean the whole of the physical characteristics of an area (subsoil, soil, fauna, flora). Keeping them all ensures biodiversity.

Criteria for the Selection of Tourist Geotopes

As new generations of tourists are composed of travelers who are environmentally sensitive, they are looking for alternative tourist destinations. These destinations contribute to the sustainable or sustainable development of the regions. That is, to a development that meets the needs of today's generations, without jeopardizing the rights and needs of future generations.

Criteria for the Selection of Aesthetic Geotopes

- The natural beauty
- Aesthetic values
- The environmental aesthetic perception

Criteria for Educational Geotopes

- The clarity of features and their diversity.
- The ability to develop educational activities.
- The visibility, ie the overall image and perspective of the geotope from a distance.
- Easy access and security so that the movement and the visit of the school groups can be done without risk.
- The relatively short distance from the school grounds.
- Their existence in the urban environment. Geotopes in the urban environment are an opportunity for people living in a city to be in contact with the natural environment.

CHAPTER 2: «MATERIALS AND METHODS»

The current project aims at the formation of an ideal geotouristic path, applicable and easy to be implemented. Such a georoute will be economically feasible and at the same time can present a multitude of both recognized and not, geotopes. In this way, it can be given quickly and effectively to all directly interested (i.e tourists) a full illustration of the need to maintain the geological diversity and geological heritage and simultaneously to preserve the value of these monuments in terms of human development, scientific research, environmental preservation, conservation and management. Fieldtrip was undertaken between the 22nd and 25th of April 2017. During this fieldwork, all identified geosites were assessed and ranked (bonitation). Previous works show that the geoconservation favorable outcome and a successful geotouristic route, depends on better preparation plans, thus we provided institutional framework and population data. Procedures are mainly based on typology followed by the identification and selection of geotopes.

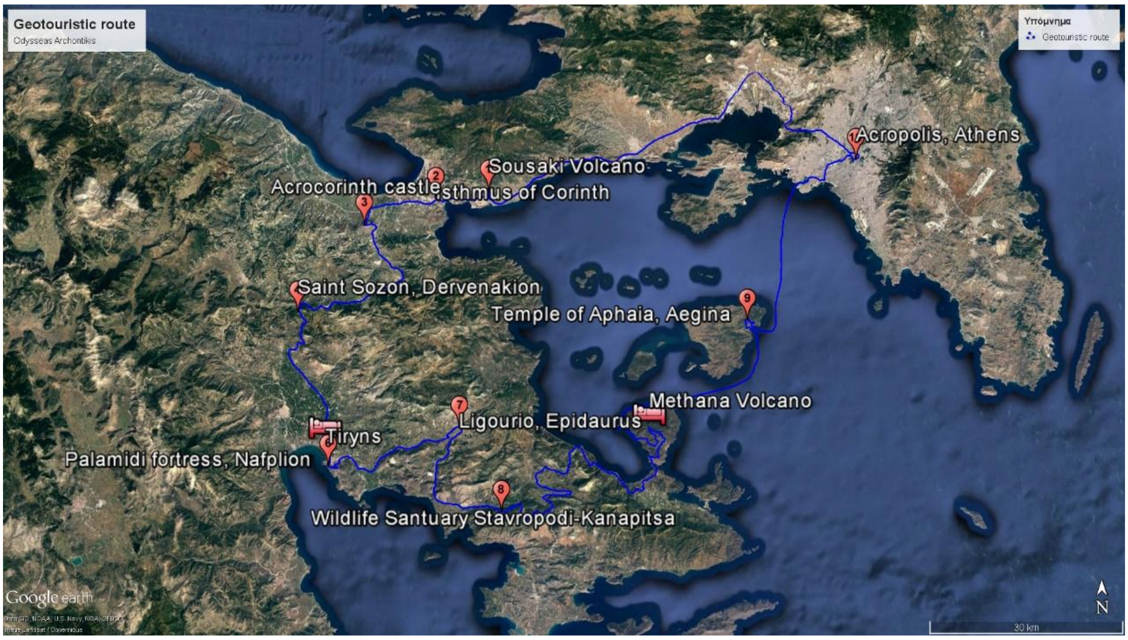


Figure 2.1: Undertaken fieldtrip. View of the proposed geotouristic route (blue line), modified after (Google Earth, 2017).

The research about numerical assessment of sites has been under development for the last decade, but the geoscientific community has not yet reached a general accepted method. Usually, quantitative methods are based on several criteria and respective indicators to which different scores or parameters may be assigned (Cendrero 1996a ,b; Coratza and Giusti 2005; Pralong and Reynard 2005; Pereira *et al*. 2007 ; Reynard *et al.*2007; Bruschi and Cendrero 2009;

Reynard 2009; Pereira and Pereira 2010; Bruschi *et al*., 2011; Fassoulas *et al.,* 2012; Pereira and Pereira 2012; Bollati *et al*. 2013). The aim of a quantitative assessment is to decrease the subjectivity associated with any evaluation procedure. The result of this numerical assessment is a sorted list of sites, which is a powerful tool for the establishment of management priorities. Sites with higher value and higher degradation risk should be given top priority. The quantitative assessment of sites works better when dozens of them are being evaluated. For small areas with just a few sites, these procedures have no practical results and may be discarded. In the present work, topographic maps, geological maps and available publications were studied. Samples were also collected, which were deemed to represent the overall lithology. Each geosite was thoroughly studied and documented by acquiring a number of photographs and coordinates. The assessment, involving 12 criteria: *Geological History, Representativeness, Geodiversity, Rarity, Conservation, Education, History-Archaeology, Religion, Visibility, Relief Differentiating, Accessibility, Touristic infrastructure, Ecological Value*, which are graded on a scoring scale from 1 to 5 (1 holds the lower power and 5 the highest). Depending on each author's point of view, greater importance is given to specific criteria, resulting to the absence of one single kind of criteria that can be applied to all geosites (Fassoulas *et al*., 2012).

Criteria	**1**	**2**	**3**	**4**	**5**
Geological History	Small participation at local level	Moderate participation in local level	Great participation in local level	Moderate participation at regional level	Great participation at regional level
Representativeness	Not at all	Low	Medium	High	Unique
Geodiversity	1	<3	<5	<10	>10
Rarity	>20	>10	>5	>2	Unique
Conservation	Totally damaged	Low	Medium	High	Intact
Education	Not at all	-	Medium	-	High
History-Archaeology	Not at all	Existing-Low importance	Minor importance	Moderate importance	Great importance-Geohistoric position
Religion	Not at all	Existing-Low importance	Minor importance	Moderate importance	Great importance-Geohistoric position
Visibility	1	2	3	4	>4
Relief Differentiating	Not at all	Low	Medium	High	Very High
Accessibility	Not accesible	Low	Medium	High	Very High

Touristic infrastructure	Not at all	Low	Medium	-	High
Ecological Value	Not at all	-	Medium	-	High

Table 2.1: Quantitative assessment (grading) of criteria for starting the bonitation process, modified after (Skentos, 2012).

For each recorded geotope, there will be a specific price (*Total Score)*, indicative of the value of the geotope as a total image, which is related to its final classification.

$$Total\ Score = {}^{Sum\ of\ rating\ criteria}\Big/_{Number\ of\ used\ Criteria}$$

From the available publication, the classification of the geotopes based on their overall score is outlined as follows:

- If Total Score >4, then it is a <u>Geotope of Global interest.</u>
- If Total Score >3.5, then it is a <u>Geotope of National interest.</u>
- If Total Score <3, then it is a <u>Geotope that is of Local interest only.</u>

It must also be pointed out that even if a number comes out as the final result of a quantitative assessment, this does not mean that it is not necessary to proceed with a critical and detailed analysis of the results. Sometimes, the result may place a certain geosite at the bottom of the list but the same site may be intuitively significant in the specific area. These kinds of contradictions need to be explained and interpreted. The <u>scientific part</u> of the whole process should have the final and definitive word about the sorted list of geosites for the area under consideration.

A database was also constructed in the present work. The information inserted into the geotope database were divided into two groups.

- In the first group, <u>general information</u> of the geotope are placed. These data identify and define each geotope. In this group the name, type, category and geographic location (region, country, location, EGG coordinates) of the geological position are recorded.
- The second group <u>consists of all necessary criteria</u> for geotope assessment (*Geological History, Representativeness, Geodiversity, Rarity, Conservation, Education, History-Archaeology, Religion, Visibility, Relief Differentiating, Accessibility, Touristic infrastructure, Ecological Value*).

For the proper use of the database, it is necessary to quantify the data of the second group so that it is possible to compare and link the geological positions to a single reference level. For example, a geotope is evaluated with the minimum value (1) in the Geological History criterion, when the participation of this geological phenomenon has the least connection in the Geological Evolution of the area. Once the database management system has been completed, we insert all the information into a spatial reference frame. Using GIS is rather helpful as we achieve further data management through geostrategic and spatial analysis techniques.

CHAPTER 3: «RESULTS»

"MAPPING THE GEOTOURISTIC VALUE OF GEOTOPES"

REGION OF PELOPONNESE

REGIONAL UNIT OF CORINTH

Financial Data

According to the most recent data available for the distribution of the Hellenic Statistical Authority within the Region of 2008, the Peripheral Unity of Corinthia (29.2%) holds the largest participation in the formation of the Region of Peloponnese, followed by (23.9%), Arcadia (17.6%), Argolida (17.3%) and Laconia (11.9%). Most of the benefit is generated in the Secondary Sector and produced in the Peripheral Unity of Corinth, despite the significant decline that occurred during the period under review (46% in 2008 compared to 60.5% in 2000).

Touristic Activity

The trend of tourist arrivals in the period 2002-2010 in the Peloponnese Region is clear. The Region's share of total arrivals in the country as a whole is between 6.5% (2002, 2006 and 2009) and 7.0% (2004). The year 2009 is recorded as the year with the highest number of arrivals (763,966 arrivals), while the year 2010 with the highest total number of arrivals of tourists (1,043,202 arrivals). The share of the total arrivals of the country was at 6.6%. At the level of the Regional Units, the Region of Peloponnese is a region of long-lasting touristic interest in the Region of Argolida and the Corinthian Peninsula, which maintains and/or increases over time their special weight in tourist arrivals. Regarding the touristic offers, 6.95% represent the country's tourist beds.

Population Data

The population density values of the Corinthia are the highest in the Peloponnese Region (67.5 inhabitants per km^2). The region's economy is heavily dependent on the region of Attica in all areas. It relies heavily on services (hotels, catering, entertainment and commerce) to serve tourists and holiday homeowners, most of them from Attica. The tertiary sector is the basis of the economy not only in Loutraki, which was originally established as a service city but largely, in Ag. Theodoroi. A small percentage of the municipality's (Ag. Theodoroi) inhabitants are employed in the primary sector while many work in industries located in an informal industrial park (not organized and without infrastructure) in Sousaki, very close to volcanic vapor.

3.1 Sousaki Volcano, Agioi Theodoroi

Geological Data

Since 1970s, surface hydrothermal indications for the existence of an exploitable geothermal field in Sousaki led to specialized detailed investigations, which included mapping of the site, full geological, geomorphological, tectonic, petrological and micropaleontological research. Moreover, drilling programs took place, while the geological surveying and geochemical research on samples of liquids and gases (Voutetakis & Fytikas, 1975; Kavouridis Th. & Fytikas M., 1988; Kavouridis *et al.,* 1991) were performed. Summarizing the information given by many researches, the broader area of Crommyonia (or Sousaki) is constructed (bottom-up) from the following formations:

- Formations of Subpelagonic Unit, consisting of i) neritic limestones of Lower-Jurassic to Lower Cretaceous, and ii) ophiolitic rocks (peridotites, serpentines and gabbros), which overlay. The overthrust between them has been created earlier than the Lower Cretaceous.

- Terrestrial and Marine Formations, including:

    - Sedimentary formations deposited during the Pliocene. They are encountered in specific positions where characteristic fossils (certifying their age) are also found. They represent sediments in a lake environment, consisting of alternations of ophiolitic/limestone/ceratolithic conglomerates, sandstones and sandy marls with small lignite inlays. The thickness of the deposits decreases to the north, indicating that the basin was being supplied from the South. In these formations there are also found dacites of a size of about 30 cm and pyroclastic materials, similarly composed (2m thick), which contain angular pieces of dacite up to 20 cm in size. These are products of the volcanic eruptions that were poured into the basin, while at the same time the deposition of the lake sediments continued. These formations, which have been ultimately affected by the fumes, dominate in the entire area of Thiochoma gorge.
    - Sedimentary formations deposited during the Pleistocene. The lower layers are lake-sediments containing large pieces of sloped Upper Pliocene limestones, while the Plio-Pleistocene upper layers consist of alternations of lake, brackish and marine materials. This is actually a fact that reveals the frequent changes in the paleogeographic conditions of the area: The extension period which was crucial during the formation of the Hellenic arc, gave way to a period of compression that during the Pleistocene, failed to start a new, intense phase. Studying though the marine deposits, it becomes quite plain that the sea has fallen to the South because of these alternations in the system. All layers have been

micropaleontologically tested and fossils of characteristic age were documented (Chrysafoudis, 2012).

- o <u>Pleistocene river conglomerates</u>: Conglomerates with mainly ophiolitic grains, whose consistency differs from place to place. The direction of the deposits leads to the conclusion that their deposition took place from the North to the South.

- Holocene sediments, which are consisted of sands, limestones and red clay deposits. In fact, they were mainly alluvial deposits, covering a larg part of the area.

All the above formations have been affected by a strong tectonic effect and are partly covered from Holocene sediments.

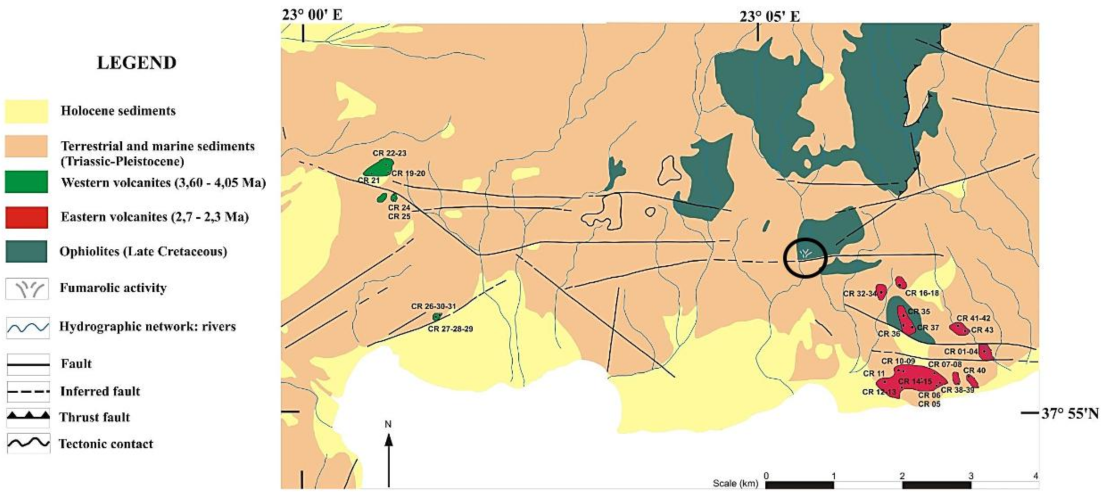


Figure 3.1.1: Digitally replicated Geological Map of Crommyonia area, modified after (Mettos *et al*. 1982, 1988, Fytikas *et al.* 1986, Rondoyanni *et al*. 2008). The eastern and western volcanic outcrops are denoted in red and green respectively. The volcanic outcrops are closely related to fault activity occurring since Pliocene. Geotope's location is within the black circle.

In the wider area, apart from lithostratigraphic and geothermal research, studies are also carried out, focusing on tectonic and seismic approaches. Sousaki, due to its location, is characterized by intense seismicity over time. According to (Mettos *et al*., 1988), the area has gone through three tectonic phases: an extension phase, a compression one, and lastly one more extension phase. The two extension phases correspond to two systems of normal faults that affect both the lower and the overlaying sedimentary formations: the main system of these fractures presents an E-W direction, while the secondary one has a NW-SE. The compression phase is detected by inverse faults during Plio-Pleistocene and, most importantly, of the Lower Pleistocene formations. More specifically, the major active fault systems as described by (Rondoyanni *et al*., 2008) are:

- The Fault system of Skinos and Pisia, north of Sousaki to the Corinthian Gulf: This area has actually two parallel normal faults with a direction from ENE to SSW, about 15 km long, which penetrate into limestones, creating sharp slopes.

- The Loutraki fault system: This zone represents a continuation of Kakia Skala. It consists of successive parallel surfaces with sharp sliding lines that indicate an active character of the fault. Thus, it exhibits continuous activity. The most striking appearances of such surfaces are located north of Loutraki, near the Monastery of Saint Patapios, and north of Ag. Theodoroi, in the Pikas River.

- The Fault system of Ag. Theodoroi: It consists of smaller normal faults that were developed within the Pliocene and the Pleistocene sediments.

The volcano of Sousaki has been explosive in two phases, during the Middle and the Upper Pleiocene (PePiper & Hatzipanagiotou, 1997). Views of the volcanic rocks are scattered over a large radius in the wider area (Sousaki, Ag. Theodoroi, Kalamaki, Koudounistra). These are mainly lava flows and individual structures of dictatorial composition - products of magma that is the typical trait of volcanoes in the South Aegean. The current activity of the volcano is considered to be post-eruptive and it is has the form of steamers that are now found in the eastern gorge of the Thiohoma area. The steamers of Sousaki are characterized as "moffettes", as coal is the predominant in the composition of the gases. In particular, the mofettes of Sousaki consist of 82% - 95% of carbon dioxide (CO_2) and hydrogen sulfide (H_2S), sulfur dioxide (SO_2), methane (CH_4), hydrogen (H_2) and helium (He). These gases are discharged from natural and artificial holes (the artificial ones were opened for sulfur exextension), which appear on the ground and on the walls of the gorge. During this discharging, they meet rocks that surround the holes (peridote and other sediments) and react with them forming opal, chalcedony, christobalite, gypsum, and crystalls of sulfur in many colors (i.e brownish, yellowish or greenish). In some places (near water vapor and hot water outlets), the secondary products reach a thickness of 10m (Kyriakopoulos *et al*., 1990). At these points, the vegetation is absent and the landscape is naked, with rock formations that look odorous as they have been transformed and disintegrated. The impression is exacerbated by the higher temperature prevailing inside the canyon, the locus-odor and the presence of dead insects and small animals near the gas outlet holes. Gases are emitted all year round, but the sight of their exit from the holes is more impressive and occurs as low as the ambient temperature.

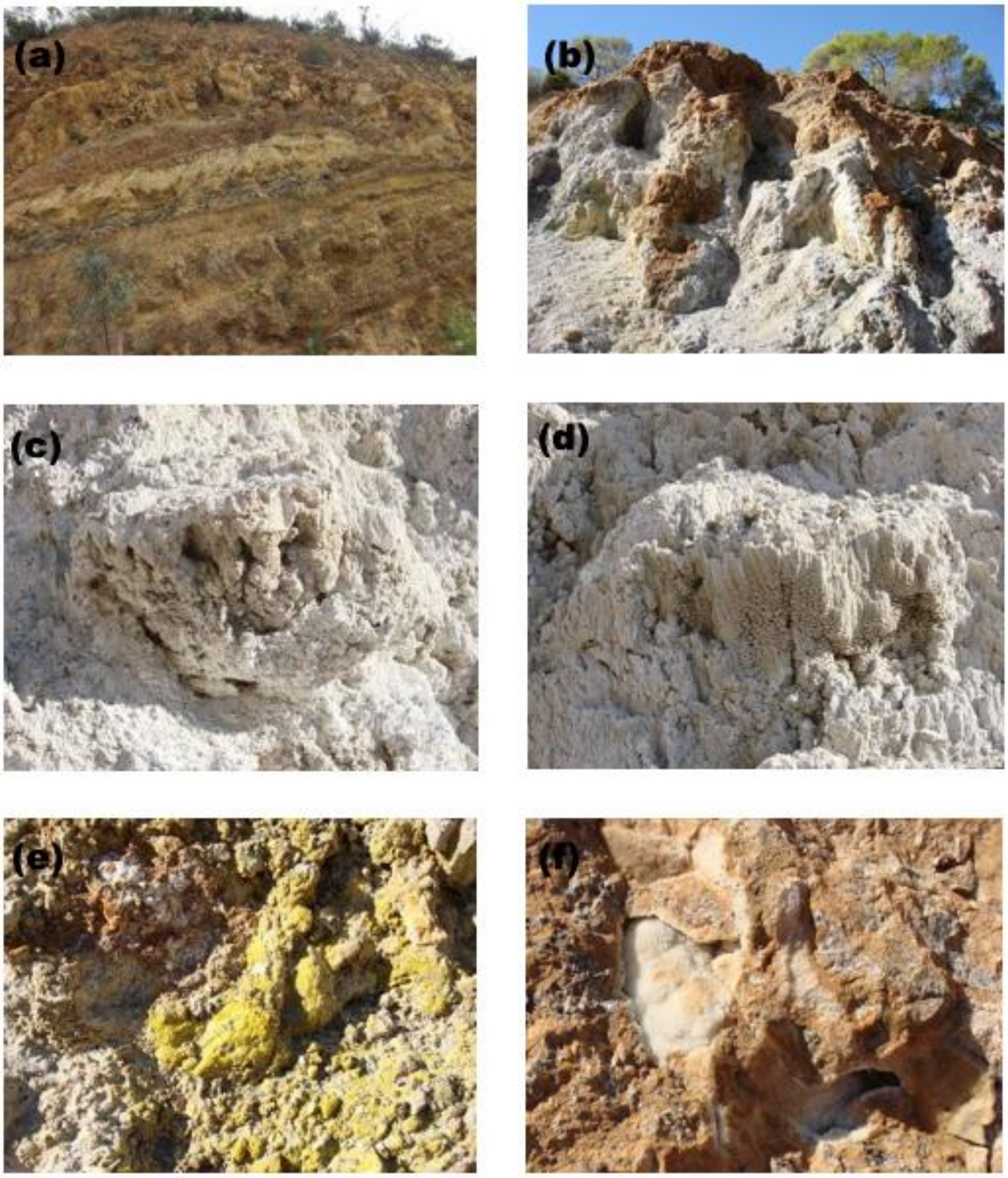


Figure 3.1.2: (a) Plio-Pleistocene sedimentary formations, (b) Ophiolitic formations. The wider area is rather smelly, which is even more intense near the holes, (c)&(d) Impressive, brittle small structures of gypsum, photos by (Chrysafoudis, 2012), (e)&(f): Crystalline gypsum structures with sulfur (yellow color) and quartz (whitish-grey color).

General Information

Sousaki is located about 65 km southwest of Athens, on the east coast of Corinth, between the Isthmus of Corinth (4.5 km east of Corinth) and the coastal town of Agioi Theodoroi. It is located in the Southwest part of the Saronic Gulf and at the same time, it is a continuation of the Corinthian moat (Kavourides & Fytikas, 1988). It is the northern tip of the volcanic arc of the South Aegean and has an altitude of 180-200 m at about the foot of Gerania- a limestone mountain in which ophiolithic rocks have been inhabited. The climate of the region is typical Mediterranean climate, with a large annual variation of rainfall; the average height is about 460-500 mm, 80% of which is distributed between October and March, while the period between June and September is actually dry.

Historical-Archaeological Information

The area of Sousaki is referred to as “Crommyonia Country”. Crommyon was a comic and actually a harbor of the Corinth near the border with Megarida. According to Pausanias (II, 1,3) and Strabo (VIII, 380), the mythical Cromyonia, lived in the area. Cromyonia or Pea was actually a terrible female wild boar that destroyed the crops and killed the peasants in the area. Its extermination was one of the works of Theseus on his way from Troizina to Athens. Thoukidides (D, 42, 44) as well as Xenophon (IV, 4, 13 and IV, 5, 19) are mentioned in Crommyon, as during the Peloponnesian War, they suffered successive occupations by the troops of the warriors. The archaeological excavation has brought to light burial finds, vases and statues exhibited at the Archaeological Museum of Corinth. On the Cape of Sousaki dominates a traditional stone lighthouse that guides the ships along their way to the Canal. It has been built in 1894 and its height is 7.5 m.

Population Data

The Municipality of Loutraki-Agioi Theodoroi has an area of 293.23 km^2 and a population of 21,100 inhabitants (according to the Interim Results of the 2011 Census issued by ELSTAT in July 2012, showing a slight increase in population compared to that of 2001). Of these, approximately 6,000 inhabitants live in the Municipal District of Agioi Theodoroi, on the outskirt of which is the volcanic geotope. The Municipality attracts mainly beach visitors, recreational tourism (directed at the Casino and other entertainment centers), users of Loutraki thermal spas, as well as religious tourism (directed mainly at the Saint Patapios Monastery, north of Loutraki).

Institutional framework

The volcanic geotope in Sousaki, although documented (Velitzelos *et al*., 2002) is not officially protected. However, this is not a problem since the protection of each geotope, recognized by the local authorities is already given. Greece has signed all the relevant international conventions and the institutional framework that has been developed guarantees the possibility of protecting and boosting even the individual Geotopes that are surrounded by incompatible uses to the model of mild and sustainable development (i.e urban environment, industrial park, etc.). In particular, the protection framework provided by Law 1650/86 for the category "natural formations-landscapes-landscapes' elements" was significantly reinforced by the new Law 3937/2011 on Biodiversity. This law expressly provides the possibility of protecting functional parts of nature or individual creations that have particular scientific, ecological, geological, geomorphological or aesthetic value, and therefore contribute to the preservation of natural processes and the protection of natural resources.

3.2 Isthmus of Corinth

Figure 3.2.1: Isthmus of Corinth. A) View of the geological layers in the Isthmus of Corinth B) View of the natural geological section. They are distinguished from the base to the roof: Corinthian Marga, Conglomerates, Sandstone, and Red Conglomerates - Clay. Γ) Natural geological section. We can see from the base to the roof: Corinthian Marl, Conglomerates. Δ) A frigid soft formation containing marine macro- and micro- fossils (corals, coccolithophores).

Geological Data

The Isthmus of Corinth is a narrow strip of land that connects the Peloponnese to the Hellenic mainland and marks the easternmost limit of the Corinth Gulf. The Canal, apart from its obvious economic significance for navigation, is also an impressive geotope: on its slopes (which are 78 m above sea level and 86.30 m from the sea bottom), the layers of sediments of various ages are the main constructers of the region, as well as the big faults (normal and inverse) that cross them. It is located in a neotectonic depression bounded by alpine mountain structures on both the mainland and the Peloponnesian sides, and it consists of a succession of uplifted, well-exposed Pliocene marls unconformably overlain by several cycles of near-shore Pleistocene conglomerates. Neogene and Quaternary sediments are cut by numerous, nearly east-west-striking, subvertical normal faults. These faults can be observed along the 6.2-km-long canal, cut at the end of the nineteenth century exactly at the place where Diolkos, existed. Because these faults belong to two different families (Mariolakos & Stiros, 1987) and dip to the north and south, respectively, the Isthmus has been interpreted as a horst (Philippson, 1890). Four major fault zones mostly influence the eastern part of the Isthmus (Fig. 3.2.2):

- The South Alkyonides Fault System
- The Loutraki fault
- The Kechriaie fault
- The Agios Vassileios fault

South Alkyonides Fault System (SAFS) was ruptured in 1981 as a result to the earthquake sequence, producing up to 150 cm of displacement (Jackson *et al*., 1982; Mariolakos *et al*., 1982; Hubert *et al*., 1996). Based on a leveling campaign it was estimated that the area of the Corinth Isthmus near the Canal was uplifted by approximately 2 cm (Mariolakos & Stiros, 1987). Generally, the area of Isthmus is uplifted due to the SAFS, while the remaining three faults subside the area (Papanikolaou *et al*., 1988; Armijo *et al*., 1996; Roberts, 1996; Morewood & Roberts, 1999; Leeder *et al*., 2002; Roberts *et al*., 2009; Turner *et al*., 2010). However, the SAFS has a significantly higherslip rate of 2-3 mm/yr (Collier *et al*., 1998) and a shorter recurrence interval (300 to 400 yr) than the other three faults.

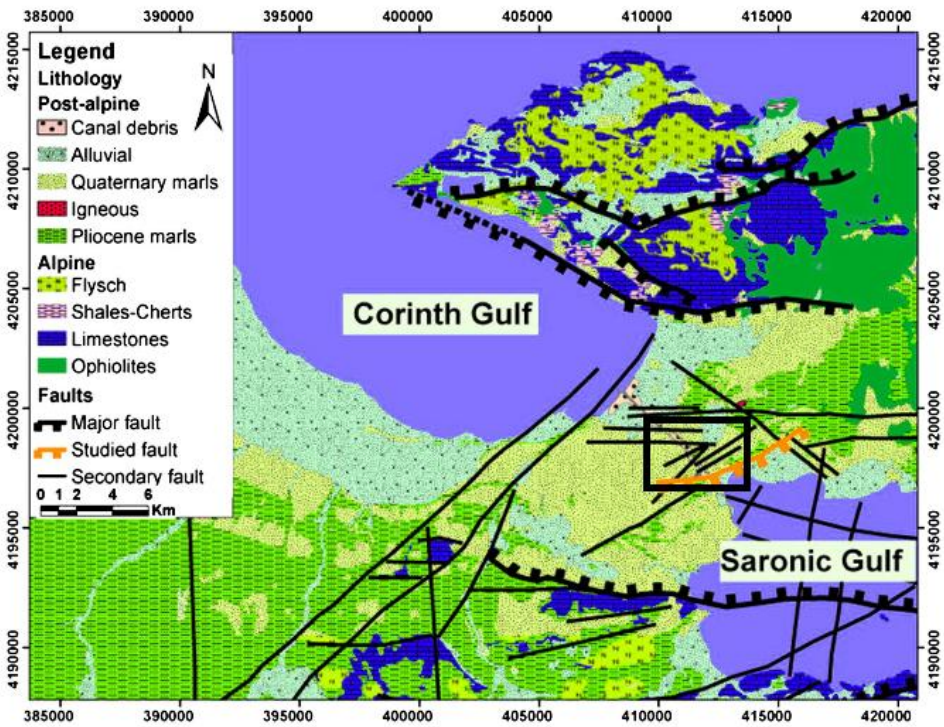


Figure 3.2.2: Digitally simplified geological map of Corinth showing the major and secondary faults (modified from Bornovas *et al*., 1972, 1983; Gaitanakis *et al*., 1985; Papanikolaou *et al*., 1989, 1996;

Roberts *et al*., 2009; Papanikolaou I., D. *et al*., 2014). The orange color shows the Kalamaki-Isthmia fault, one mostly important active normal fault that crosses the Corinth Canal and the area of the Isthmus. Geotope's location is shown inside the black square.

These faults actually display low slip-rates, estimated at about 0.2 to 0.5 mm/yr (Papanikolaou *et al*., 1988, 1989; Collier & Thompson, 1991; Papanastassiou & Gaki-Papanastassiou, 1994; Goldsworthy & Jackson, 2001; Rondoyanni *et al.,* 2008; Zygouri *et al*., 2008; Roberts *et al*., 2009, 2011), revealing that the Corinth Canal is constantly uplifted (Collier *et al*., 1992; Dia *et al*., 1997, Papanikolaou I.,D., *et al*. 2014).

Moreover, there is also a regional uplift estimated at approximately 0.2 mm/year (Armijo *et al*., 1996; Turner *et al*., 2010) that some researchers suggest, it is caused by isostatic adjustment of the lithosphere (Leeder *et al*., 2008). This continuous tectonic uplift of the area influences the sedimentology of the Corinth Isthmus. Indeed, the Canal exhibits a range of facies including marls, sandstones and conglomerates representing offshore, shoreface and coastal environments. The sedimentation began with the deposition of lake (or brackish) marls. This process took place for a million years and due to a change in the nature of sedimentation, it was followed by the deposition of conglomerates. Over the conglomerates, psammitic formations are overlaying, which indicate successive elevations and sinkings of the area, being exposed to the exogenous factor of erosion. Therefore, we understand that the area presents phase changes that correspond to different sea level episodes and it is being dictated by transgressive cycles. In other words, several alterations in littoral and marine deposits that have been identified, reveal a series of transgressive cycles bounded by unconformity surfaces (Freyberg, 1973; Collier *et al*., 1992) responding to different paleoenvironments.

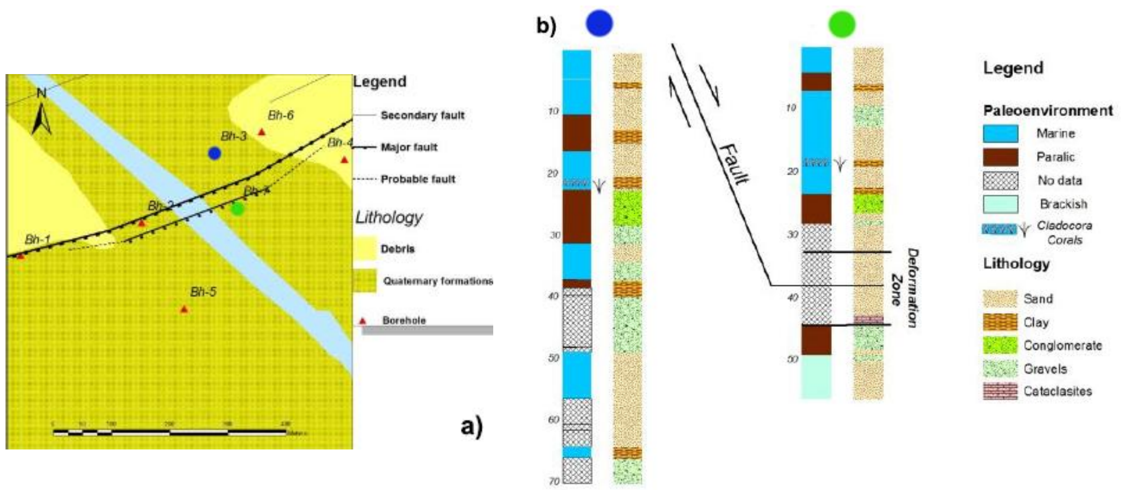
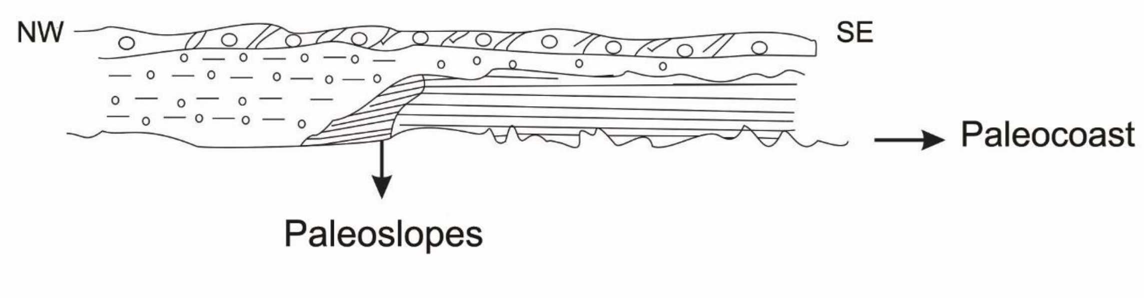


Figure 3.2.3: a) Simplified geological map of Isthmus of Corinth, showing the Kalamaki-Isthmia fault, b) View of the stratigraphic columns and the depositional environment of the two boreholes (blue, located on the immediate footwall and green located on the immediate hangingwall of the Kalamaki-Isthmia fault), modified after (Papanikolaou I., D. *et al.* 2014).

These alterations are thought to be the product of interplay between the rate of global sea-level change and the rate of tectonic uplift of the area. According to Anagnostopoulos *et al.* (1991), the Up. Pliocene and Pleistocene marls are distributed by the Corinth Canal, whereas Collier & Dart (1991) and Collier & Thompson (1991) have described the lithological formations on both sides of the Canal. Thus, the reconstruction of the paleomorphology of the Isthmus over the last 200,000 years has been successfully accomplished.



Schematic representation 3.2.1: Schematic drawing in the region of Isthmus of Corinth. The arrow (downwards) shows the small slopes of the formations, while the right black arrow shows the existence of the "paleocoast".

This natural geological area is characteristic due to the peculiarity of its formations, their connection with geological time and the paleoenvironment they represent. Therefore, it is highlighted as a site of great geological importance, worthy of preservation as a genuine and authentic sample of geotope.

General Information

The Isthmus of Corinth is a narrow strip of land that unites Central Greece with the Peloponnese, while the canal that is open to it joins the Saronic Gulf with the Corinthian Gulf. It is about 6 km long and the narrowest point is where the Corinth Canal was built (1880-1893). It was a strategic point and for that reason a wall was built already in the ancient times (late 5th century BC), which had been preserved to the Byzantines (Examilion).

Historical-Archaeological Information

The Isthmus has passed into history as a bridge of communication between the Peloponnese and the rest of Greece, as a defensive bastion of the Peloponnese, but also as a place for concluding conventions and convergence of Congresses of Greek cities. The idea of creating a canal in the Isthmus in order to avoid the navigation of the Peloponnese was first formulated by the tyrant of Corinth “Periander” in the early 6th cent. B.C. However, the poor technical means of his time did not allow him to accomplish his thought. Nevertheless, he succeed in the the construction of the Diolkos, a paved road between the Saronic and the Corinthian. Its final realization began in 1882 on the line drawn by Nero's engineers and the cost of its construction is linked to one of the Greek state's bankruptcies. In the Isthmus there was the great temple of Poseidon with the stadium and the theater where the greatest -after the Olympic- Panhellenic “nude, horse and musical competitions” were held initially with a funeral character. The games of the Isthmus remained important until the end of the ancient world; It seems that the spectacle of the inner structure of the land and its sacred character is a spectacle for most people, despite the general lack of knowledge of geology.

3.3 Acrocorinth, Ancient Corinth

Geological Data

Modern Corinth as well as the ancient Corinth and Acrocorinth are situated at the southeastern margin of the Gulf of Corinth. The modern city is located at the Isthmus of Corinth and connects the Peloponnese with mainland Greece. The on-going regional uplift affects the northern part of the Peloponnese and the eustatic sea level changes throughout the last 0.5 Ma (Hayward, 2003). Thus, the wider Corinth region presents a complex and interesting geological background.

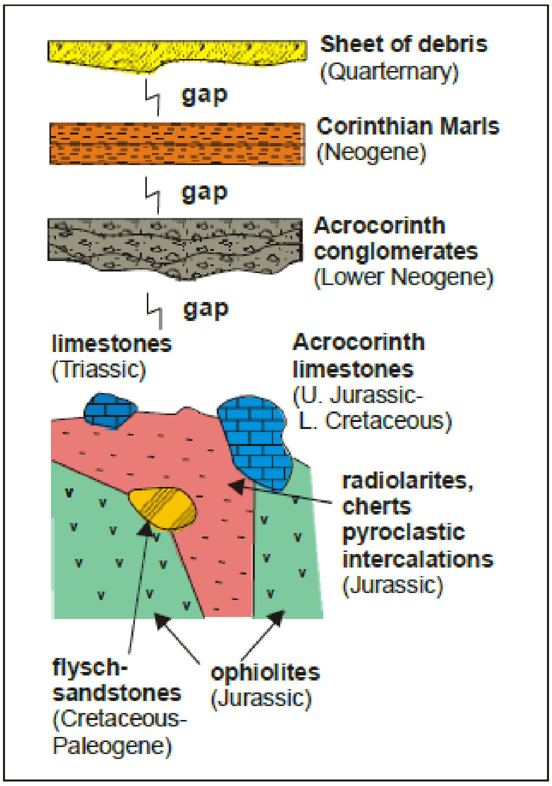


Figure 3.3.1: Schematic profile of sequences in the Corinthian area showing the stratigraphical position of the main geological units, according to (Hartwig, 2011).

- The northeastern Corinthia is dominated by unconsolidated Quaternary deposits (IGME, 1972), which form a coastal plain that extends up to 4 km inland. Along the shore, there are noticed recent beach deposits mainly consist of sand and gravel, while at various places, consolidated sediments form beachrock complexes may also be found. The coastal plain is bordered by a sequence of marine terraces.

- The southeast of Xylocastro (Heights up to 820 m) is made from terraces, sculpting the topography of the southwestern Corinth. These terraces belong to the highest uplifted marine ones worldwide. The main formations that can be observed are yellow to white marls of Pliocene to Pleistocene age. The marls are overlain by marine and nearshore sands and conglomerates, covered by both alluvial and colluvial Holocene deposits. These marls have been formed during sea level high stands and subsequent tectonic uplift and can be protected from further erosion as they are found in some places, beneath porous Pleistocene deposits, which serve as a protective cap. Macrofaunal remains including *Strombus bubonius* classify that the conglomerates have been deposited during Pleistocene (Keraudren & Sorel, 1987).

More specifically, the ***geological sequence in Acrocorinth*** starts in the middle Mesozoic:

- *<u>Neritic limestones and dolostones</u>* formed on the Parnassus carbonate platform as part of the Centralhellenic Systems.

- *<u>Pelagic cherts and ophiolitic sequences</u>* in the center of the Ocean as a sub basin of the Pindos Ocean. During the closing of the Böotian Ocean, *<u>carbonates, cherts and ophiolites</u>* were tectonically mixed as part of an accretion in the subduction trench thus forming a mélange belt between the Parnassus- and Pelagonian-plates (Gielisch, 1993, 1994).

- The youngest components of these *<u>mega-breccias are of Eocene age.</u>*

- The alpine orogenesis of Greece is completed in the Lower to Middle Miocene. During the Upper Miocene the alpine Hellenides were fragmented by a phase of intense brittle faulting. The major systems of the Greek intra-mountainous graben-systems developed during the Upper Miocene and the Lower Pliocene.

- During and directly after these phases of brittle faulting the *<u>Acrocorinth conglomerates</u>* have been deposited over the Mesozoic units. Components of the conglomerates comprise mainly local and regional geological units (carbonates, cherts, serpentinites of the ophiolites, quartzites) (Richter *et al*., 1992).

- *<u>Exotic clasts</u>* like olivine-gabbros, marbles and other metamorphic rocks show a connection to source rocks, which are nowadays located further away.

- Following after the Acrocorinth conglomerates, *<u>the Corinthian Marls</u>* formed in the Neogene and cover all other geological units.

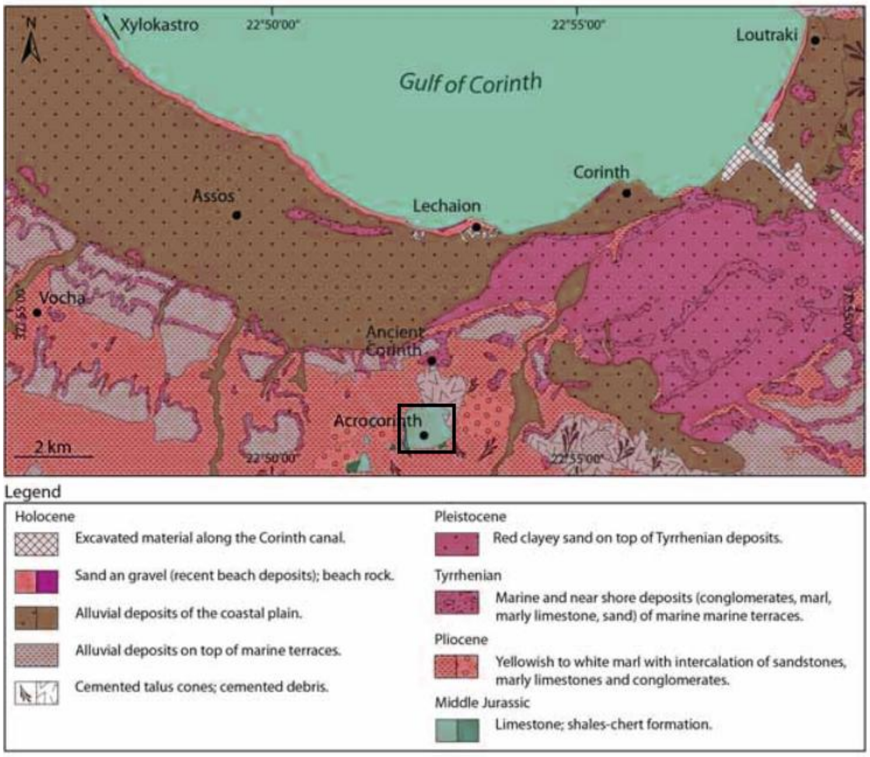


Figure 3.3.2: Simplified Geological Map of Corinth, focusing on Ancient Corinth and Acrocorinth Castle (modified after IGME, 1972; Roberts *et al.* 2011). The black square shows the position of the geotope.

In the beginning of the Pliocene, the Graben of Corinth started to sink. As compensation for the deepening of the graben the Parnassus-Ghiona Mountains rose in the north, while in the south the Trapazona Mountains and isolated areas north, including Acrocorinth have been up-lifted pushing through the Neogene and Quaternary sediments. At Acrocorinth marine terraces are developed at 220 m. The age of the terraces is Pre-Paleotyrrhean (460,000 to 400,000 a) thus verifying an uplift of the hill of some 200 m in the last 400,000 years (Sedat, 1986). Today the components of the Mesozoic mélange form the top of the Acrocorinth hill as well as a smaller hill west of Acrocorinth, (Penteskufion). Acrocorinth conglomerates occur east and west of the hill, pushed up during the up-lift of Acrocorinth, with circular dip directions outwards on the flanks. West of the Penteskufion the conglomerate also occurs, dipping also into a westerly direction. In the eastern and western areas the conglomerates are covered by Corinthian Marls. In the south of Acrocorinth, conglomerates do not outcrop. Here the Corinthian Marls are directly in contact with Mesozoic layers. On the northern flank, conglomerates do not outcrop. The outcropping units on the northern flank of the hill are interpreted to be breccias with angular components and not conglomerates (Hartwig, 2011).

In areas, where western terraces have been uplifted to higher elevations, increased erosion has led to a removal of the protective cap and exposure of the Pliocene marls leading also to the development of badlands (Hayward, 2003). The hilltop of Acrocorinth comprises an eastern and a western summit with the maximum elevation occurring in the eastern part and a central saddle (Carpenter & Bon, 1936). The western flank of Acrocorinth is connected to the surrounding hills by the low shale ridge whereas the northern and eastern flanks are characterized by steep cliff-like slopes. The northern flanks of the hill collapsed during the 8th century and a mixture of natural rocks and cultural debris formed talus deposits, which cover the main parts of the northern flanks (Fig. 3.3.3). These slide breccias have been cemented in the following centuries and can therefore, be misinterpreted as conglomerates. However, the angular to sub-angular character of the clasts point to an origin as breccias in contrast to the well-rounded clasts of the Acrocorinth conglomerates.

Figure 3.3.3: Sheets of debris at the Northern flank of the Acrocorinth. (a): base of fine to medium coarsed sheet of debris: components sharp-edged, up to 10 cm diameter, lightly cemented with terra fusca and terra rossa. (b): base of very coarse sheet of debris: components sharpedged, up to 50 cm diameter, lightly cemented with powdery, carbonate matrix, according to (Hartwig, 2011).

The hill of Acrocorinth as one geotope of geologically and historically great importance, with its summit at 574 m above sea level represents one more prominent feature in the topography of Corinth. It mainly consists of limestones from the Middle Jurassic and sporadic layers of shale (Higgins & Higgins, 1996; Bornovas, 1999). Its creation is mostly due the intense tectonic actions of Pliocene and Pleistocene with the upward and downward movements in the whole area of Corinthian Bay. Geomorphologically, Acrocorinth is a residual form of a previous relief (inselberg hill).

General Information

Acrocorinth is this natural monument, under of its imposing protection, there is a small settlement that was built near the area of Acrocorinth, Efyra, which later evolved into the immense and proud Corinth. This castle was the natural sign of the city's existence, and was fortified in an exemplary way, being the most important fortification of the area from antiquity to the recent years.

Historical-Archaeological Information

In antiquity, Acrocorinth served as a refuge for the population of ancient Corinth. Overlooking the Isthmus of Corinth and controlling the passage between the Peloponnese and mainland Greece, it was of great strategical importance. It was fortified for the first time by the tyrant Periandros and his father Kyplesos in the 7th-6th century BC and slowly evolved into an Acropolis. Acrocorinth castle has passed to many conquerors; from the 11th century onwards, the fortress at Acrocorinth was under Frankish, Byzantine, Venetian and Turkish control, as still visible from numerous building remains, but it was lastly retaken from the Greeks during the Greek War of Independence in the early 19th century (Scranton, 1965).

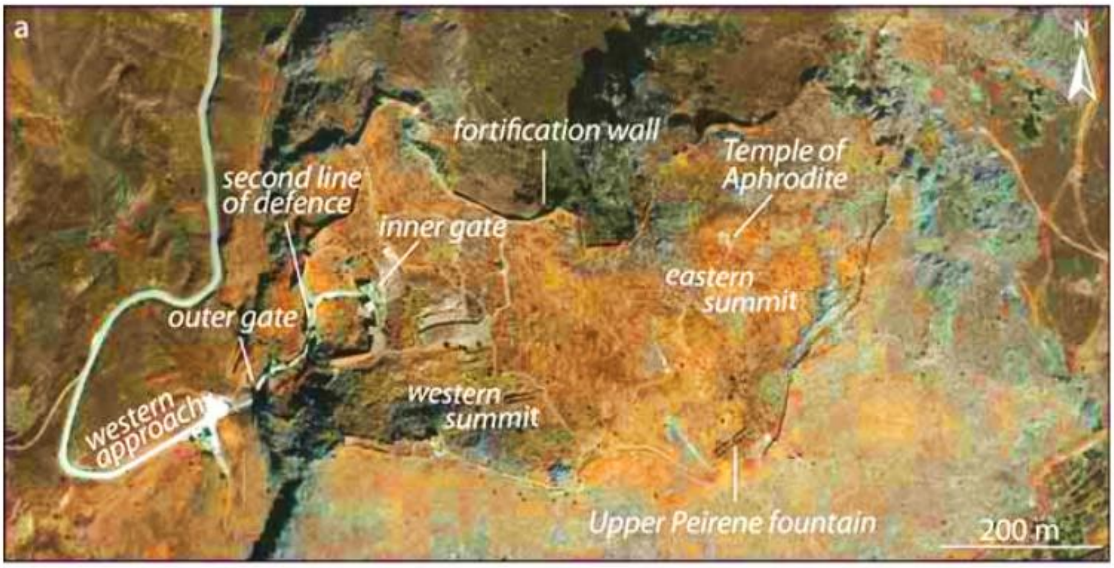


Figure 3.3.3: Fortifications of Acrocorinth in an aerial view (modified after Google Earth image, 2009).

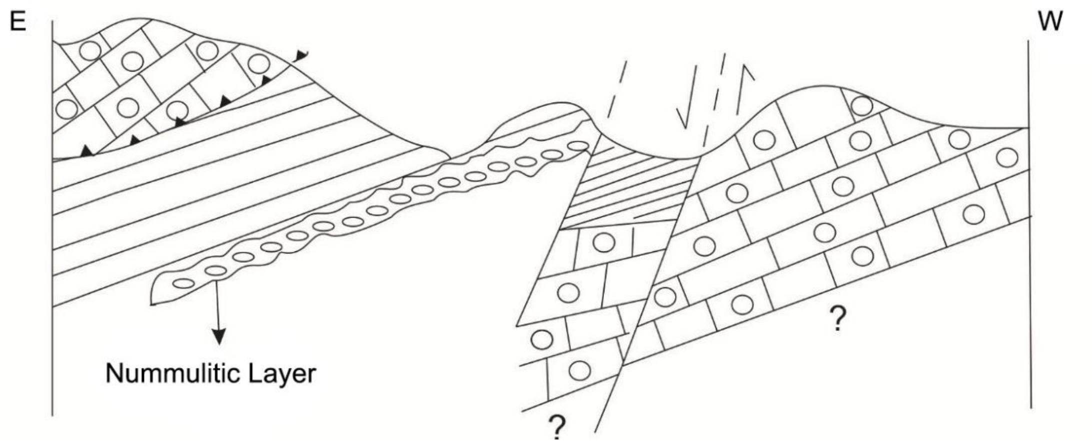
Due to its geomorphology, the fortress was quite easy to defend. A further fortification of the site by walls as well as a continuous water supply by the Upper Peirene fountain made Acrocorinth a secure stronghold. According to Greek Mythology, Peirene fountain was created from river god Asopus as an etermal fountain to Sisyphus, the king of Corinth, promised to tell Asopus where his lost daughter had been. Today, various fortifications are still preserved, as best visible from satellite images (Fig. 3.3.3). The fortification wall visible today is predominantly of medieval age, but follows the circuit of the ancient wall. The excavation and reconstruction of the site began in 1929, conducted by the American School of Classical Studies at Athens.

3.4 Saint Sozon, Dervenakion, Corinth

Figure 3.4.1: View of Dervenakion, Corinth.

Geological Data

The southwestern margin of Dervenakia is actually included in Eastern Greece geotectonic unit, the formations of which are overthrusted on the flysch formation of “Gavrovo” Unit (Papanikolaou 2015). The southern region is constructed by the extensive and continuous occurrence of carbonate rocks (northern sector Arachnaio) from the region of Dervenakia in the west to the shores of the Saronic Gulf in the east (Barnert, 1981; Gaitanaki *et al*. 1985). These formations are thick limestones and dolomites, of Eocene (approx. 38Ma), that have been affected by the rift tectonics that formed the Corinth Gulf in its present form and both tectonic trenches and horns of the eastern Corinth area. These neritic limestones are overlaid by the Gavrovo flysch, which represent a deep pelagic clastic formation with nannofossils (i.e coccolithophores). In the limestones, they can be found *Nummulites,* very well preserved charasteristic neritic benthic foraminifera that suggest shallow environments. In other words, the area was a carbonate platform. E-W faults and fault zones are dominant in the area. These faults, from the area of Dervenakia to the end of the eastern Corinth, St. Basil - Klenias and Athikia-Rito are presented as large fault zones, covered by lateral scree. These fault zones delimit the mountainous carbonate mass of Arachnaion the Neogene basin of Corinth, in the north (Papanikolaou *et al.* 1990). Along these fault zones there are small occurrences of schist-chert sediment formations with ophiolitic bodies. The same sediments occur along the EW overthrust in the region of Angelokastro (Tataris and Kallergis 1965; Tataris *et al*.1970). In the northern part, the continuation of the Neogene basin is interrupted by multiple occurrence of alpine background (Mapsos, Mavri Ora, Acrocorinthos, Onia). Plio-Plistocene post-alpine sediments consist of marls, sandstones and conglomerates. The conglomerates in the margins of the basins overlay on the carbonate formations of the background. Focusing briefly on the Dervenakia margin, the combination of the geomorphology, tectonic structure and micropaleontology enhance the area as a characteristic natural geotope.



Schematic representation 3.4.1: Simplified sketch geological section of Dervenakia area. With black straight lines is shwon the flysch of Gavrovo geotectonic unit that overlaps the Gavrovo neritic limestones containing *Nummulites*, fossiled specimens.

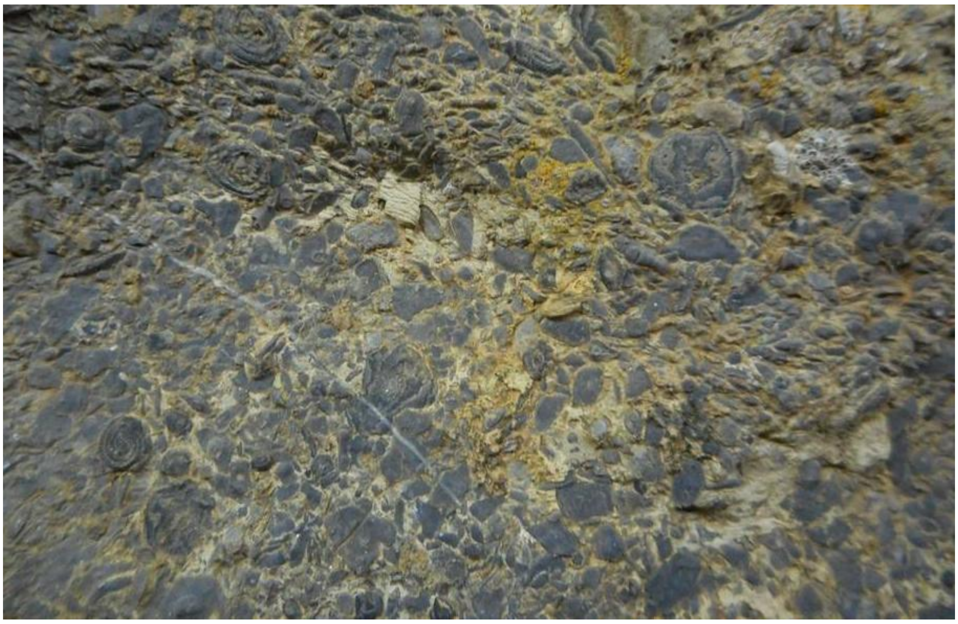


Figure 3.4.2: Particular case of finding neritic fossils in a deep-pelagic clastic formation due to the erosion. The fossils are *Nummulites* and are in spherical shape inside the flysch material.

General Information

Dervenakia belongs to the municipality of Nemea of Peripheral Unity of Corinthia located in the Peloponnese Region and has been in history due to the battle that took place there between Greeks and Turks in July 1822.

In the Dervenakia of the Prefecture of Corinth, in a large gorge, there is the chapel of Agios Sostis, which at the beginning of the 20th century had four official holidays. On July 26th, the anniversary of the Battle of the same name, which took place in 1822, is celebrated in Dervenakia. Furthermore it was included the creation of a statue of the winning "Theodoros Kolokotronis" and the speech of the feast day.

Historicall Information of the Saint Sozon Church

In the place of the church of Saint Sostis, there was a Byzantine church dedicated to Saint Sozon, destroyed by the Turks in 1715. The present earlier ship was built in 1860 by the son of Kolokotronis (Geros Moria) as witnessed by the inscription on the icon of Saint Paraskevi. However, there is another tradition, according to which the reconstruction was started by Panagiotis Raka, who became rich. Being grateful to St. Sozon for his luck, he built his new temple in honor, and until the end of his life, he was devoted to him. During the rebuilding of the temple, General Kolokotronis passed by, who used to visit Saint Sostis for pilgrimage purposes. Therefore, he was willing to contribute to its completion and construction of the iconostasis offering everything necessary for its operation.

Figure 3.4.2: A) Saint Sozon Church, B) Honorary mention to Archimandrite Arsenios Krestas (Paparsenis).

The Battle of Dervenakia is also attached to the Saint Sozon Church, as it was one of the most important battles that took place during the Greek Revolution of 1821. It was actually a victorious outcome for the Greeks and a great destruction of the Ottoman forces under Commander Dramalis. This battle took place on July 26, 1822, near the two of the four small mountain passes (Dervenakia), between Corinth and the Argos valley, hence its name.

Population Data

In total, the permanent population during 1991-2001, according to the Hellenic Statictical Analysis (EL.STAT) inventories 1991 and 2001 respectively were increased in the Prefectures of the Region of Peloponnese, with the exception of N. Arcadia, in which was recorded a decrease of 4.86%. In contrast to the period 2001-2011, both in the Peloponnese region and throughout the country, there is a decline in the permanent population.
On the contrary, the only Regional Unity that shows an increase in its population is that of Corinthia. The factors that appear to have influenced the population sizes of Corinth among others are compared to other regions of the Peloponnese. Typical examples of them are

- The better access to the national roads,
- Its proximity and the improvement of transport infrastructure to and from the Athens,
- Urban planning complex, as well as its developed production base.

REGIONAL UNIT OF ARGOLIS

Financial Data

In relation to the regional distribution of GDP in Greece, the Region of Peloponnese in 2008 and 2009 produces about 4.7% of the total GDP of Greece. In particular, with respect to the per capita GDP of the Regional Districts (Prefectures) of the Region in the period 2000-2009, the Corinthian, Arcadian and Argolida regions have a GDP per capita higher than that of the country and the region, while the remaining ones Of the respective indices, with the Messenia region and especially Lakonia low performance.

From the analysis of the magnitude of the AMMs at the level of the Region, from 2000 to 2008, there is a clear turn of the Peloponnesian economy in the tertiary sector, at the expense of the primary and secondary sectors. The percentage of participation of the primary sector in the formation of the Region's MFA in the period 2000-2008 shows a decrease of 38.33%.

Most of the added value generated in the Primary Sector is produced in the Regional Unity of Argolida (26.9% in 2008, compared to 21.5% in 2000), which exceeded Messinia during the period considered, which now holds the second place (21 , 9% in 2008 compared to 25.3% in 2000). The third place in the value added generated in the Primary Sector is held by Laconia (20.3% in 2008 compared to 17.2% in 2000).

By contrast, most of the benefit generated in the Secondary Sector is produced in the Peripheral Unity of Corinth despite the significant decline that occurred in the period under review (46% in 2008, compared to 60.5% in 2000). Arcadia is followed by Arcadia (21.1% in 2008 compared to 18.5% in 2000) and Messinia, but there is a significant development of the secondary sector in the period under review (18.5% in 2008, compared with 8.6% in 2000). Finally, most of the added value generated in the Tertiary Sector is steadily produced in the Regional Unity of Messinia (26.3% in 2008 compared to 26.1% in 2000) followed by Corinthia (24.8% in 2008 compared to 23.5% 2000) and the Regional Unity of Argolida (19.9% in 2008 compared to 19.1% in 2000).

Tourist Activity

At the level of the Regional Districts, the region's long-standing tourist destinations include the Argolida and the Corinthian WP, which maintain and / or increase over time their specific weight in the arrivals of tourists. Based on the latest available data (2010), although the Peloponnese region absorbs 6.6% of the country's total arrivals, its share of overnight stays is only 3.8%. The mismatch between arrivals and overnight stays is a clear indication that Peloponnese is a destination for day trips rather than leisure and / or business tourism.

Regarding the touristic offers, the Peloponnese Region in 2010, accounted for 6.95% of the country's tourist beds. More specifically, the Region accounted for 8.37% of the hotel and similar accommodation in the country, most of which are based in the Argolida region (24.2%) and the Messinian WP (21.6%). However, in all Peloponnese, a significant number of hotel accommodations are located, as in the Lakonia District, which maintains the last position among the Region's Regions, 15.9% of the hotel's accommodations are located in the Region. On the other hand, in the Peloponnese region there is a particularly significant number of tourist camping sites, which represent 19.4% of the total accommodation in 2010. The largest number of such units is located mainly in the Argolida Region (36.1% of the Region's camping) and the Messenia Region (29.5% of the Region's camping).

Population Data

With the capital city of Nafplion, the Prefecture of Argolida accounts for 1% of the population of the country with a downward trend, as the natural decline in the population of 1996 and 1997 (birth predority/1,000 inhabitants: -0.9) accelerated in the next years reaching ~1.34 in 2001. In the Prefecture of Argolis are included two urban centers: Argos with 24,239 inhabitants and Nafplio with approximately 13,822 inhabitants, almost 1/3 of the total population of the prefecture (census 2001). In Argos and Nafplion, most economic and commercial activities are concentrated, as are all public services with similar employment of residents. On the contrary, in the regional settlements the inhabitants are exclusively engaged in agriculture and livestock farming, with a few exceptions to tourism and fishing.

Geological Data

Southern Argolis Peninsula (SE Peloponnesus) is of great geotouristic importance, as the variety of the geological structures (Alpine, Post-Alpine and Volcanic formations), and the interchange on the terrain (mountains, hills, plains, valleys, morphological discontinuities), are the main reasons that Southern Argolis has great interest not only from the geological, but also from the geomorphological and geotouristic point of view. It is consisted of linear structures with different directions in also different parts of the area; we can easily identify the following areas: Region of Didyma - Iria, Adheres, Kranidi-Ermioni, Porto-Cheli, Poros Island, Methana Peninsula. Each region is characterized by different formations and has its own tectonic structure. Terrain's morphological peculiarities, among others, depend on tectonic phenomena and geological formations. In other words, Alpine and Post-Alpine Formations cover the Southern Argolis Peninsula that are part of the following Geotectonic Units: Sub-Pelagonian (Papanikolaou, 1986, 1989, 2015), Arvi-Miamou-Adheres (Papanikolaou, 1989, 2015) and Akros Unit (Baumgartner 1985; Papanikolaou *et al*, 1992, 2015) including the ophiolite nape of the Ocean Pindos-Cyclades.

The formations of Argolis Peninsula are characterized by thrusts and over-thrusts of Upper Jurassic - Lower Cretaceous (Vrienlynck, 1978a, b, 1980; Baumgartner, 1985) and Upper Eocene (Vrienlynck, 1978a, b, 1980; Baumgartner, 1985; Gaitanakis & Photiades, 1989, 1991, 1993; Papanikolaou *et al,* 1992; Vassilopoulou, 2010).

Observed folds in the whol area are aged after thrusts and over-thrusts (Upper Eocene – Oligocene), while the last tectonic facies of the region is represented by the faulting tectonics of Neogene- Quaternary along with the volcanicity of Saronic Gulf (last 5 Ma).

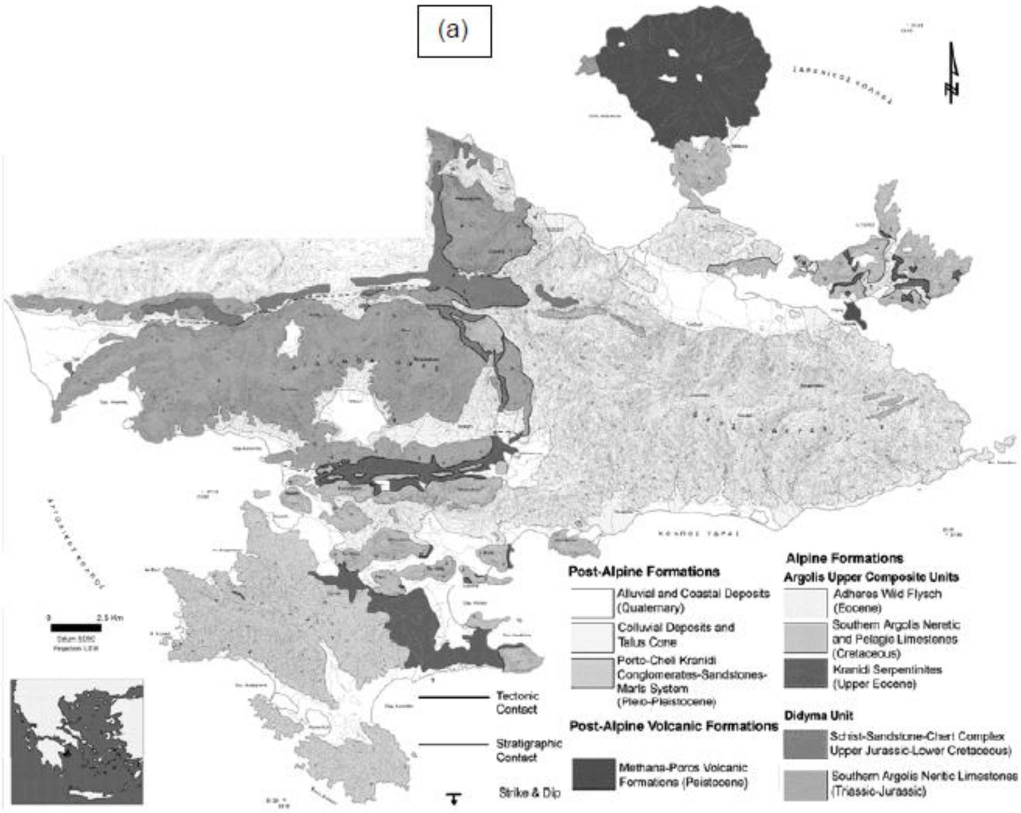


Figure (a): Synthetic Geological Map of Southern Argolis Peninsula, modified after (Vassilopoulou, 1999).

Each region of the Southearn Argolis Peninsula is characterized by different formations and has its own tectonic structure. Terrain's morphological peculiarities, among others, depend on tectonic phenomena and geological formations. An analytical description of these formations is mentioned (according to Papanikolaou *et al*. 1989; Vassilopoulou, 2010) beneath:

Post-Alpine Formations:

- <u>*Alluvial and Coastal Deposits (Quaternary*</u>): Unattached sands, clays, pebbles, breccias and gravels are observed. They are usually developed over the plains that are between the mountains or along watercourse, coastal areas, river mouth etc.
- <u>*Colluvial Deposits and Talus Cone*</u>: They consist of pebbles, breccias and congelifracts in different size, either cohesive and agglutinate or unattached. They mainly occur in watercourse mouth or along faulting zones etc.

- *Porto-Cheli - Kranidi Conglomerates - Sandstones - Marls System (Plio-Pleistocene):* The system covers the southern region of Argolis Peninsula and is overlaid on the "Kranidi Serpentinites" (in unconformity). It is characterized by small dip to the S-SW. Mainly calcareous but also serpentinites and psammitic pebbles consist the conglomerates. The matrix is calcareous or gridstone and pack sand as well as some times marly. Calcite dykes, calcite fragments and incrustations are observed. The system is overlaid on the lacustrine-terrestrial red pelitic fossil soil in several positions.
- *Methana - Poros Volcanic Formations (Pleistocene):* They consist of loose volcanic materials, pyroclastic deposits as well as concentrations of volcanic materials, domes and lava flows of dacides and andesites. They cover Methana Peninsula and the southern region of Poros Island.

Alpine Formations: They cover the rest of the region having the major extent. Two units can be distinguished: Argolis Upper Composite Unit, which is in tectonic contact with Didyma Unit.

- *Argolis Upper Composite Unit (synthetic upper tectonic unit of Southern Argolis Peninsula):*
  - Adheres Wild Flysch (Eocene): It belongs to Arvi-Miamou-Adheres Geotectonic Unit. Marls, calcareous-marly and turbidity sandstones, breccias and conglomerates compose the flysch.
  - Southern Argolis Neritic and Pelagic Limestones (Cretaceous): Dolomites and quartz conglomerates occur in the base, while neritic, pelagic and intermediate limestones follow.
  - Kranidi Serpentinites (Upper Eocene): It is an ophiolitic tectonic melange of serpentinites, hartzburgites, gabbros, amphinolites, andesitic lavas and marbles. This is the lower formation of the unit.

- *Didyma Unit (SubPelagonian - neritic basement):*
  - Schist-Sandstone-Chert Complex (Upper Jurassic - Lower Cretaceous): Schist-sandstone-chert complex with ophiolites are observed. This formation is in tectonic contact with "Southern Argolis Neritic Limestones".
  - Southern Argolis Neritic Limestones (Triassic - Jurassic): Fine granular red limestones, neritic limestones of Pantokratoras and Ammonitico Rosso compose this formation.

3.5 Tiryns, Argolis

Geological Data

Tiryns belongs to Argive Basin (AB), which is a south-widening, fault-bounded Late Neogene-Quaternary extensional sedimentary basin (van Andel *et al.,* 1990; van Andel, *et al.,* 1993; Georgiou and Galanakis 2010). The underlying bedrock consists of folded and tectonically fractured Triassic to Upper Paleogene karstic carbonates thrusted against folded post-Eocene continental flysch deposits during the Alpine orogeny. The bedrock is overlaid by an Upper Pliocene package of marl and sandy marl conglomerates passing to interbedded Quaternary marsh to fluviotorrential-alluvial deposits both of coastal and terrestrial origin (Tataris *et al.* 1970; van Andel *et al.* 1990, 1993; Apostolidis and Koutsouveli 2010). The stratigraphic thickness and geometry of the Pliocene–Quaternary sediments is yet poorly known; however, they are prone to cause strong non-linear soil amplification during earthquakes and potential liquefaction (Karastathis *et al*. 2010).

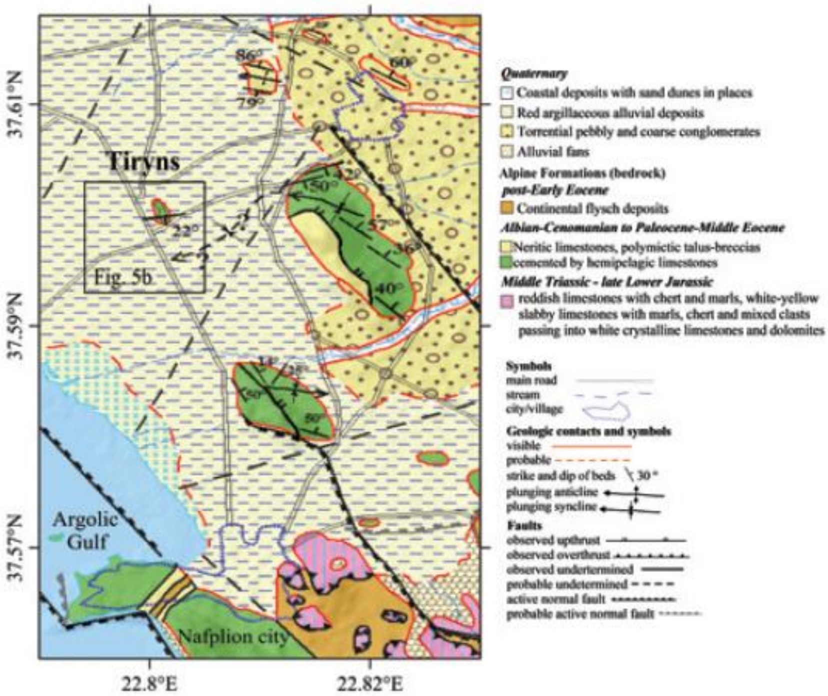


Figure 3.5.1: Geological map of Tiryns and greater Nafplion area (modified after Tataris *et al*. 1970; Georgiou and Galanakis 2010; Hinojosa-Prieto *et al*. 2015). The black square indicates the place of the Geotope.

The stratigraphy outside the fortification walls of Tiryns is made of:

- *Post-Mycenaean soils* of which 0.50 m–3 m are modern gravelly top soil covering a 3m-7m thick Holocene alluvium (Zangger, 1993).
- *Holocene alluvium* is composed of chaotically interbedded, poorly sorted sandy gravel, silts, sandy silts, sandy clays, minor pebbly gravel–silts, and lesser silty sands deposited in the second half of the Late Helladic (LH) IIIB period either during or shortly after the construction of the final palace (Zangger 1993, 1994).
- *Late Pleistocene clays/silts* (paleosoils), well consolidated, which are overlaid by Holocene alluvium. Their thickness and geometry remained poorly estimated, but now have been further studied.
- *Limestone bedrock*, covered by the paleosoils. The Late Pleistocene-Holocene soil unit once formed the foundation of the LT.

Figure 3.5.2: (a) Photo of western flank of Tiryns (looking east) showing the fortification walls erected on bedrock (white solid line marks the contact), subvertical joints (white dashed lines) and bedding (black solid lines). (b) Typical sedimentary structures in the bedrock include fine-grained calcite veinlets, (c) coarse-grained calcite veins, (d) geopetal structures, according to (Hinojosa-Prieto *et al*. 2015).

Remnants of Mycenaean Tiryns still stand above a thickly bedded, asymmetric bell-shaped, strongly karstified, heavily fractured, limestone ridge of fair to very poor rock mass quality, rising above the soft cohesive soils (e.g., fine-grained) of the AB, southern Greece.

General Information

The low hill of Tirynth, in the 8th kilometer of road Argos-Nafplion, was continuously inhabited from the Neolithic Age to Late Antiquity. In prehistoric times, the area flourished mainly during the early and late Bronze Age. Now, it is considered as one of the most important archaeological sites of the Argolida, and therefore it is included in list of monuments of world heritage of UNESCO. Large number of collaborators (archaeologists, designers, skilled and unskilled workers) participated in the program of upgrading it.

Figure 3.5.3: View of the Cyclopean walls, Tiryns.

Historical Information

The Mycenaean culture emerged and declined in the Late Bronze Age (LBA) (from ca. 1700/1650 to ca. 1050 BCE). Some of its political cores, such as Mycenae, Midea, and Tiryns citadels, flourished in the (AB) of eastern Peloponnese, Greece (Maran, 2010). During the Late Bronze Age, Tiryns fortified the hill gradually and surrounded it within the "Cyclopean" walls of the palace complex. The walls bounding the citadel of Tirynth were built in three main construction phases and fortified gradually from the south highest to lowest north-sixes. The structural collapse of Tiryns citadel has been attributed to earthquakes at the end of the LBA based on archaeological and geomorphological information and morphotectonic observations (Kilian 1996; Zangger 1994; Gaki-Papanastassiou *et al.,* 1996). Three earthquakes during the duration of the Late Helladic (LH) IIIB period (ca. 1300–1200 BCE) presumably damaged its palatial buildings (Killian 1996). Respectively, they are deduced from destruction layers at 1300–1260 BCE, 1240 BCE, and 1200–1190 BCE described by tilted and curved walls and foundations, some containing fallen pottery and human skeletons presumably killed by collapsing buildings. In particular, the structural collapse of Tiryns is attributed to the ca. 1200 BCE earthquake. This earthquake hypothesis remains untested by archaeoseismological techniques, e.g., seismic site effects have not been determined so far.

3.6 Palamidi fortress, Nafplion

Geological Data

The wider area of Nafplion serves as geopark that fulfills all the criteria for its emergence in a geological monument of local and world scale. In terms of geology, the Mesozoic carbonate sequences and the flysch successions in the Nafplion area (Fig. 3.6.1) were interpreted by Tataris *et al*. (1970) as being continuous stratigraphic sequence successions. However, recognition of various Mesozoic carbonate sequences with flysch differences lead to the realization that the continental collision in the part of Nafplion and generally of the internal Hellenides was a more complex tectono-sedimentary series of events than originally suspected (Photiades, 2010).

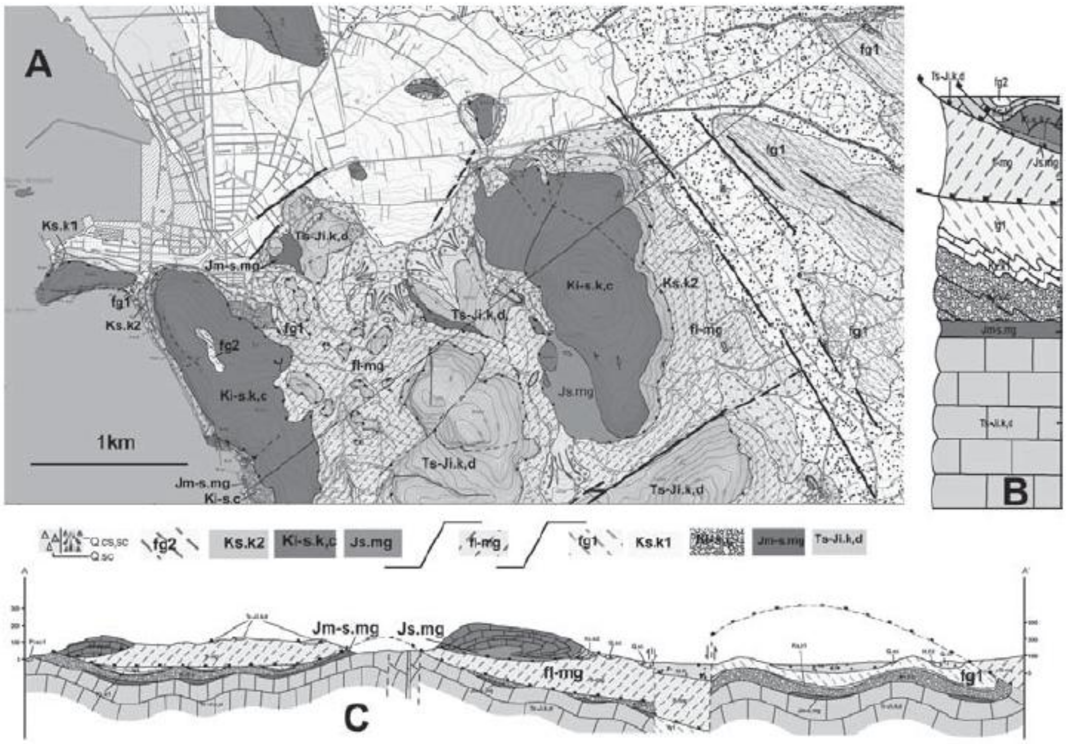


Figure 3.6.1: (A) Geological Map of the greater Nafplion area. (B) Tectono-stratigraphic column and (C) Geological section, according to (Photiades, 2010). Lower Unit, Triassic-Jurassic shallow-water carbonate (Ts-Ji.k,d), tectono-sedimentary ophiolitic mélange (Jm-s,mg), Mesoautochonous series with Cretaceous carbonates (Ki-s.c & Ks.k1), post-Ypresian flysch; Middle Unit, flyschoidal mélange complex, probably of Upper Cretaceous age; Upper Unit, serpentinite sole (Js.mg), Triassic-Jurassic carbonate outlier (Ts-Ji.k,d), Cretaceous carbonate outlier (Ki-s.k,c & Ks.k2) with post-Upper Cretaceous flysch and late Eocene tectonic phase.

Palamidi fortress and the wider Nafplion area is built by Upper Triassic to Lower Jurassic platform limestone and this series overthrust during the late Jurassic by pillow-lava ophiolite nappe. Then the area turned into deeply eroded during Cretaceous times. Upper Cretaceous pelagic and coarse clastic sediments breccias rich in basalts, serpentinites and shallow-water limestones record the important extensional intra-Cretaceous rift phase, which affects the Argolis peninsula. These sediments unconformably overlay the Upper Triassic to Lower Jurassic platform limestone and certify the ongoing erosion of the pillow lavas ophiolite nappe in a high relief, deeper marine environment. These Meso-autochthonous series with detrital levels are evolved progressively into pink and red pelagic limestone of Upper Cretaceous. Up section follow of Paleocene limestone interbeds, which are conformably covered by post-Ypresian flysch. However, the imbricated pre-Neogene stacking units of greater Nafplion area have been caused by the northwestward post-flysch overthrusting of the flyschoidal melange and of the Upper unit over the previous autochthonous Subpelagonian series. The flyschoidal melange and the overriding Upper tectonic unit could be interpreted as thrust sheet units that record the collapse of the Pelagonian continental margin (Bortolotti *et al*., 2003), and were contemporaneously thrusting northwestward over the post-Ypresian flysch of the meso-autochthonous Subpelagonian series of Argolis Peninsula (Photiades & Skourtsis-Coroneou, 1994; Photiades & Karfakis, 1998). This post-orogenetic tectonic phase, of significant geodynamic importance is leading during the late Eocene to the tectonic accretion of the Subpelagonian and Pelagonian Units in Argolis Peninsula. Flyschoidal melange and Upper tectonic unit could be interpreted as thrust sheet units, telescoped from Pelagonian Zones (Photiades, 2010), towards the northwestern onto the Subpelagonian Meso-autochthonous series of Argolis.

General information

Nafplio or Anapli, the capital of the prefecture of Argolis, is the main port of the eastern Peloponnese. According to the 2011 census, it had 14,203 inhabitants. It is one of the most picturesque cities in the country, and it was the capital of the Greek state during the period 1828-1833. It has been characterized as a traditional settlement. Apart from administrative it is also an important tourist center, with constant traffic throughout the year. According to mythology, the city owes its name to the settler of Nauplion, the son of Poseidon and Amymonis. During antiquity, Nafplio was basically in the shadow of Argos, serving as its port but later, its importance as a commercial center was increased. Nafplio has experienced the occupation of various conquerors, first of the Franks, then of the Venetians and then of the Turks, with a small “break” during the Second Byzantine domination.

Figure 3.6.1: Nafplion, Argolis. A) View of the Nafplion area, B) Palamidi Castle, Nafplion, Γ) Arvanitia beach (area Natura 2000) on the southwest side of Nafplion, Δ) Archaeological finds from the area.

The Palamidi fortress, preserved in excellent condition, is one of the most important achievements of the Venetian fortification architecture. A Palamidi hill, named after the Homeric hero Palamidis, did not seem to have been systematically fortified until the years of the Second Ottoman domination. The construction of the fortress took place on the days of 1711 to 1714, making the fortification a real achievement both in terms of architecture and in terms of construction speed. It was designed as a fortress based on a system of mutually supportive and reinforced ramparts, which are staggered on the West-East axis and connected to walls. The eight altar bastions of the castle are self-contained, so if one of them is captured, the defense continues from the rest. Palamidi's role in Greek Liberation is significantly important. From Palamidi began the liberation of the city by the Turks, after a long siege. Every year on this day, the city's liberation is celebrated by praise in this historic chapel. However, Palamidi, apart from a great fortress, was also a place of gloomy prisons. In 1833, during the Expansion, he was imprisoned in the bastion of Miltiadis, Theodoros Kolokotronis, being accused of ultimate betrayal. Around 1840, the Miltiadis basin, which is the largest in size, was converted into one of the toughest gravitational prisons, which operated there until about 1926.

3.7 Ligourio, Epidaurus

Geological Data of Epidaurus

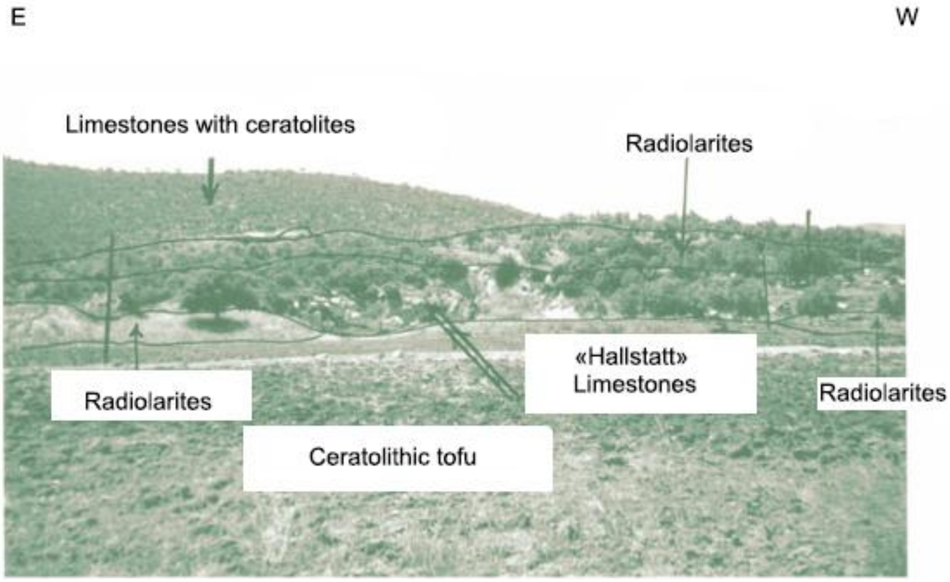


Figure 3.7.1: View of the "Hallstatt" limestones at their intersection with other layers, modified after (Tselepidis, 2000).

Epidaurus has been from 1906 until today one of the most important geological places, comprising both paleontological and paleogeographical sites of interests. It first came to the front, from a research in 1906, when Triassic micritic limestones were found. This formation inspired many geologists and paleontologists worldwide to study the area, as all fossils were well preserved, especially the cephalopodes, which were used to interpreting the stratigraphic role of "Hallstatt" limestones. It actually represents one of the most important geological formations in the entire area of Argolis. Its length is approximately 600m long and its thickness (28m) is laterally decreasing. "Hallstatt" limestones overlay volcanic rocks, while radiolarites are presented over the first, through a tectonic contact (Fig. 3.7.1). Lithologically speaking, from bottop to top, we can observe:

- *Reddish limestones*, 8m in thickness. They are characterized by frequent occurrence of parallel iron and manganese oxide concentration surfaces and ammonite layers, often oriented parallel to the layer.

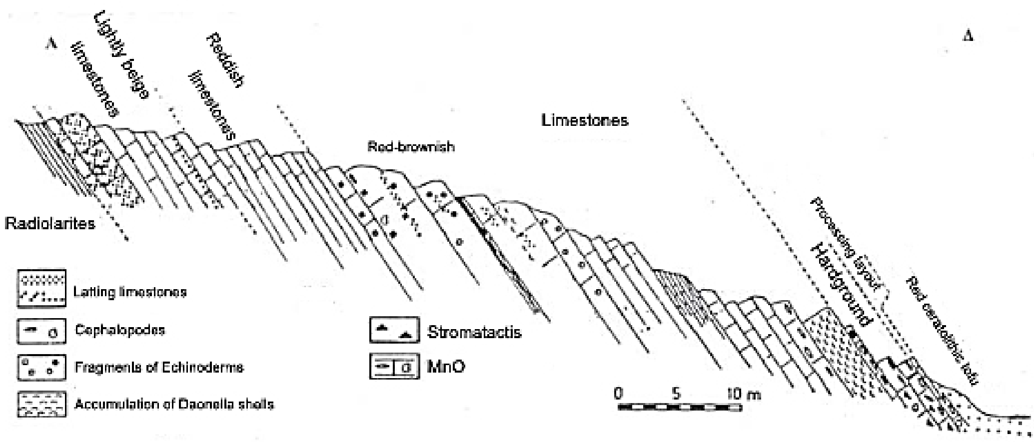
- *Alternations of lightly and dark red limestones:* The paleofauna and oxide surfaces are clearly being reduced even to total absence.

- *Lightly beige limestones:* These limestones are enriched with Fe0, $Fe_3 0_2$ and Fe hydroxides, which are responsible for a interlace texture. This texture becomes clearer and clearer to the top of the layers.

- *Red ceratolithic tubers*, on the upper layer.

- *Radiolaritic material*, found in vertical faults.

- *White sparitic calcite*, filling the crackings.



Schematic Representation 3.7.1: Geological Section of the region of Epidaurus near the Ancient Theater, modified after (Tselepidis, 2000).

Briefly, the main feature that erects Epidaurus in a geotope is the "good" preservation and the uniqueness of the “Hallstatt” phase of the Triassic, which is present in the area. Generally, the pelagic series of Epidaurus is constructed from pyroclastic materials, dacite toff layers of 5-10 cm, red solid limestones of Anisian-Carnian, Hallstatt phase and hardground in which fossils of ammonites and belemnites are included. Characteristic and well-preserved fossils of ammonites, belemnites, lopherites and a number of rare minerals are also found in the area, most of them preserved in the Natural History Museum of Kotsiomitis.

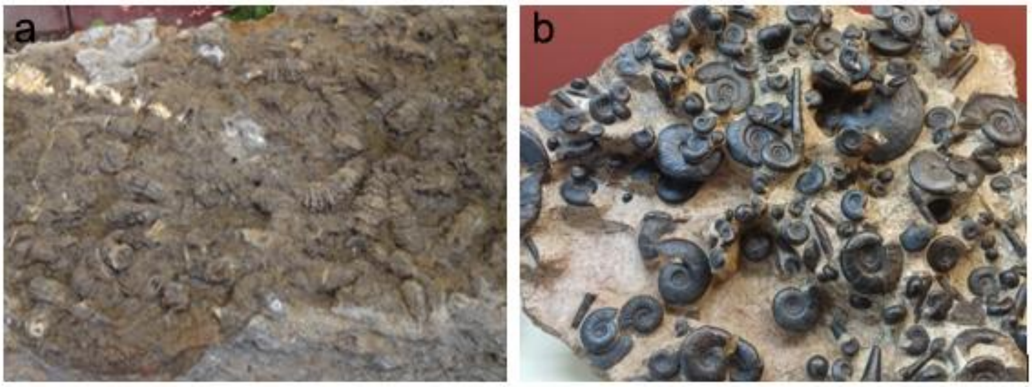


Figure 3.7.2: Collection of the museum Kotsomitis. a) Block with rust fossils, b) Massive rock with well-preserved ammonites from the area of Ligourio, Epidaurus.

General Information

Ligourio town is located in the Municipality of Asklipieion in the Prefecture of Argolida, which is also the main residential complex of this Municipality at a distance of 5 km from the Ancient Theater of Epidaurus. This theater is one of the world's top cultural monuments. Within this cultural environment, which captures and memorizes the top points of human adventure in time, land and geology reveal the natural evolution not only in its reference region, but of its wider terrestrial space. Utilizing the rich palaeontological finds and human civilization history, it aspires to be a focus of the organized presentation and study of the wider earthly natural history.

Historical Information

Ligourio is known for excavations that were executed from 1881. The excavations were undertaken by the Archaeological Society. Important role in the course of the excavations was the selfless offer of the residents of Ligourio, who, apart from their help, offered their land located near the archaeological site. In 340 BC, the theatre of Epidaurus was build. Among all the ancient theatres, Epidaurus theatre is the most beautiful and best preserved. Today’s preservance is one of the creative backdrop of the unwavering effort of iboth government and residents, having discovered all the natural wealth of their region, and at the same time making use of this wealth as a stimulus for systematically engaging in the course of natural evolution and civilization.

3.8 Wildlife Sanctuary Stavropodi-Kanapitsa

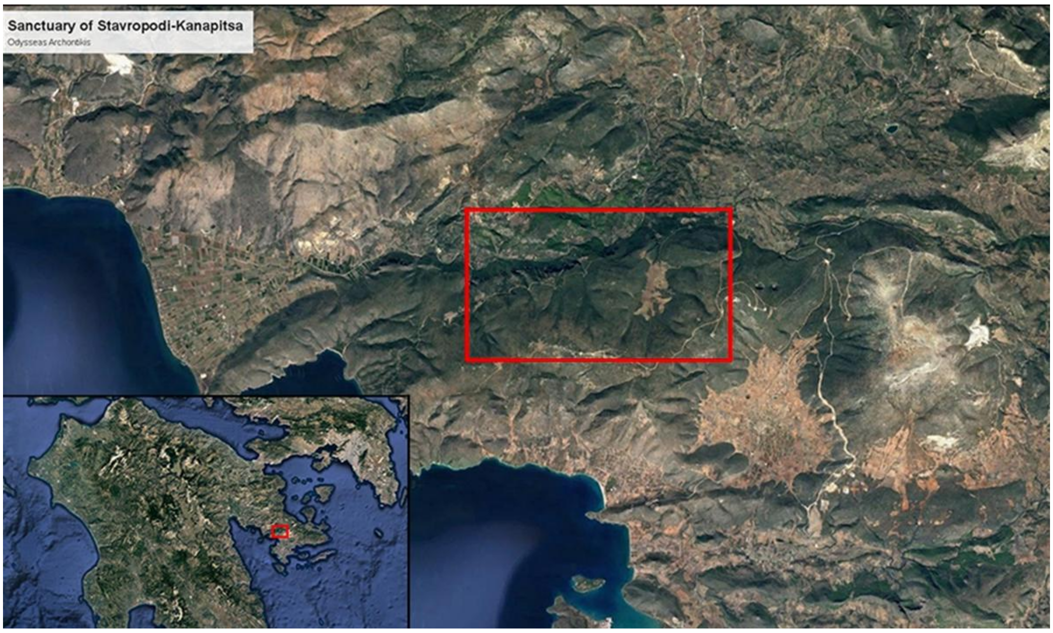


Figure 3.8.1: Location of Wildlife Sanctuary of Stavropodi-Kanapitsa.The red square shows the position of the geotope.

Geological Data

The stream of Sella, or as it is often called the river Rados (Bendeni), is the main torrent of central Argolis, about 20 kilometers west of the Trachia settlement of Argolida. It crosses the Bendenian Gorge throughout the winter, several years to June and flows into the Argolic Gulf in the plain of Iria, forming a multitude of different river and structural terraces. The main geological formations, found in this area are:

- *Southern Argolis Neritic and Pelagic Limestones* of Cretaceous age.
    - *Dolomites and quartz conglomerates* that occur in the base,
    - *Neritic, pelagic and intermediate limestone*, which follow.
- *Alluvial deposits*, found mainly between the mountains
- *Colluvial deposits*, found mostly in faulting zones.

In the area of the sanctuary, dolomites and mainly neritic limestones are found. Alluvial and colluvial deposits are covering the area near the invasion points of Rados River, causing weathering of the carbonate formations. From a geomorphological point of view, alluvial colluvial deposits are most important as their thickness reaches 600 m (Bakalis *et al.,* 1993). Near the invasion points of the river, the observed deposits are mainly corrode gravels and sand, which gradually become fine-grained to the central part of the Sanctuary. Generally, in Argolis peninsula there are four different hydrogeological units (Ntontos, 2009) with different aquifers. These aquifers are developed in the Neogene - Quaternary basins of the Prefecture and consist of sands, clays, and conglomerates, all alternated in the vertical and in the horizontal direction. Variations in the composition (granulometry) of the formations are due to the very significant fluctuation of their permeability, resulting in huge differences in the flow rates of the boreholes that have been drilled. Indicatively, the acquifer in the wider area of Kanapitsa is characteristic for its water balance and included average annual inflows (Giannoulopoulos P., 2002) from various sources (rainfall, torrent infiltration, irrigated irrigation flows, losses of irrigation networks, artificial enrichment, side underground inflows). The vegetation and fauna that prevail due to the climate, the composition of water and the geomorphs is unique and varies from shelter to shelter. The cover of the land in the wider area is hardy-green vegetation, transitional woodland and coniferous forest. The scrubs as well as the Mediterranean Scales of Sclerophylla are types of Natural Habitats of Community Interest whose conservation requires the designation of areas as Special Conservation Areas (Appendix I to CS 33318/3028/1998, Government Gazette 1289 / B '/ 28-12-1998).

Figure 3.8.2: View of the Rados River, entering the area of Wildlife Sanctuary of Stravropodi-Kanapitsa. (a): Upper Cretaceous neritic limestones, (b): Alluvial deposits, covering the area.

General Information and Institutional framework

This wildlife retention shelter (under the code K457) includes the areas of Irias, Carnazians and Gemini. It spreads over an area of 17000 acres and has been designated by a decision of the Ministry of Agriculture (Government Gazette 600 / B '/ 24-04-1976). Part of this area is the Gorge of the monastery of Avgous. Coverage of land in the wider area according to the Corine Land Cover in 2000 was hardy vegetation, transitional woodlands and coniferous forest.

REGION OF ATTICA

REGIONAL UNIT OF ISLANDS, ATTICA

Financial Data

Methana is included in the Region of Eastern Attica, which produces 38% of the national gross domestic product (NSSG, 2005). More specifically, per-branch participation in regional GDP amounts to 3.2% for the primary sector, 14.3% for the secondary sector and 82.50% for the tertiary sector (NSSG, 2005). The annual per capita GDP of the region amounts to 20,632.92 euro and corresponds to 117.6% of the average per capita GDP of the country (NSSG, 2005). For Methana as an individual unit, citizens are mostly occupied with fishing activities and cultivation. In respect to Aegina, it consists mainly of arable land formerly included, along with lowland areas and many semi-mountainous areas, where there were terraces that nowadays are abandoned and only olives are left. Aegina had a lot of oil production, hence it had a lot of olive oil. Today these olive oils can be found in Perdika, Mesagro and Kypseli. Previously, cultivations were focused on grain, fruit and vegetables, vines, etc., thus having transformed much of the island into a beautiful garden. Later, pistachio became the main concern of cultivators and now all other crops have almost been abandoned.

Touristic Infrastructure

Over the last few years, the island has presented frightening rhythms and a rapid, massive, and often fraudulent building activity. This activity comes to cover the intense housing pressures for a holiday home near Athens. It is therefore expected that the professions related to the construction sector will be particularly flourishing. It is also estimated that over the last decade, 1600 new buildings were in progress. Control by the municipality is not easy to carry out in the buildings as it does not have the staff and the appropriate technical means. In addition, there is no general urban plan on the island. The general urban plan is of paramount importance because it determines the land uses and prevents inconsiderate landscaping.

Population Data

The Municipality of Troizinia-Methana is a municipality of the Attica Region that was established in 2011 in implementation of the Kallikratis Program, from the merging of the pre-existing municipalities of Troizinos and Methana. It corresponds to the oldest homonymous province, if the island of Poros, which is a separate municipality, is removed. Originally, the name of the municipality was the Municipality of Troizinias. From 2014, the name was changed to Municipality of Trizinia-Methana. It has a population of 7,143 inhabitants, according to the 2011 census and is home to Galatas. Regarding Aegina, at the 2001 census, Aegina had a population of 13,552 inhabitants, of which 7,783 reside in the city of Aegina and the rest in the settlements of Vatheos, Kypselis, Mesagros and Perdika. The population has an amount of 157 inhabitants per square kilometer.

3.9 Methana Volcano, Methana

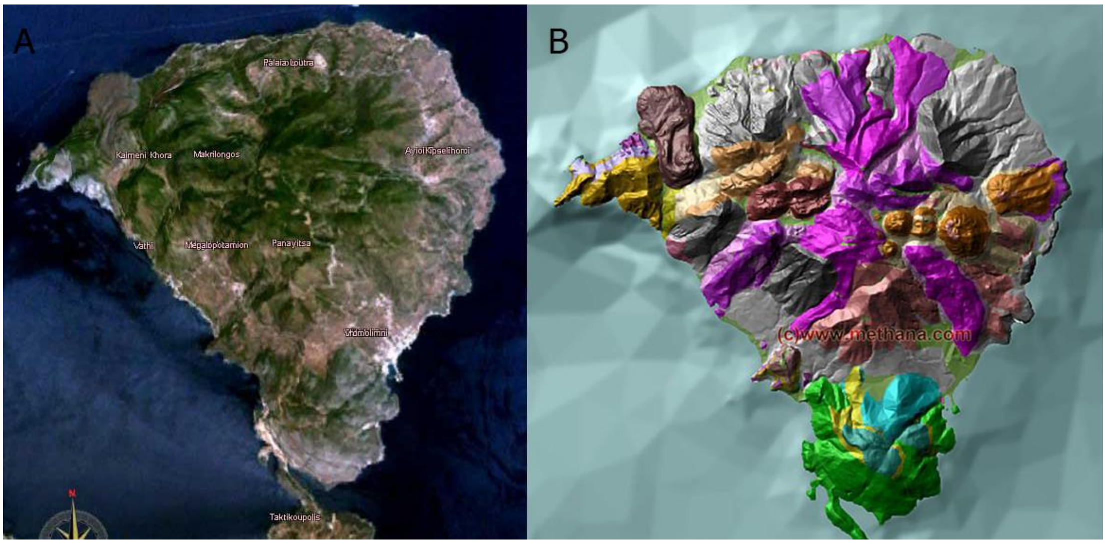


Figure 3.9.1: Methana. A) Satellite image of Methana, modified from (Google Earth, 2008). B) Geological map of Methana region, 3-d image by (Hurni L., 2016).

Geological Data

The volcanic field of Methana is located on a peninsula at the southern coast of the Saronic Gulf (Fig. 3.9.2) and is bounded by the Trizina Graben in the south. It features the longest record of volcanic activity in the South Aegean Volcanic Arc, with the oldest products being late Pliocene in age and the youngest being erupted during historic times. The latter refers to the andesitic products, which erupted as a result of a flank collapse at the Kammeno Vouno centre at 230BC (Stothers & Rampino, 1983).

The geological formations of Methana peninsula generally comprise:

- *Andesitic to dacitic lava flows*,
- *Block-and-ash flows and debris flows*, which extend from the centre of the peninsula towards the coast (Pe-Piper & Piper, 2002; Fytikas *et al*., 1986). Multiple dacitic fissure eruptions in northwestern parts of the peninsula may also be present.
- From the Triassic to the Jurassic, the formation of *a limestone similar to Pantocrator type* is taking place. They are grey to whitish, thick-bedded formations representing oosparitic biomicrites with many species of coral and algae.
- *Ophiolites*, due to the Late Jurassic, ophiolithic intrusion.
- *Thin layers of reddish radiolite and serpentinites* overlying the ophiolites.
- *Sandstones and marls, clastic metarial* that represent fllysch formation.
- *Neogene shallow sea formations* with a thick of 30m.

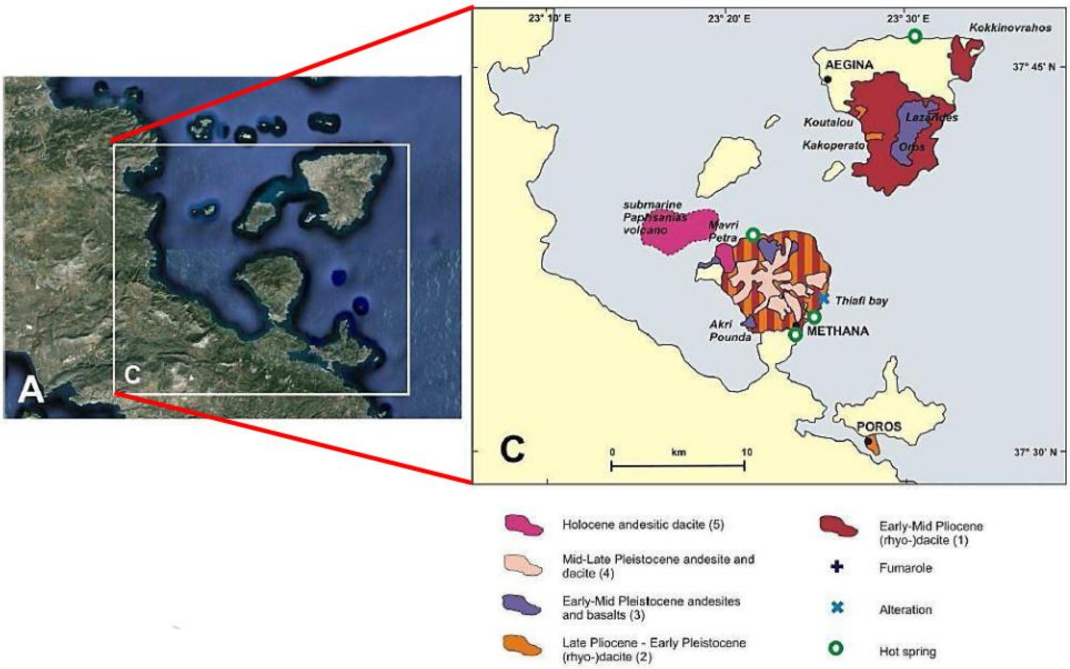


Fig. 3.9.2: Schematic geological map for the different volcanic centres in the Saronic Gulf. (A) Google Earth map of the Saronic Gulf designating the Methana, Aegina and Poros volcanic fields. (C) Distribution of volcanic deposits on the Methana, Aegina and Poros volcanic fields. Methana and Poros are located at the southern coast of the Saronic Gulf, while Aegina lies at the centre of it. The purple color indicates the existence of the submarine volcano "Pausanias". Image reproduced from (Smet, 2014; Soens, 2015).

Methana is still considered an active volcanic field owing to the occurrence of solfataras and hot springs located in southern parts of the peninsula (Georgalas, 1962). Several authors (e.g. Pe-Piper & Piper, 2002; Fytikas *et al.*, 1986) have recognized the importance of faulting during the emplacement of the Methana volcanic rocks. Volcanic activity was not restricted to the peninsula itself, but was also observed within an E-W trending neotectonic graben, 2 km NW of Methana. The two large fault systems are as follows: The first during Holocene consists of SW-NE rdirection, while the second, which has been reactivated, is oriented from northwest to southeast. Regarding, the geomorphology of the Methana region, important geomorphological elements, such as beams, rivers, huge rocks and barren land are observed. The area is divided into three different categories: The first includes the center consisting of forests, the second is actually the area around the center where there are scrubs and finally the third, which represents the region towards the sea, dominated by the cultivated area.

General Information

The Methana peninsula is located in the southeast cape of the Peloponnese and administratively belongs to the Municipality of Troizinias of the Attica Region. The peninsula is known for its baths and the historic volcano in the village of Kaimeni Chora (or Kameni Chora). Methana, along with the volcanoes of Milos, Santorini and Nisyros, belong to the volcanic arc of the South Aegean and are characterized as an active volcano. Its name was probably taken from the methane associated with volcanic activity. Methana is rich in prehistoric and ancient finds. In 1990, a settlement of the Mycenaean era was found near the spa town of Agios Konstantinos. In Vathi, in Paliokastro, under the Megalohori, there is the ancient Acropolis of Methans.

The most important settlement is the city of Methana (Loutra).

The Methana peninsula, combining beautiful beaches, spas and lush landscapes, is an ideal geo-destination. Methana´s scenic landscape and its nature could be a target for sustainable tourism, protecting at the same time Methana´s environment. The creation of a geopark is emerging as an idea during the last years, only if georoutes will be developed in favor of geotourism. Still a lot of work will be needed until the idea of a geopark and sustainable tourism will be successful on Methana.

Figure 3.9.3: Methana volcano. A) View of volcanic crater in the central area of Methana, B) Volcanic rocks inside the volcano, which have collapsed due to seismic activity, Γ) View of volcanic rocks in the wider region. View from the volcano, Δ) Inner part of the damaged volcanic crater.

Historical Information

The Volcano of Kammeni Chora is one of the youngest in the volcanic arc of the Aegean. His explosion must have taken place during the reign of Antigonus of Gonatas (277-240 BC), according to the reports of Strabo (Geograph.A, c59,18), of Ovid (Metamorphoses, XV, p.296 - 306), as well as what Pausanias mentions in the work of Greece Exploration, II, 34. Ovid says that the whole area around Kammeni settlement was an extensive and rich plain, but the loud eruption of Hephaestus covered much of it with huge volumes of lava and ash. Thirty craters have been recorded on the peninsula, with the latest recording in 1987 and involving a submarine crater at a depth of 200 meters. The largest land crater is located at Throni, west of the city of Methana. Other large craters are located southeast of the Turtle hill, at the Stavrogogos site, as well as the Makrygogos site. In addition, volcanic craters are found in the Mouskas and Kypseli. Those craters, who acted last, were those near Kameni Chora, evidenced by the mining material of the area and the current topography of Methana.

3.10 Temple of Aphaia, Aegina

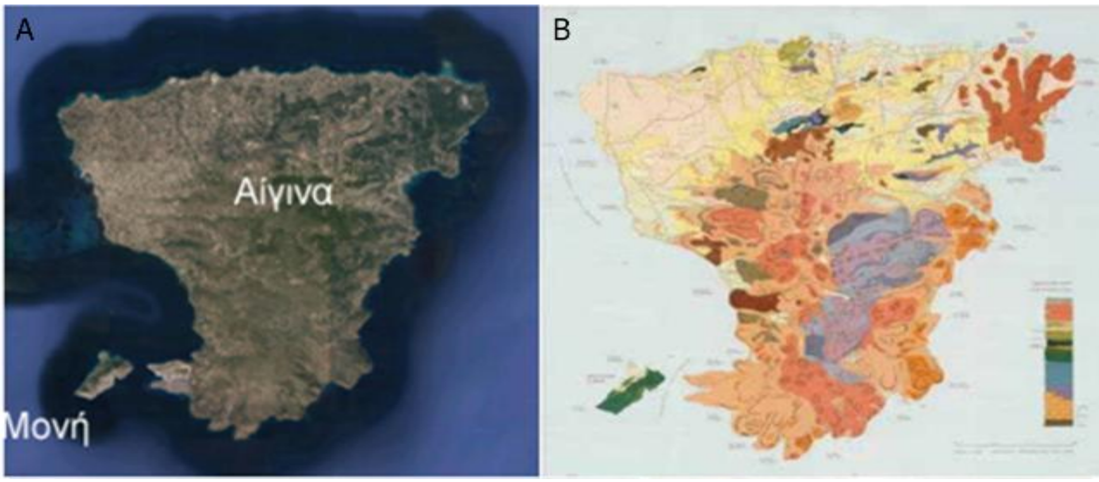


Figure 3.10.1: Island of Aegina. A) Satellite image of the island, according to (Google Earth, 2009). B) Extract of geological map of Aegina (according to Dietrich *et al*., 1991, ed. IGME).

Geological Data

Volcanic activity in Aegina is inactive for the last 720,000 years (Morris, 2000). The island is geologically associated with the Saronic Gulf, most of which is a tectonic draft created at the same time as the Corinthian Gulf (Middle-Upper Miocene). These tectonic dips are active until today. The formations, found on the island are divided into three groups:

- *Alpine basin with limestones* of Permian until Cretaceous, which appear cracked and slightly folded in the neritic phase.
- *Neogene and Quaternary sediments* of land, lake, sea and brackish origin, occupying 1/3 of the area of the island, mainly in the northern part. Those sediments are inconsistently placed on the alpine background and
- *Volcanic rocks* occupying 2/3 of the total area of the island, contributing to the creation of the relief. Those rocks are categorized on two different volcanic phases based on different explosions.

    - The **first products** mainly included *rhyodacitic tuffites and pumice flows to andesitic pillow lavas and associated hyaloclastites*. This accounts for the occurrence of both phreatomagmatic and effusive eruptions, as Aegina was still predominantly located in a shallow marine environment. Volcanic activity peaked around 3.9-3.0 Ma and largely developed andesitic-dacitic lava domes, which included a number of lava flows, volcanic breccias, plugs and fissure eruptions in the southern and central parts of the island, which evolved into a subaerial environment (Dietrich *et al*., 1991; Fytikas *et al*., 1986).

- The **first eruptive phase** terminated with the emplacement of *dacitic pyroclastic and epiclastic flows*, after which volcanic activity generally diminished as reflected by the lack of lavas encountered between 3.0 -2.1 Ma.
- The **final phase** occurred during early Quaternary times (2.1 -2.0 Ma) and was related to an intensive episode of faulting and uplift, which resulted in the construction of *(basaltic-)andesitic lava domes with accompanied lava flows* (Pe-Piper *et al*., 1983; Fytikas *et al.*, 1986; Dietrich *et al*., 1991; Pe-Piper & Piper, 2005). This face was presumably associated with two fissure eruptions at the centres.

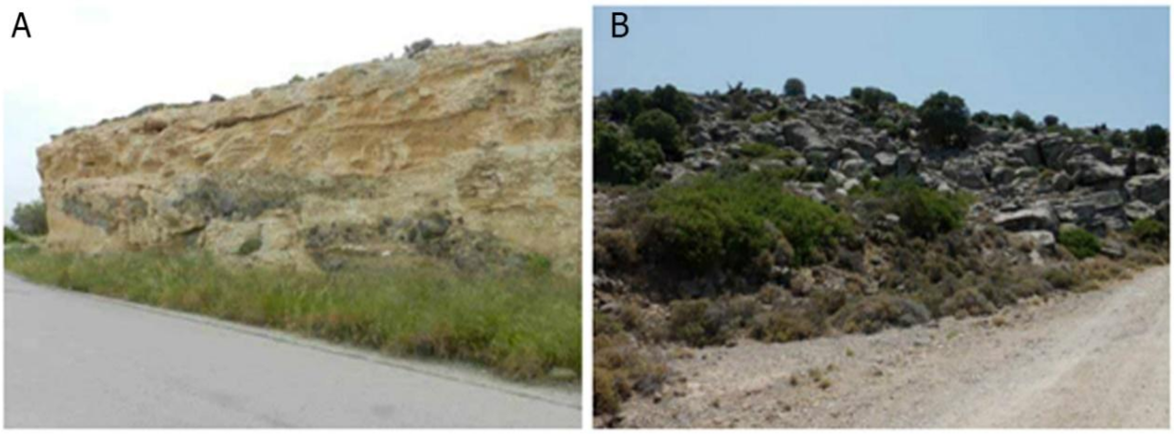


Figure 3.10.2: Geological formations in the area of Eastern and Central Aegina. A) Pleiocene and Pleistocene sediments, B) Andesitic rocks to the area of mountain "Oros", according to (Koutsouveli *et al*. 2013).

To the north of the island, near the temple, occurrences of ophiolithic rocks, pillow lavas and basalts have been found and are subject to radiolarites. The actual position of the temple is upon yellowish-lined limestones. In the West of the temple, there is an appearance of greyish Triassic limestones and in the Eastern part, dacitic lavas of the first volcanic activity may be found.

General Information

Aegina is located in the center of the Saronic Gulf, surrounded by Agistri, Methana, Troizina, Poros and Piraeus and has a total area of 82.63 square kilometers, making it the second largest island of Argosaronikos. The temple of Aphaia dominates the top of a pine-covered hill in the northeastern part of Aegina. It is the most important monument that is preserved from the sanctuary, which was dedicated to the goddess Aphaia (Athena) and seems to have been established in a place where there was worship activity since the Mycenaean era. The temple was built around 500-490 BC. The sanctuary of Aphaia was not maintained for a long time. Gradually it collapsed and only a few repair works occurred in the 4th century.

Figure 3.10.3: View of Temple of Aphaia, Aegina

Mythology-Historical information

Its first research was made in 1811 by researchers who visited the site and excavated the sculptures of the pediments that were transported to Italy. The German Archaeological Institute carried out systematic excavation of the monument in 1901 and in 1964-1981. In 1956-1957 work for restoring it was carried out. According to mythology, Zeus, the father of the Gods, fell in love with the most beautiful of the 20 daughters of god Asopos, Aegina. She kidnapped her and carried her to Oinon Island. There they acquired a son, Aiakos and the island took her name Aegina. One of the greatest and most significant parts of this temple is the main particular geocultural feature it presents. Its location along with the Parthenon in Athens and the temple of Poseidon in Sounio forms the Athens Riviera (or Holy) triangle (Fig. 3.10.4). This famous placement is the perfect isosceles triangle formed between the Acropolis of Athens, the Temple of Poseidon at Cape Sounion and the Temple of Aphaia (Athena) at

Aegina Island. These buildings were based on geometric shapes, revealing the invisible link between them.

Figure 3.10.4: Athens Riviera Triangle shaped by the positions of the Parthenon temples in Athens, Poseidon at Sounio and Aphaia in Aegina, modified after (G Design Studio).

The Athens Riviera Triangle is a typical example of land and culture (-civilization) which gives a new meaning from a difference perspective: how geology, land and mathematics played a significant role in the life of the ancient Greeks and the subconscious influence they had on the citizens' human thinking.

REGIONAL UNIT OF CENTRAL ATHENS, ATTICA

Financial data

The Region of Eastern Attica produces 38% of the national gross domestic product (NSSG, 2005). More specifically, per-branch participation in regional Gross Domestic Product (GDP) amounts to 3.2% for the primary sector, 14.3% for the secondary sector and 82.50% for the tertiary sector (NSSG, 2005). The annual per capita GDP of the region amounts to 20,632.92 euro and corresponds to 117.6% of the average per capita GDP of the country (NSSG, 2005).

Tourist Infrastructure

Tourist services (accommodation, restaurants) contribute 6.09% to the Gross Domestic Product (GDP) of the region and 36.89% to the total tourist services of the country (NSSG, 2005). At the Region of Attica, there are 1.14 beds per 100 inhabitants, which suggests that the tourist activity is insignificant for the population (Tsartas *et al*., 2010). In the classification of regions in Boudeville, the Region of Attica is ranked in the first regional press (favorable sectoral structure, positive local factors) both in the economy as a whole and in the tertiary sector (Lagos *et al*., 2004).

Population Data

Attica Region is the first in the population region of the country. In particular, the population of the region in 2004 was amounted to 3,940,099 inhabitants (NSSG, 2004) and also covered the 35.7% of the total population of the country. What is interesting is the population density, where it differs significantly in the two regional units. In particular, the population density for the Athens Capital Region (2004) was calculated to 7,379.8 inhabitants per km. (NSSG, 2004), while in the same year for the rest of Attica the population density was 169.4 inhabitants per km^2. (NSSG, 2004). According to the NSSG statistics, a natural increase of the population of the region of 6.8% (NSSG, Censuses 1991, 2001) was observed.

Geological Data

The Athens basement belongs to alpine formations outcropping in the mountains and the hills of the area.

- Recent post-alpine sediments often cover the slopes of the mountains as well as areas of low altitude.
- A complex alpine structure comprises mainly
    - *Mesozoic metamorphic rocks* occurring at Pendeli and Hymmetus mountains and

- *<u>Mesozoic non-metamorphic rocks</u>* of the eastern Greece geotectonic unit, occurring at Parnitha, Poikilo and Aegaleo mountains, respectively (Katsikatsos *et al*. 1986; Papanikolaou 1986; Papanikolaou *et al.* 2004).

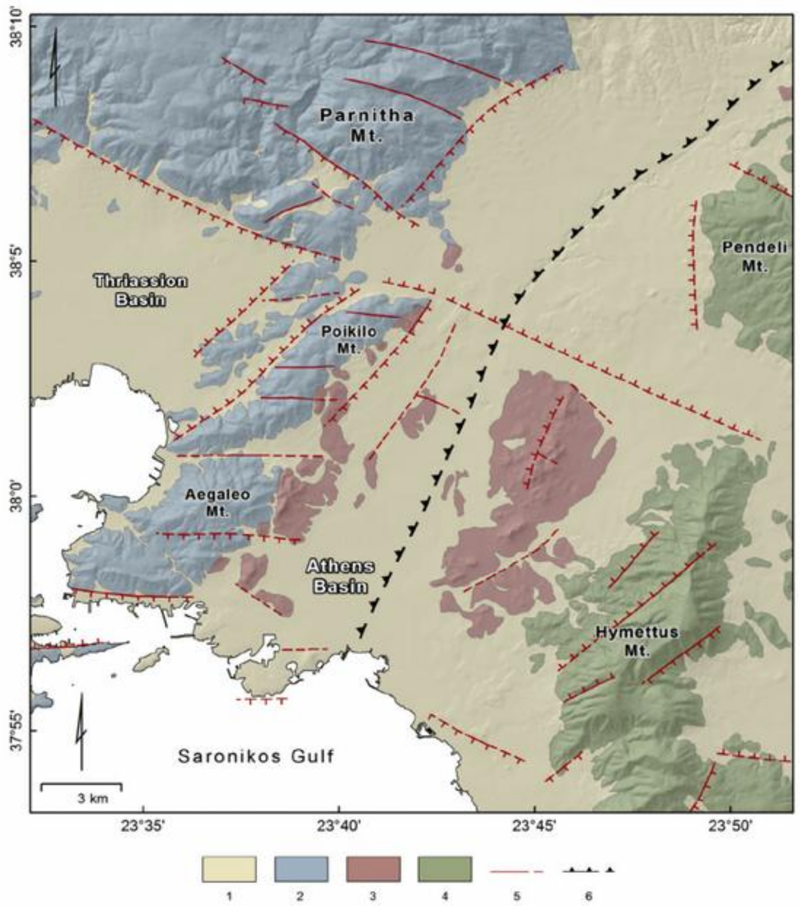


Figure (b): Geological map of Athens, according to (Foumelis *et al.* 2013). (1) post-Alpine sediments, (2) non- metamorphic rocks (eastern Greece geotectonic unit), (3) allochthonous system (Athens schists), (4) metamorphic rocks (Attica geotectonic unit), (5) fault zone and (6) major tectonic boundary.

The boundary between the metamorphic and non-metamorphic geotectonic units is covered with Neogene and Quaternary deposits (Fig. b). The metamorphic basement displays a more compact behavior with a dense fabric with little internal deformation due to their exhumation from a depth of 30 km since Oligocene times. In contrast, the sedimentary Alpine formations display a rather loose behavior, with significant internal brittle deformation distributed in several E-W normal faults, exhibiting higher deformation rates.

3.11 Acropolis, Athens

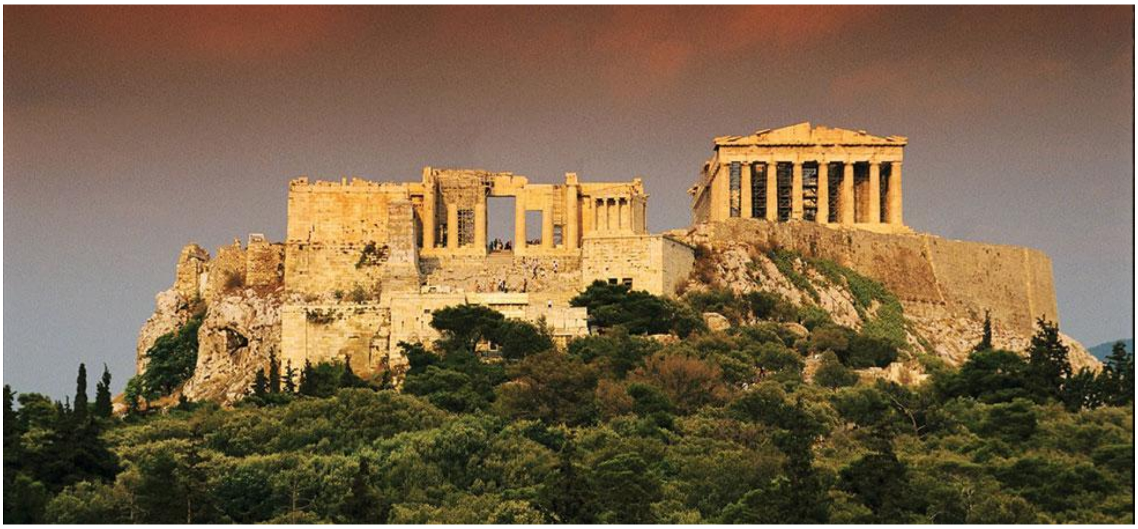


Figure 3.11.1: View of the Acropolis Hill and the Parthenon Temple in Athens, Greece.

Geological Data

The Acropolis hill belongs to Athens, located in a large topographic basin surrounded by Parnitha, Egaleo, Penteli and Hymettus. It is covered by thick bedded and massive limestones of Upper Cretaceous on the formation of the so-called Athens schists, consisting at the base of the slopes of the schist-sandstones-marl series.

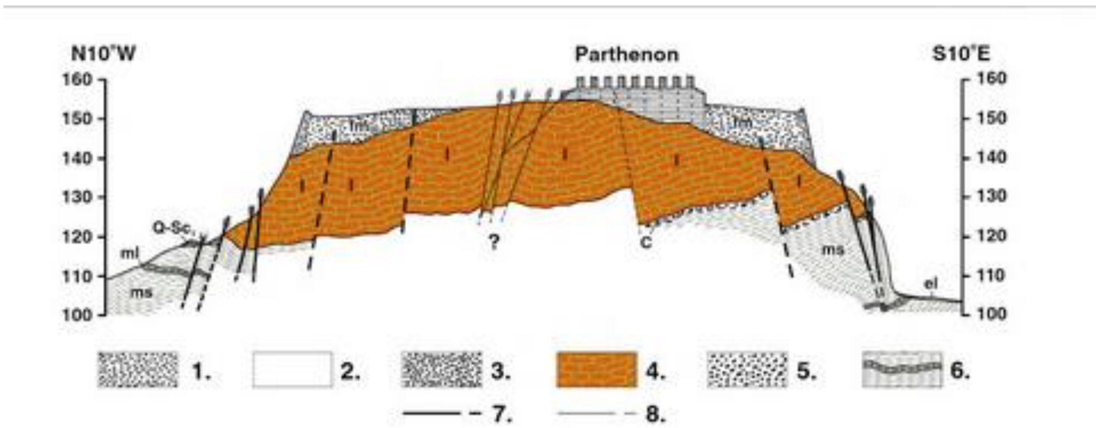


Figure 3.11.2: Geological section of the Acropolis hill, modified after (Koukis *et al.* 2015). (1): Artificial earthfill (fm), (2): Eluvial deposits (el), (3): Talus (Q-Sc), (4): Limestones (l), (5): Conglomerates, (6): Schist-sandstone-marl series (ms-ml), (7): Fault observed and its probable extension, (8): Plateau

The main geological layers, forming the Acropolis Hill are the:

- *Athens schist:* Represents quite heterogeneous formations of low-grade metamorphic and relatively soft rocks. Very distinct reddish formation of Upper Cretaceous age (Requeiro *et al*. 2014) composed of alternating beds of sericite sandstone, shales and phyllites, locally with intercalations and lenses of crystalline, usually microclastic, limestones.

The Athens Schist bedrock shows remarkable weathering and intense folding, shearing and extensional faulting, which completed the structural "downgrading" of the rock mass. An overburden of 2 to 5 km rock pile on top of the Acropolis klippe is quite feasible. According to Marinos *et al*. (1971), the Athenian schist represents a flyshoid phase of delta-type deposit of the Upper Cretaceous (Maastrichtian, 70 Ma), that is, what we see today was once the talus of the delta of a huge river.

- *Crest limestone:* Upper Cretaceous limestone, called locally "Formation Turkovounia" (Karfakis & Loupazakis, 2006), constructs all the hills in the eastern part of the basin of Athens, such as Lycabettus, Areopagus, Acropolis and Philopappus. The limestone underlying the temples, dated from the Upper Cretaceous (more than 100 Ma ago), was initially a soft mud sediment, deposited 120 km south of its current location and later on the calcareous mud consolidated and transformed into a limestone by diagenetic processes.

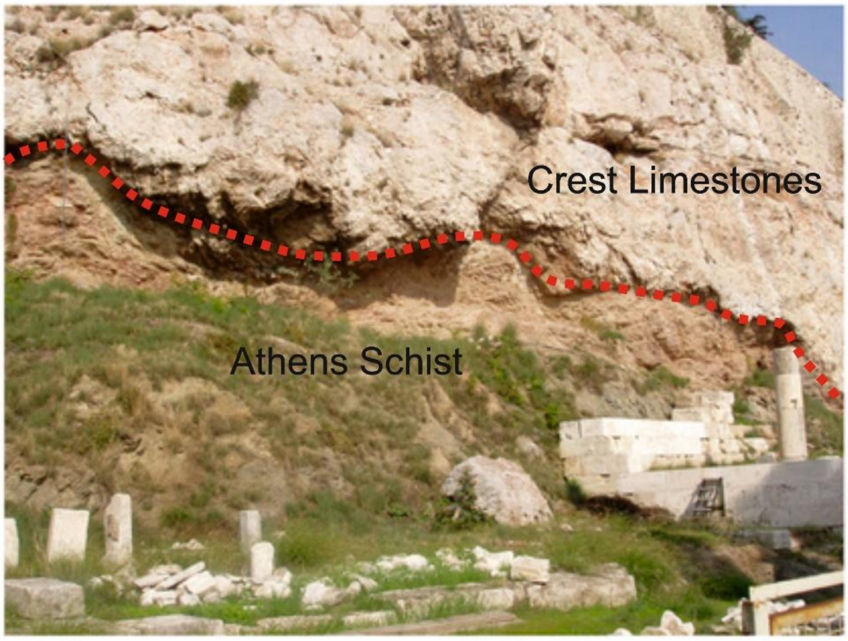


Figure 3.11.2: South slope of the Acropolis Hill. Tectonic contact (red dashed line) of limestones and the underlain series, modified after (Koukis *et al.* 2015).

At the southern and western slopes a horizon of conglomerates appears, having a thickness up to 10m. These develop upwards, through an evolutionary transition to the limestones of a thickness 30-35 m, implying an autochthonous stratigraphic series of a continuous sedimentation without unconformities (Koukis *et al.*, 2015). The limestones appear with an intense and multifarious rupturing and are strongly karstified with the presence of cavities and caves. This explains the strong erosional action by the water of an extent and thick limestone formation residues, of which consist the remaining hills in the town of Athens. The above sedimentary rocks are folded together in a syncline structure. Schists-sandstones and limestones present differential mechanial behaviour (plasticity and inflexibility respectively), thus explaining the observed asymmetric and disharmonic fold.

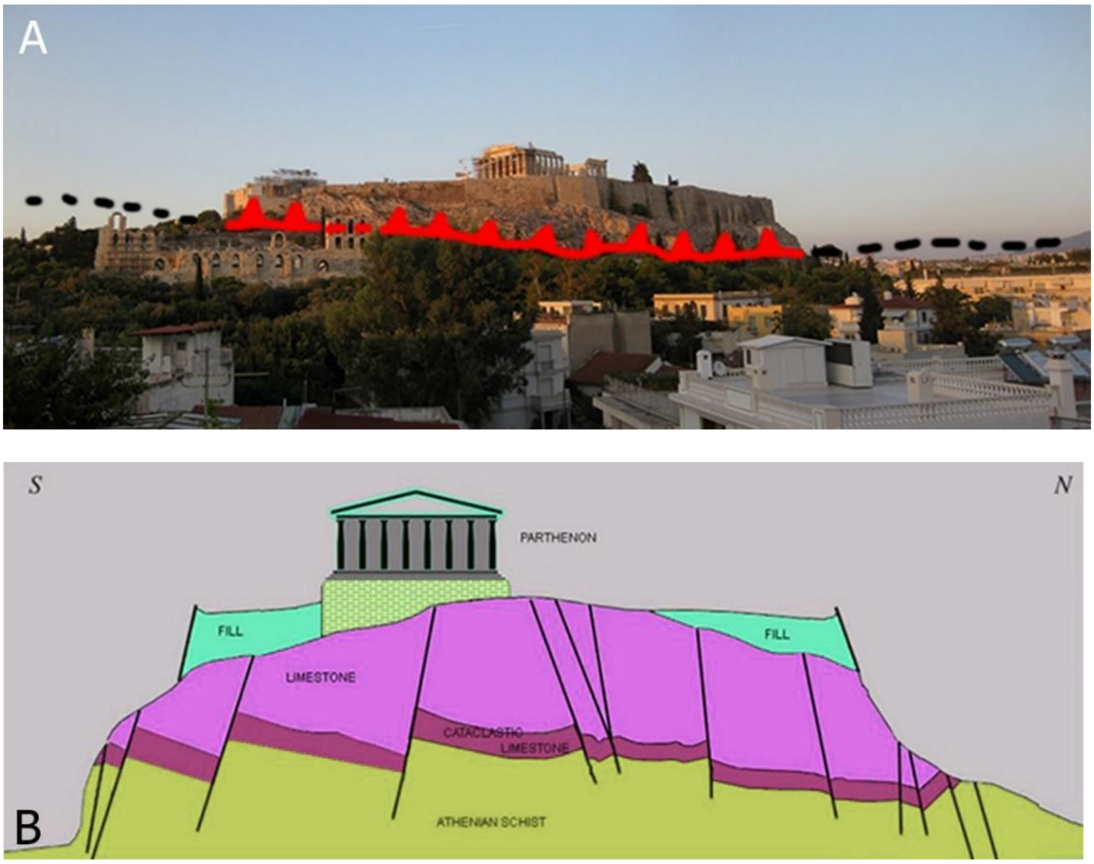


Figure 3.11.3: Hill of the Acropolis, Athens. A) View of the hill and depiction of the tectonic contact of the Turkovunia limestone overlaying the Athenian schist. B) Simplified geological profile of the Acropolis Hill modified after (Higgins & Higgins, 1976; Regueiro *et al*., 2014).

The recently created rock from the crest limestone has moved during the Upper Eocene due to the colossal but extremely slow continental collision of the Alpine orogeny. Its new position was over the Athens Schist by thrusting and brought the limestone to where it is presented today. The evidence of that long journey can be observed in a special type or rock called cataclastite in the foot of the hill (Requeiro *et al.,* 2014). Erosion did the rest and left the limestone hill isolated and surrounded by the younger schist, as found by the first dwellers of Athens. Sacred land and geology meet in the rocky heights of Athens, enhancing Acropolis as the ultimate monument of global reognizability. Acropolis of Athens, one of the most important UNESCO World Heritage sites, is undoubtedly a unique historical site. However, its geological background is an additional feature that can explain the construction of the Parthenon at this point, its preservation to the passing of time, and of course, its geotouristic value as a combination of many, different but interrelated approaches. Understanding both features is probably the key to sustainable use of the archaeological-geological site.

General Information

On the rocky hill of the Acropolis, which dominates the center of modern Athens, it was the most important and majestic sanctuary of the ancient city, dedicated mainly to its protector goddess Athena. This sacred site relates to the most important myths of ancient Athens, the great religious feasts, the oldest cults of the city but also some of the decisive events for its history. The monuments of the Acropolis, harmoniously combined with the natural environment are unique masterpieces of ancient architecture that express pioneering correlations of rhythms and trends of classical art and have influenced the spiritual and artistic creation for many centuries later. Bestowing in the perfect way the greatness, power and wealth of Athens at the time of Acropolis' greatest prosperity is known as the "Golden Age" of Pericles.

Historical Information

The hill was selected from the Neolithic years (4000 / 3500-3000 BC) as the site of the inhabitants of the area. In the middle of the 6th c. BC, when the tyrant of Athens was Peisistratus, the sanctuary gained great glory. Panathenaia was established, the greatest celebration of the Athenians in honor of the goddess, and the first monumental buildings and temples were founded for its worship. In the middle of the 5th c. BC, when the seat of the Athenian Alliance was transferred to the Acropolis and Athens was the most important center of the spiritual world. After the liberation of the Greeks, the monuments of the Acropolis were brought under the care of the New Greek State. The first excavations in the rock took place between 1835 and 1837. In 1975, the Acropolis Memorial Conservation Committee was set up to study and conduct large-scale consolidation and restoration projects, which are still ongoing in cooperation with the Acropolis Monument Restoration Service and the first Ephorate of Prehistoric and Classical Antiquities of the Ministry of Culture.

Having collected all the necessary data from the fieldwork, the evaluation process of all selected geosites is attempted. The average of all these values delineates the final classification of the geotope. This evaluation process is based on all observed data before, during, and after our staying in each geotope.

Number	Name	Type	Geological History	Representativeness	Geodiversity	Rarity	Conservation	Education	History	Religion	Visibility	Relief Differentiating	Accessibility	Touristic Infrastructure	Ecological Value	**Total Score**
1	Sousaki Volcano	Volcanic Vapors	4	4	3	5	3	4	1	1	3	3	4	3	4	3,231
2	Isthmus of Corinth	Isthmus	5	5	5	4	3	3	4	2	5	3	5	3	5	4,000
3	Acrocorinth	Inselberg	5	4	3	4	5	4	5	3	5	5	4	4	2	4,077
4	Saint Sozon, Dervenakia	Stratigraphic Section	4	3	3	4	3	3	4	3	2	2	2	1	4	2,923
5	Tiryns, Argolis	Alluvial Deposits & Limestone bedrock	4	5	3	5	3	4	5	4	3	2	4	3	2	3,615
6	Palamidi fortress	Monadnock	4	4	4	4	5	4	5	2	5	4	4	4	2	3,923
7	Ligourio, Epidaurus	Fossiled fauna	4	4	4	5	2	4	2	1	3	2	3	3	3	3,077
8	Sanctuary Stavropodi-Kanapitsa	Endangered floral-fauna species	3	4	4	3	4	1	1	1	3	5	4	4	5	3,231
9	Methana Volcanic Center	Volcano	5	4	4	4	3	3	3	1	3	4	2	1	3	3,077
10	Temple of Aphaia	Volcanic Vein	3	4	3	4	4	3	4	3	4	4	2	4	2	3,385
11	Acropolis	Klippe	5	5	4	5	5	5	5	4	5	5	3	4	3	4,462

Table 3.1: Total Scoreboard for selected Geotopes and Final Ranking. The numbering in the first column corresponds to the stations on the geotouristic route map (Fig. 2.1), while the other values (from 1 to 5) define the degree of assessment of the geotope in each criterion. Red color implies values higher than 4, Green higher than 3.5, Yellow lower than 3 and White between 3 and 3.5.

The described geotopes and the georoute we chose and followed, cover a small but significantly important part of the Greek civilization, since they summarize spherical historical, geological, economic, etc. elements of the Greek land, nation and development. The combination of these can seriously facilitate the interpretation and in-depth understanding of the evolution of the interaction human-geoenvironment as a single system, through which the formation of human thought relied on. The study of the history, traditions, architecture, economy, legal and institutional framework, climate and geology of each place, as well as the direct contact with the geotopes, were carried out in order to practically assess their value. The evaluation made in this thesis includes also the degree of coverage of the criteria for the geotopes' recognition at local or global level and, above all, the creation of a substantial, constructive, feasible, informative and entertaining geotouristic route. With the completion of our research and the final classification of the geotopes, it is concluded that:

In the category **"Geotopes of Global Range"** belong:

- Isthmus of Corinth, Corinth
- Acrocorinth Castle, Corinth
- Acropolis, Athens

In the category "**Geotopes of National Range**" belong:

- Palamidi Fortress, Nafplion
- Tiryns, Argolis

In the category "**Geotopes of Local Range**" belong:

- Saint Sozon Church, Dervenakia, Corinth

Despite the adapted categorization, many geotopes showed a *Total Score* between 3 and 3.5. In that case, we see that the proposed publications did not give a clear distinction in refer to the category of the geotopes we have chosen, and thus it is required a more detailed outline of their value. Therefore, in any case, based on the research that has been carried out for this thesis, we express the need of a more specialized research, one that can clearly capture more features, new or already known. Such an excursion into the nature can boost geotopes of local scale into geosites of national range and the other way round. In the present work, for the sake of pure objectivity, we form a new category under the title "Geotopes of Regional Range".

So, in the category, "**Geotopes of Regional Range**" are added the following:

- Sousaki Volcano, Agioi Theodoroi
- Ligourio, Epidaurus
- Wildlife Sanctuary Stavropodi-Kanapitsa
- Methana Volcano
- Temple of Aphaia, Aegina

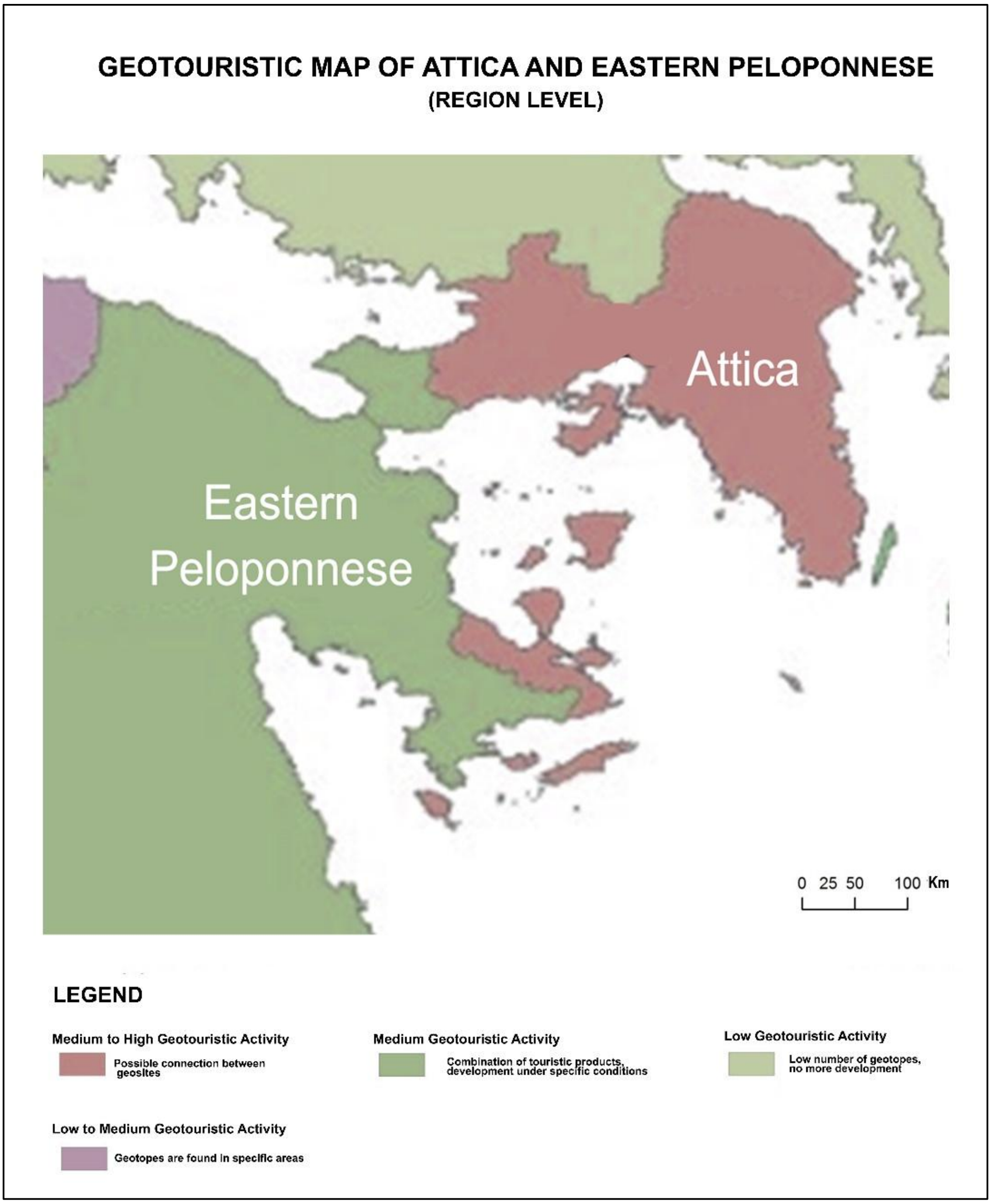


Figure 3.a: Geotouristic Map of Attica and Eastern Peloponnese. Composition of economic-touristic-geological data with geotouristic assessment at the regional level, modified after (Skentos, 2012).

CHAPTER 4: «DISCUSSION & CONCLUSIONS»

In terms of geotouristic development, several of these monuments may have been studied, while others have not. The evaluation in the present work based on the combination of many parameters, eventually made quite plain the reason for the conservation of geotopes during the time. The different approaches to geosites, geologically, historically, touristically and ecologically, have allowed us to focus on historical knowledge, ecological features and geological data, thus forming a proper and feasible geotouristic path. In every case of a geological monument, it becomes clearer (than it was) how geology and land have subconsciously influenced human thought since the old times and therefore formed the history, the traditions and the religious beliefs of the Greek people.

- We realize that the classification of all these geotopes, is actually a planning procedure after a sensible series of perceptions, decisions and actions. It covers an important picture of geoconservation, environmental and ecological preservation, management strategies, whose combination can be used in order to ensure the development of geotourism and the preservation of natural beauty.

- Of the selected geotopes, several either are elevated to a higher grade or are identified as lesser value's geotopes. In both cases, due to human factor and subjectivity, one or more characteristics may not be assessed in the same way and therefore the different geotopes fall into different categories from previous researches. The present study therefore proposes the adoption of a new category of geotopes with features between local and national levels. This distinction can provide a clearer picture upon the status of these monuments, the need for geoconservation and the direct or indirect financial measures to be taken in order to ensure their protection.

Touristic development has been promoted the last few years only because its alternative forms are compatible with the protection of the natural and cultural environment.

- Ensuring the sustainability of natural and human resources is gaining ground, thus tourism is one of the most important growth and revenue gates for the Greek economy.

- The two regional units (Peloponnese and Attica) have been known for their specific tourist products at different reasons. In the Attica region, there is the possibility of interconnecting the largest number of geotopes located in the continental part of the region and creating a feasible georoute. The region of Peloponnese is susceptible to the development of geotourism, mostly around important geological and historic locations, where history along with natural wealth can be used to enhance a probable geotouristic route. It is also expected to develop and improve geotouristic activities in the future by completing infrastructure projects.

- The region of Attica is defined as a service economy as the share of the tertiary sector in regional GDP amounts to 84.15% (NSSG, 2005). The secondary sector accounts for 15%, while the primary sector is almost non-existent. The region as a whole has medium to high geotourism activity developed in locations with the ability to connect geological positions and the creation of tourism. The present geotouristic activity is a synthesis of many factors.

- The region of Peloponnese presents geological monuments that are dispersed across the prefectures. About the economic structure, high rates are shown in the primary sector and the tertiary sector, which shows its highest percentage in the Prefecture of Laconia, reaching the 73.9% (NSSG). The region as a whole has medium geotourism activity, but can geographically connect the geotopes, utilizing all the touristic tools of the region (i.e natural wealth, history).

- The selected geotopes can play an important role in boosting the touristic economy of the country. Both Attica and Peloponnese represent regions with local low-cost touristic products that facilitate the regional development (Triantaphyllou, 1992). The scientific though consideration and study of geotopes by specialized geoscientists, the dissemination of information to the tourism public and the interconnection of geological positions with the cultural heritage of the regions is the basic factor for the implementation of geotouristic development policies, like geotouristic paths.

- Such geotouristic routes like the proposed one, between geotopes of different geological, historical, geomythological-geocultural significance and perspectives, can provide a comprehensive and meaningful mapping of the need to preserve the geoenvironment. The goal, which is ultimately feasible, is to educate people through an informative and entertaining process with direct contact to the geotopes.

- The developed infrastructure, interpretation material and educational activities, will be in accordance with a generic action and management plan that will finally be delivered with progressive efforts for the adoption of a geoprotective consciousness, aiming to sustainable and responsible development of these areas under the means of an applied eco-friendly developmental policy.

In a nutshell, georoutes in favor of geotourism and especially geoheritage, through its capabilities and its constraints, is becoming the key to a geoenvironmental developmental planning. Besides, preserving the natural beauty and simultaneously achieving a better quality of life, was and remains the ultimate goal of both geoconservation, geological heritage and sustainable development.

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