INVESTIGATIONS ON THE KARST OF NORTH ATTICA *

By Gasparis G. Mistardis**

INTRODUCTION

1. In a communication to the Symposium "Physico-Chimie of karst" in Granada (1975) are exposed certain conclusions of my researches on the fossil karsts of Mt. Parnassus (2457m) in Eastern Middle Greece (lat.c. 38° 35') belonging to the High Karstic plateaus tectonic-facial zone of the Inner Hellenides.

In this paper are exposed certain conclusions of my researches on the fossil Prealpine karst and the Postalpine karst of the mountainous (alt. till 1411m) calcareous (mostly) north Attica (lat. c. 38° - 38° 15') considered as belonging to the Sub-Pelagonic tectonic-facial zone of the Inner Hellenides, but more probably to a side variety of it or to a complex.

2. The Sub-Pelagonic, considered as a zone of a marine trough in the eugeosynclineum of the Inner Hellenides is consisting of:

a) Young Palaeozoic schistes, sandstones, grawakes and intercalations of calcareous lenses and eruptive rocks of thickness unknown.

b) Triasic limestones and dolomites. Total thickness till about 650 m.

c) Limited outcrops of Jurassic schists and shale-sandstone chert in which are found ophiolithic rocks effused or intrused or overthrust.

d) comparatively limited outcrops of Cenomanian and Turonian-Senonian limestones till about 220m thick in total.

3. The Sub-Pelagonic zone is considered as a tectonic nappe pushed from E to W upon Paleocene flysch, limited remnants of which are found in north Attica.

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* ΕΡΕΥΝΕΣ ΕΠΙ ΤΟΥ ΑΣΒΕΣΤΟΛΙΘΙΚΟΥ ΤΟΠΙΟΥ (ΚΑΡΣΤ) ΤΗΣ ΒΟΡΕΙΑΣ ΑΤΤΙΚΗΣ, ἀπὸ τὸν Γάσπαρη Μηστάρδη (Γεωγράφου, τακτικοῦ μέλους τῆς Ε.Σ.Ε.). Ἀνακοινώθηκε στὸ VIIο Διεθνὲς Σπηλαιολογικὸ Συνέδριο τοῦ Sheffield (Ἀγγλίας) 1977.

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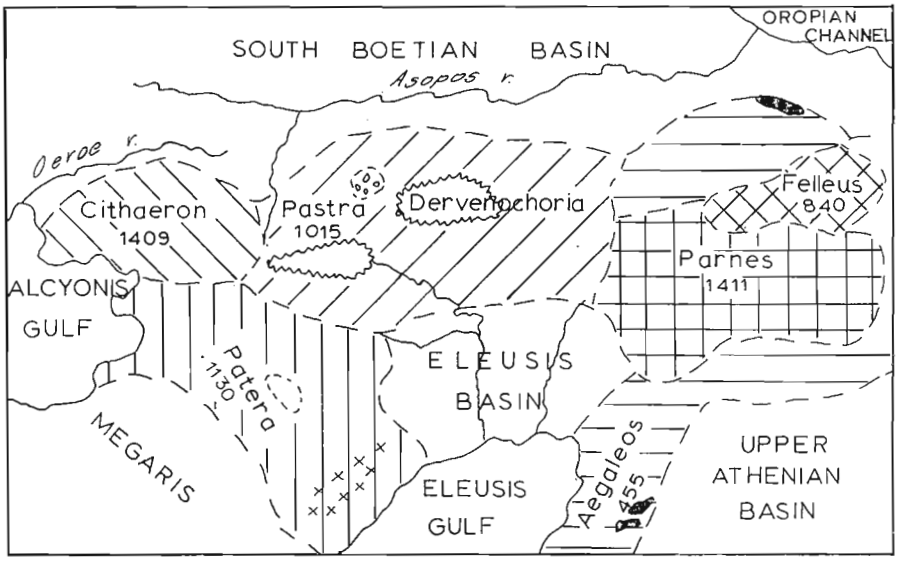
However the tectonic structure of this area seems more complicated. The Young Palaeozoic strata are not rarely covering the Mesozoic (calcareous chiefly) rocks.



Avlon-Acharnae unit
Felleus (Beletsi) unit
Parnes unit
Dervenochoria unit
Patera-Mandra unit
Cithaeron unit
polje
characteristic doline field
area rich in bauxites (fossilized prealpine karstic surface)
iron ores
defossilized prealpine karstic surface

Fig. 1. Geotectonic complex of the mountainous North Attica.

They are also sensible differences in the series of strata in the various parts of the area.

4. It is thus considered that we are in presence of a certain number of lesser structural units (Fig. 1), the following:

a) of Cithaeron, in NW
b) of Patera-Mandra, in SW
c) of Dervenochoria, in the highland's central part
d) of Parnes, in the east-central part
e) of Phelleus (Beletsi), in NE

Outside them, arround the eastern part of our area is occuring another unit, that

f) of Avlon-Acharnae, which is dipping under the complex of the units a-e.

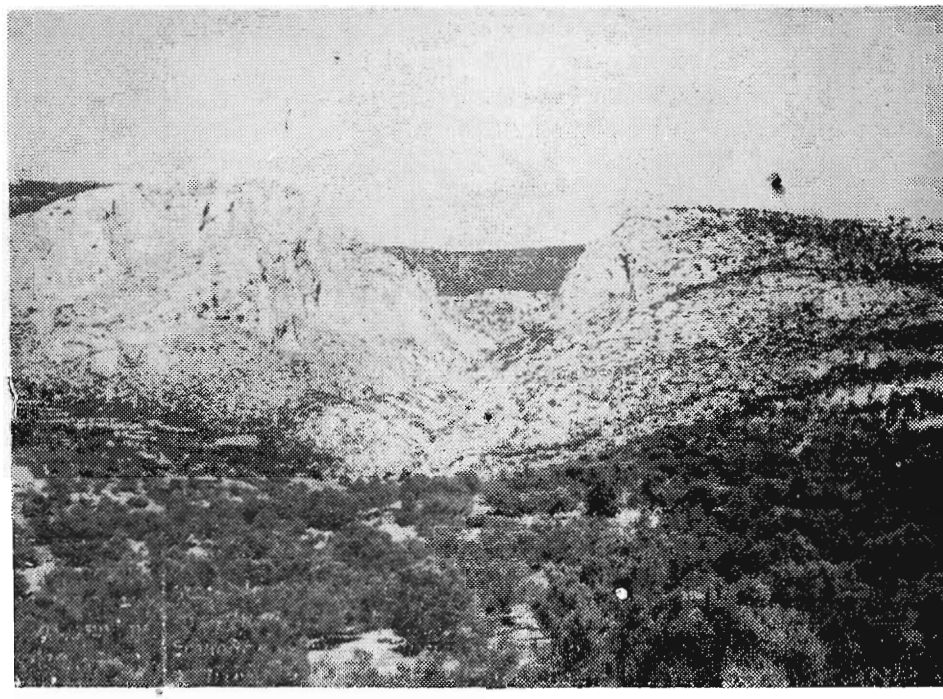


Fig. 2. Valley of Giannoula

Background: In the middle: Platy Vouno (1160 m.) surface A (p. 87 § 17).

Foreground: Banal karstic forms.

Intermediate ground: The strong karstified Arma (left) — Tamilthi (right) calcareous mass: In the middle the wild canyon of Kleiston (p. 93, § 35) In the abrupt wall of Arma impressive megakarstic carvings.

FIRST PART

THE FOSSILIZED PRE-ALPINE KARST

I. Beginning and evolution of the karstification

5. It is at about end Trias-early Jurassic that the area of north Attica-eastern Megaris complex was emerged. On its surface were outcropping chiefly limestones, less dolomites, schists, sandstones and certain other rocks. The non carbonate rocks (chiefly Newpaleozoic) as less hard were in greater part easily destructed by the erosion. As, thus, the underlying carbonate rocks were outcropping, the karstfied surface was little by little considerably enlarged.

6. During the very long space of time between Lower Jurassic and the Cenomanian (Middle Cretaceous) sea transgression, in the greater part of the emerged land, because of the erosion a very thick part of the strata was destructed.

Grace to this transgression the greater part of the Prealpine extend Karst surface was fossilized by the deposit of marine sediments upon it. Thus we can have an idea of the prevailing then in it epigean (superficial) chiefly forms (dolines, lapiaz etc) and of the degree of their evolution.

II. Bauxite deposits

7. In periods when climatic conditions were favourable laterizations of ophio-

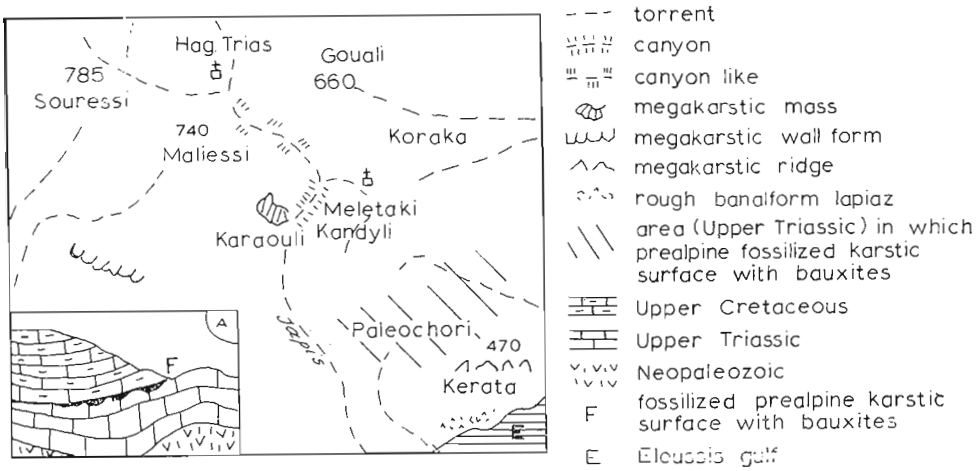


Fig. 3. The southernmost part of Mt. Patera.
A-Cross-section in a region of north Attica where bauxite.

lites took place from which resulted afterwards bauxite. In a great number of the epigean karstic forms (dolines etc) of the fossilized surface (§ 6) are found bauxites.

Where the sediments covering this surface were washed up by the erosion, the Prealpine karst is outcropping with in some places remnants of bauxite layers. It is for instance the case in the central part of Mt. Patera at an altitude of c. 1000 m.

8. It is in the part of the Prealpine fossilized karstic surface extending in the Patera- Mandra unit, chiefly in its southern section (Fig. 3, 9), that bauxites are found in great abundance. In the units of Devrenochoria, Parnes and Phelleus, the known at least bauxite layers are not of great importance.

III. The non fossilized in Cenomanian karstic surface.

9. In the non fossilized by the Cenomanian sea transgression parts of the

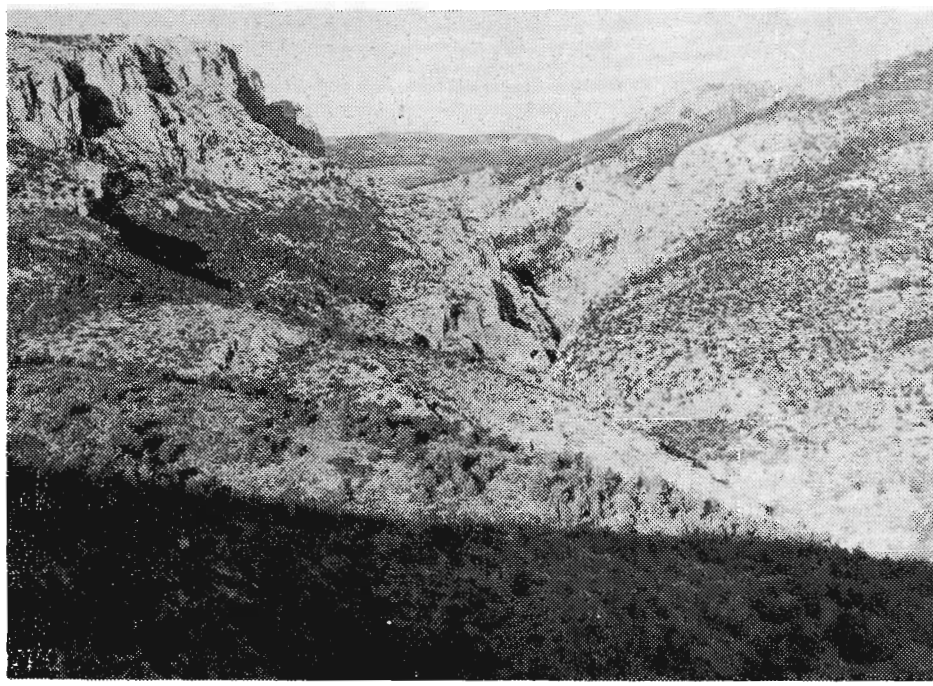


Fig. 4. The canyon of Kleiston

In the background the Platy Vouno karstified surface A (p. 87, § 17)
In the foreground the southern end of the canyon.
In the indermediate the upper part of the canyon.
Left: Arma (867 m): Over ancient karstified surface. Calcareous wall with impressive mega-karstic carvings. Terraceform calcareous surface.

Prealpine surface, the karstic erosion continued. Thus, the thickness of the carbonate rocks decreased further enough notably. At the Upper Senonian the sea covered the Prealpine surface in the Parnes unit. The bauxite layers are there ovelaid by conglomerates, upon which are found marine sediments, considered as of Maestrichtian the more probably age, which had fossilized the Prealpine surface in this unit.

IV. Influences of the Alpine tectonization.

10. Because of the intense tectonization during chiefly the main phases of the Alpine orogenesis, the various parts of the Prealpine fossilized surface are found in various altitudes, thus, for instance, in the central part of Mt. Patera till c. 1000m, while in its southern part at lower altitudes and probably also enough lower of the level O. They are also presenting mostly great inclinations.

The hypogean chiefly kasrtic forms rarely are presenting very notable deformations by the tectonization and very great alterations by the erosion.

SECOND PART

THE POST-ALPINE KARST SINCE THE ISOLATION OF THE NORTHATTIC HIGHLAND

I. The emergence and uplift of the land.

11. After the Pyrenean phase of the Alpine orogenesis in Upper Eocene our area began to emerge. A new cycle of erosion starts. The washing of the non hard Youngpaleozoic rocks and of the Paleocene -Lower Eocene flysch, conducted to the development of a very accused uneven surface.

The Savic phase of the Alpine orogenesis, at about the end of the Oligocene does not seem to had exercised an important influence in North Attica.

12. During the long period between Upper Eocene and the middle of Miocene, because of the erosion of great parts of the impermeable Youngpaleozoic strata and the flysch, the calcareous surfaces gained greatly in extension.

Ground karstic erosion, favoured by the uplift of the area had enough advanced in depth. Important hypogean karstic nets of galleries, halls etc were developed, which little by little were connected during various phases with relics of prealpine ones of those not strongly alterated.

13. On the surface, the karstic erosion had successively creating various epigean forms (dolines etc), alterating-destructing them later and creating new ones.

Thus, the surface was lowering and the calcareous masses became less and less thick.

An exact datation of this ancient surface is now not possible owing to the lack of fossiliferous sediments upon it etc.

14. Because of the later tectonization, the various parts of this post-alpine very important ancient surface are found now to notable different altitudes, mostly between 800 and 1200 m.

II. Important remnants of the surface A.

15. It is on Mt. Parnes that are found the more important traces of this more ancient surface (A), evidently very greatly alterated by the erosion.

The actual epigean forms are dating from more recent ages, very numerous of them from Quaternary.

16. The central highest ridge of Karabola (1411 m) and Ornio (1365 m), in Parnes, enough karstified (Groupaes etc) is the more probable a remnant of this surface very greatly alterated by tectonization and erosion. Perhaps also the narrow ridge of Mt. Cithaeron (1409 m) presenting not great differences of altitudes in its central part is another relic of the surface A.

17. But, the more well conserved and more extensive remnants of this surface rich in epigean recent karstic forms (dolines etc) of various types and sizes, and in various stages of evolution are found around the highest central part of Parnes at altitudes mostly 950-1100 m.

The more important of them are those of:

a) Plati Vouno (alt. 1000-1160 m) close southwest of the highest part, with well developed epigean karstic forms chiefly dolines (Fig. 2, 4).

b) Keramidi-Koumbula (alt. 900-985 m) southwards of the precedent, not well conserved.

c) Kyras-Ancient Sanatorium (alt. 1000-1145 m) southward of the highest part of the mountain.

d) Mavrovuni-Flamburo (alt. c. 1000-1081 m.) ENE of the precendent. By the deep very narrow valley of Theriza is subdivised in tow halves.

e) Xerovuni (alt. 1000-1121 m) northeastwards of the precedent, limited extensive.

f) Mola-Dendra-Ntrey (alt. c. 950-1100 m) close, northwards of the Karabola-Ornio highest part of the mountain. It is rich in epigean karstic forms, chiefly dolines less in greater pits (Lakka Leventi etc). The very abrupt slope of the Karabola-Ornio highest ridge towards this extensive plateau is attesting in favour that the difference in altitudes of 300-400 m is due to the tectonization.

III. Other ancient surfaces.

18. Eastwards of the Mola-Dendra-Ntrey high plateau is extending a lower one (alt. c. 700-820 m), that of Ntriza with certain important karstic forms, underground (Trypa Ntaveli) and surficial (Lakka Tsaoussi). In the lowest part (alt.c. 650 m) is found an important sink-hole (Vythisma).

Northwards of the Mola-Dendra-Ntrey plateau is extending another lower one (alt. c. 680-800m) that of Patima-Saloniki, epigean karstification of which is less developed.

Southwestwards of it beyond the narrow deep valley of Mpatheza the ancient surface is more accidented (alt. c. 650-900 m) extending till Klimenti-Lentriza with certain important epigean and underground karstic forms (Megali Lakka, Spilia Mastora etc).

19. It is difficult to date these ancient, northward and westwards of the main part of Parnes karstified surfaces. They could belong either to a less ancient surface (B), or the surface A, the difference in altitude due to the tectonization.

20. It is also the case for the enough extended ancient karstified surface between Parnes and the polje of Dervenochoria, in which altitudes of the ridges increasing from south to north are mostly till c. 700-900 m (Katsulieri 690 m, Gurisi-Kasumbi 880 m, Kutrulieza 865 m etc).

It is likewise for the eastwards of Cithaeron less karstified (chiefly dolines) surfaces of Lestori-Lukisthi-Pastra (alt. mostly 800-1000 m) but here rather probable to the ancient surface A, at least the highest part of Pastra.

21. In the northern part of Mt. Patera known as Makronoros the karstified high surface of Koliahoudo-Imadi alt. 900-950 m, with little dolines and the eastward little lower (alt. 750-850 m) very elongated karstified surface with numerous little dolines the bottom of which is covered by Quaternary deposits and are presenting an advanced evolution, belong perhaps to the surface B.

22. As concerns the karstified highest surface in the central part of Mt. Patera (alt. c. 1000-1050 m) on which limited bauxite remnants (Geol. map 1 : 50000 Erytrae sheet) and little dolines in the bottom of which Quaternary-deposits little thick and presenting an advanced evolution belongs probably, at least partly, to a defossilized prealpine surface renewed at the period of the post-alpine surface A of which became a part (Fig. 10).

23. The more lower, very uneven and notably karstified with some little canyons enough impressive (Dardeza a.o.) though moderately deep, as also two longer canyonform narrow valleys those of Sarantapotamos and Kato Palaeochoriticos) and altitudes of which are 400-600 m belongs perhaps to a more recent surface (C).

IV. The dating of these Post-Alpine ancient karstified surfaces.

24. Because of the lack of fossiliferous deposits upon these surfaces is not possible, at least now, to date them yet approximately.

Owing to that lacustrine deposits in the Upper Cephissos basin are considered as of an Helvetian age, above ancient karstified surfaces could be considered as probably of Middle Miocene age, at least A and B, and of Upper Miocene the C.

25. Certain of them belong perhaps to a Pre-alpine karstified surface defossilized by the erosion as is the case the more probable for that on the highest part of Mt. Patera (§ 22).

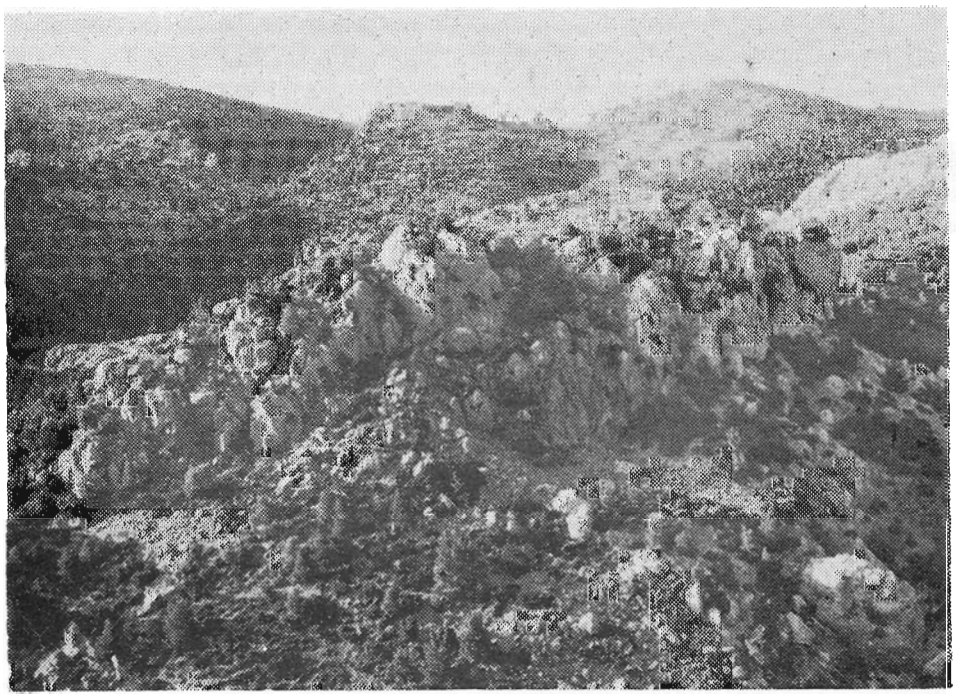


Fig. 5. Ancient Phyli area

Background: in the middle the characteristic table on which the ruins of an ancient greek important castle.

Foreground: rough banalforms lapiaz field.

THIRD PART

EVOLUTION OF THE KARST AFTER THE ISOLATION OF THE NORTHATTIC HIGHLAND

I. Tectonization-Uplift.

26. It is during the period of the Styrian phases of the Alpine orogenesis (Middle Miocene) that, because of intense faultings and important vertical etc displacements of the pieces was isolated as a horstlike relief the actual mountainous north Attica.

Eastwards of it was formed then a lower plateaulike region, the Diacria, northward the important Southboetian basin, west-northwest the basin of Alcyonides, westward the istmus (now)-basin of Megaris, southward the bas in of Eleusis and southeastward that of Athens.

27. It is difficult to place the formation of the surface A before the first Styrian phase or little after it, propably dates from before the second Styrian phase.

28. As consequence of the foldings and feultings were disjunctions, various deformations etc. in the hypogean karstic nets (galleries etc) as also later verious readaptations between them.

As consequence of the isolation-uplift was an advance deeper of the hypogean karstification and the epi-hypogean (canyons etc), as also the little by little formation of the actual valleys etc.

Thus, since the Uppermost Miocene the mountainous North Attica begins to acquire the great lines of its actual relief.

II. The important karstic basins (poljes).

29. In the mountainous North Attica are found two enough important karstic basins, this of Dervenochoria in the highland between Parnes and Pastra and that of Oenoe between Pastra and Patera.

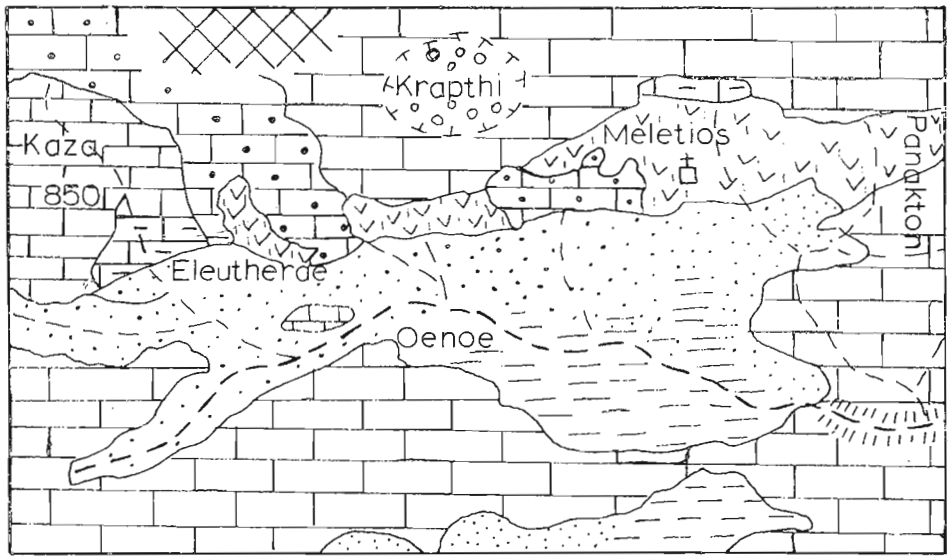
Both are of about the same extent (c. little more than 50 km^2), but they are presenting many differences in geologic and morphologic point of view.

The first, long of about 15 km (E-W) with mean wide c. 4 km is a plateau basin at an altitude of more than 500 m. The second, long of about 14 km (E-W) and wide till c. 4 km is a deep basin at an altitude of less than 400 m.

30. Are not known surely the dates of the begining of development of these poljes and of the various phases of evolution of them. As concerns the process in evolution of these karstic basins and the characteristic geomorphological features of them are to be noted the followings:

Polje of Dervenochoria.

31. This karstic basin is created chiefly by the erosion of the Mesozoic calcareous strata of the vault of an anticline. Thus at the bottom of the polje are occuring



- – – torrent or river
- canyon
- characteristic dolines field
- probable remains of surface A
- alluvions
- ancient Quaternary deposits
- Upper Triassic limestones and dolomites
- Middle Triassic
- Lower Triassic cherts, limestones e.t.c.
- Neopaleozoic schist-sandstones e.t.c. and volcanic rocks

Fig. 6. Area of Oenoe - Os. Meletios basin
(between Mt. Pastra and northeastern Mt. Patera).

the Young-Paleozoic impermeable rocks, covered nowin great part by Pleistocene chiefly deposits.

The borders of the polje, except in west where Young-paleozoic rocks (argillaceous shales and sandstones alternating with graywackes, conglomerates etc), occur are consisting of calcareous strata dipping, those of the north border towards N and those of the southern to S. They are very alterated, in certain places yet covered by very recent deposits. In this polje in very advanced evolution few calcareous low hills are arising from the pleistocene deposits of its bottom (hums). More than once probably lake in the past now is drained undergroundly; an important sink-hole (katavothra) is found on the base of the north border.

Polje of Oenoe.

33. This karstic basin is created by the erosion in a syncline. It was probably more than once lake in the past. Now the rainwaters, at least mostly, are drained by the very narrow valley of Sarantapotamos (to wards the basin of Eleusis).

The north border forms the important calcareous ridge of Pastra (1015 m). However on its lower part are occuring enough extented Young-Paleozoic rocks (argillaceous shales and sandstones alternating with graywakes, conglomerates etc).

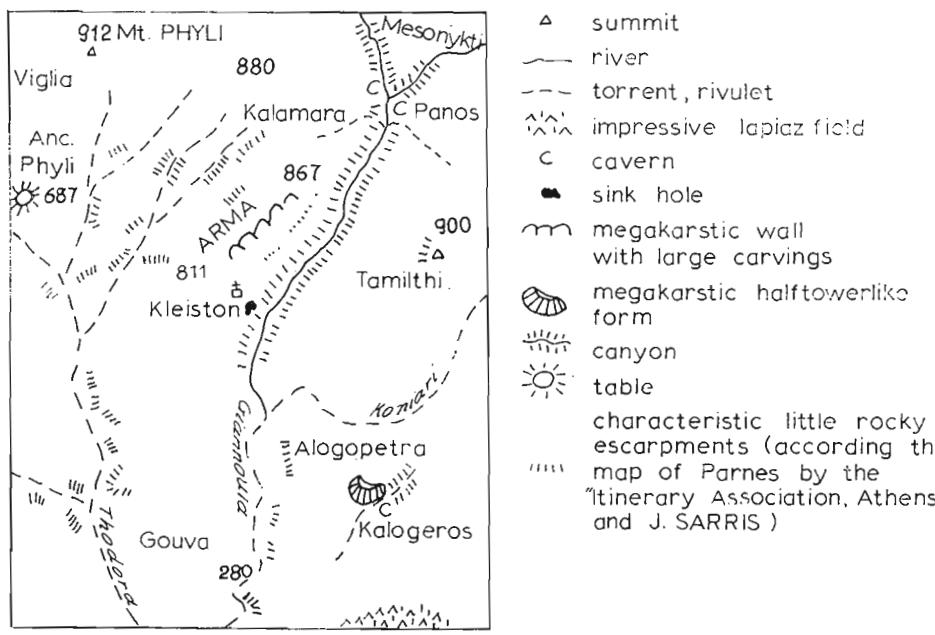


Fig. 7. Phyli - Kleiston region (south western part of Mt. Parnes)

On the contrary of the north, the south border is not high and abrupt. (calcareous heights). One enough important and two very little hums are found near the village of Oenoe (Fig 6).

III. The canyons and canyonlike valleys.

34. As consequence of the little by little very notable uplift of the mountainous North Attica the valleys became many parts very deep.

Where the ground into which advanced the deepening of the valleys was calcareous, they acquired there a canyon or canyonlike shape. Thus the valleys present mostly an alternation of calcareous canyons or canyonlike shape forms where traverse calcareous masses and other shapes, mostly like a V where traverse non calcareous rocks.

The calcareous canyons are the more impressive karstic forms (epi-hypogean) in the mountainous North Attica.

35. The more impressive and more long (c. 2,5 km.) is that of Kleiston of the

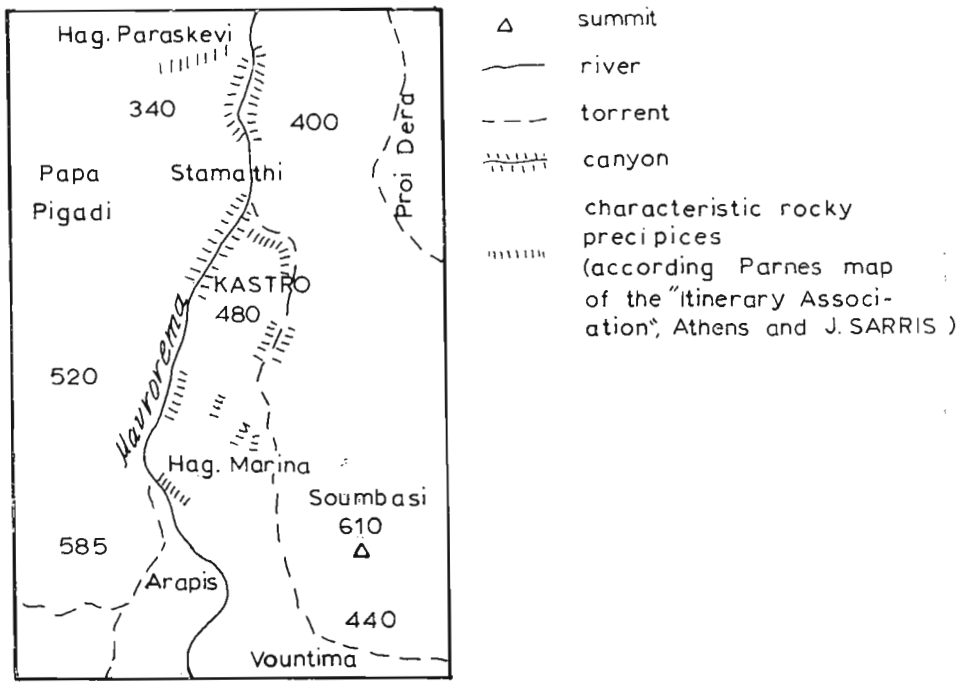


Fig. 8. Middle Mavrorema region (north-westernmost part of Parnes)

river Giannula valley in the southwestern part of Parnes separating the Tamilthi (alt. 899 m) from the extremely impressive Arma (alt. 867 m).

This canyon of an impressive wild grandness begins at Messonykti and ends below the Kleiston convent. In its northern part near the conf luence of Kampera valley is found the important cavern of Pan (Fig. 7). Because of the very notably difference between the beginning and the end of it in many places are found little waterfalls. Southwards of the Kleiston canyon, between Katsoulieri (691 m) - Skaliza and Evraeopetra (558m) the Giannula river valley presents a canyonlike (calcareous) shape long also of c. 2,5 km.

36. An alternation of little calcareous canyons or canyonlike shapes parts in a valley is presenting that of Mavroremma northeast of Parnes in its lower section between Hag. Marina and Hag. Paraskevi and the lower also part of its tributary Vountimoremma (Fig. 8).

37. A characteristic canyon in shape of a meander was developed in the middle

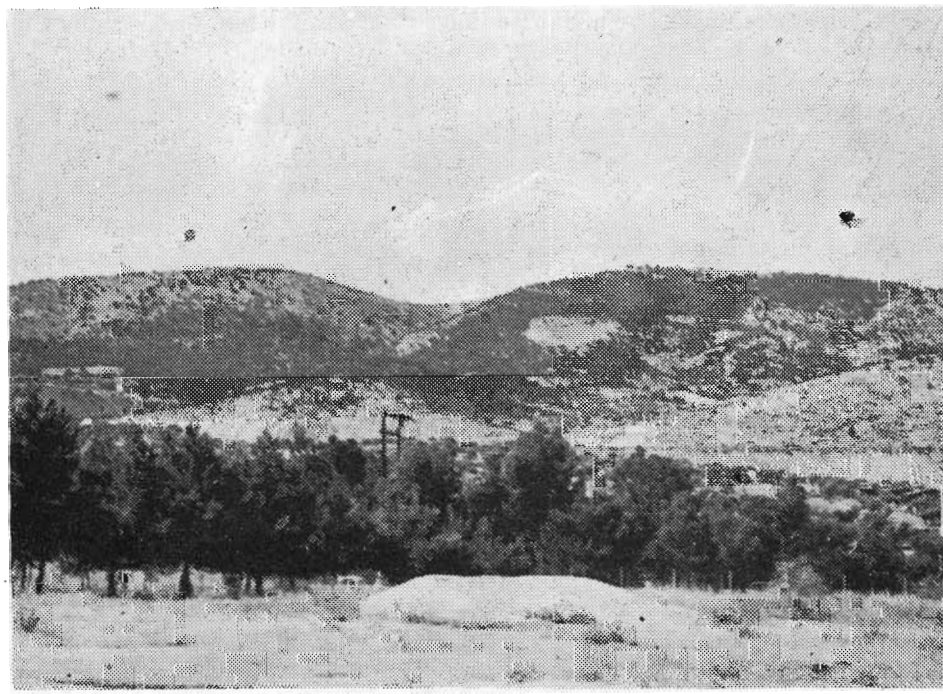


Fig. 9. Southernmost part of Mt. Patera.
The left part consists of Upper Cretaceous limestones.
The right part of Upper Triassic calcareous rocks. In it fossilized prealpine Karstic surface with abundaut bauxites. (p. 85, § 8).

part of the Charadros river valley between Makrychorapho (alt.c. 600 m) and the western border of the little plain of Aphidnae (alt. c. 350 m).

38. Enough impressive is the little calcareous canyon of Dardeza in the southeastern part of the Pateras range which near Villiari joins the Skylorrema valley.

More impressive is the calcareous canyon of Meletakin the southwestern part of the Pateras range at the exit of the Koulouriotikos torrent to the plain of Megaris. The upper part of this valley (Zoireza) is rather of a canyonlike type (Fig. 3).

39. The more long canyonlike valleys (more than 5 km) are those of Kokkinos (red) river in some maps, Sarantapotamos in others, and of the Paleochoritikos in some maps, Sarantapotamos in others (tributaries one to the other) in their middle sections developed into the lower karstic surface area (§ 23) between the Dervenochoria highland and the Pateras mountain range.

40. It is chiefly in calcareous masses of Middle-Upper Triassic limestones and dolomitic limestones white to white-gray, massive to thick-bedded and strongly jointed, that the calcareous canyon and canyonlike karstic forms are developed in the mountainous North Attica.

FOURTH PART

INFLUENCES ON THE EVOLUTION OF THE POSTALPINE KARST OF THE MOUNTAINOUS NORTH ATTICA

I. Influences of landmovements.

41. The Aegean plate deformations in the zone between the main mass of it and the outer arc were enough marked since the end of the Miocene (Neotectonic period). In the mountainous North Attica situated in this zone, influences of certain of them should be evidently notable on the hypogean karstification of it.

Thus, the compression tectonic deformations, as provoking uplifts, were favouring the advance of the karstic erosion in depth. They favoured also the deepening of the valleys and thus the formations of canyons and canyonlike shapes where calcareous rocks were encountered.

II. Influences from base levels variations.

42. The deeper parts of the tectonic basins surrounding the mountainous North Attica (§ 26) in their deeper parts were covered by continental, in great part lacustrine, deposits little by little. In the basin of Upper Cephissos the older of them are considered as of an Helvetian age, in the others are known only more recent.

These sediments present various inclinations, greater chiefly the older of them.

The changes of the bottom level in these basins, because of the above mentioned sedimentation and by the Neotectonic dislocations etc, were not without notable influences upon the hypogean karstification in the mountainous North Attica.

43. Thus, for instance, could be cleared up the hypogean watersheds in the western part of our area between Mt Pastra, western limits of the Oenoe polje, Hag. Sotira (of Mandra), Hag. Trias of Mt. Pateras, western limits of Mavron Oros and Villia, for the hypogean drainage (ground water is moving towards the Alcyonides sea) are different from those of the epigean (surface streams are moving towards thə Eleusis gulf.

III. Influences of climate fluctuations.

44. Climate fluctuations had naturally affected notably the evolution so much

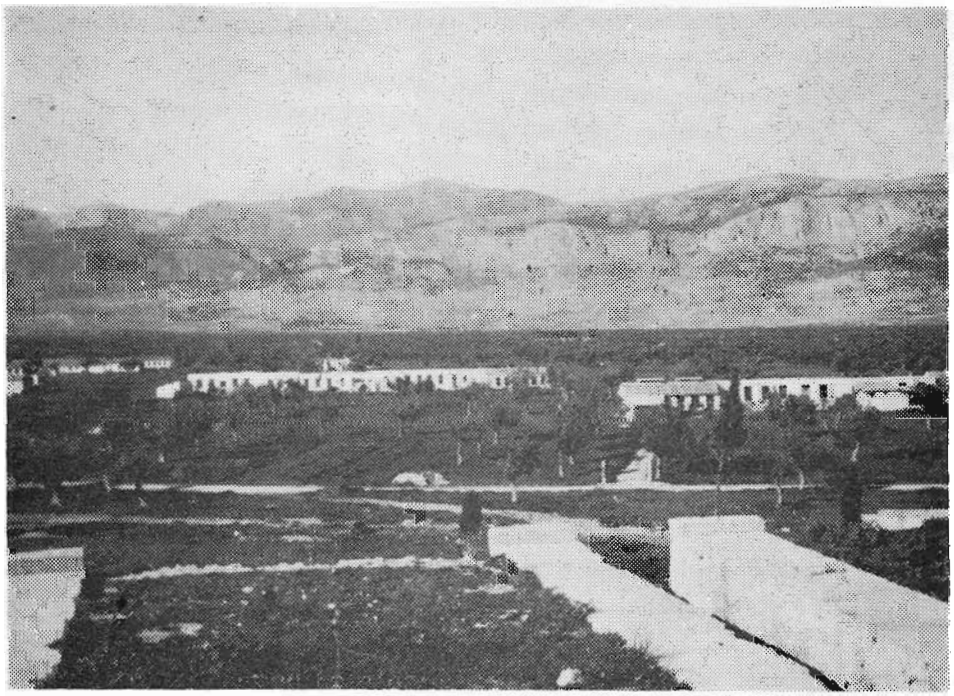


Fig. 10. Mt. Patera (from W.)

1.— Remnants of the karstified surface A. In the middle the highest summit Elatos (1130 m.) near which the defossilized prealpine karstic surface (p. 85 § 7 and p. 88 § 22) with remnants of bauxites.

2.— Megakarstic wall with impressive carvings.

3.— Lower eastern part of the Megaris plain.

of the epigean, as also of the hypogean karstic forms, provoking alternations of intense activities and inertnesses in the karstification.

45. From the fossilized faunas species (Pikermian etc) from the Messinian till Middle Quaternary in neighbouring regions, as also from the study of certain lithologic formations and certain edaphologic researches in them we have an idea of the climate fluctuations in North Attica and neighbouring areas. From certain glacial and periglacial traces-formations in eastern Sterea Hellas also for the Middle and Upper Quaternary.

During the Quaternary predomine alternatives of colder and warmer climates. From Messinian to the end of Pliocene alternatives of dryer and wetter climates.

46. Alternatives of wetter and dryer climates influenced notabley so much the epigean karstic forms evolution, as also that of the hypogean, while alternatives of colder and warmer climate chiefly the epigean.

In the mountainous North Attica the evolution of the Post-Alpine karst was influenced chiefly from the alternatives of wetter and dryer climate.

IV. Influences of sea lrevel fluctuations.

47. Perhaps in Astian (Upper Pliocene) the sea had enough approached the western part of North Attica, but sure traces are not known. As concerns the Tyrrhenian sea transgression, traces were found in abundance in the neighbouring SW Perachora peninsula-eastern Corinthia. It is not possible however, now at least, to attest if influences of sea level fluctuations are sensible yet in the westernmost part of the mountainous North Attica.

SOME FINAL REMARKS

Character of the karst.

48. The karst of the mountainous North Attica, developed in a calcareous mostly mass, thick till probably c. 900 m is more or less continuous, not interrupted but by comparatively limited outcrops of Young-Paleozoic, chiefly impermeable rocks.

It is more evoluted in some sectors etc of the area and less in others.

49. The spatial differentiations which is presenting are to be attributed chiefly to:

a) the from long ago, or from short ago washing of the impermeable (chiefly Paleozoic) rocks overlaying the limestones.

b) the various kinds of limestones (massive, thick or thin bedded, strongly or not strongly jointed), dolomitic limestones and dolomites.

Thus for instance, karstification is more developed where are prevaling the

Middle Triasic calcareous rocks, moderately where Turonian or Upper Triasic and less where Cenomanian or Lower Triasic.

50. In general, the karst of the mountainous North Attica can be considered as a merokarst.

Rarely, localy, as for instance in the area of Devrvenochoria where the karstification had advanced largely till the underlying the calcareous rocks impermeable Young-Paleozoic strata, presents an aspect of a rather holokarst in which a polje with hums and borders very evoluted.

The mountainous North Attica a very proper field for karstic researches.

51. From that is exposed becomes evident that the mountainous North Attica an area of about 1200 km^2, consisting chiefly of limestones, dolomitic limestones and dolomites of various kinds as concerns permeability, and comparatively limited of impermeable rocks, and presenting on the other hand a very complicated structure, is a very proper field for researches so much on Prealpine karsts, as also on the phases etc. of evolution of Postalpine Mediterranean karsts in the Inner zones of the Dinaro — Hellenic arc, in a belt where we are in presence of alternations of extension and compression tectonic deformations of the Aegean lithostratigraphic plate.

ΠΕΡΙΛΗΨΗ

Εἰσαγωγή.

Ἡ ὀρεινὴ Β. Ἀττικὴ (ὑψ. μέχρι 1411 μ.) εἶναι ἕνα πολὺ ἐντυπωσιακὸ ἀσβεστολιθικὸ (καρστικὸ) τοπίο καὶ θεωρεῖται ὅτι, γεωτεκτονικὰ ἀνήκει στὴν Ὑποπελαγονικὴ Ζώνη. Πιθανότερα ὅμως εἶναι πλάγια παραλλαγὴ αὐτῆς ἡ γεωτεκτονικὸ πολυσύνθετο (complex), ἀποτελούμενο ἀπὸ 6 μονάδες (units) τὶς ἑξῆς: Κιθαιρωνικῆς, Πατέρα-Μάνδρας, Δερβενοχωρίων, Πάρνηθας, Φελλέως καὶ Αὐλώνας-Ἀχαρνῶν (Εἰκ. 1).

Τὸ ἀπολιθωμένο Προαλπικὸ ἀσβεστολιθικὸ τοπίο.

1. Ἡ ἀρχὴ τῆς καρστοποιήσεως τοποθετεῖται στὸ τέλος τοῦ Τριαδικοῦ — ἀρχὴ τοῦ Ἰουρασικοῦ, ὅταν ἐξάρθηκε ὁ χῶρος, στὸν ὁποῖο βρισκότανε ἡ σημερινὴ Β. Ἀττική.

Κατὰ τὸ πολὺ μεγάλο χρονικὸ διάστημα μέχρι τοῦ Κενομανίου (Μεσοκρητι-

δικοῦ), Ὅταν ὁ χῶρος αὐτὸς καλύφθηκε κατὰ τὸ μεγαλύτερο πιθανῶς μέρος του ἀπὸ τὴ θάλασσα, πολὺ ἀξιόλογο πάχος τῶν ἀσβεστολιθικῶν στρωμάτων διαβρώθηκε.

2. Ἔτσι στὴν καρστικὴ ὑψιπεδοειδὴ ἐπιφάνεια, ποὺ μὲ τὸν τρόπο αὐτὸ διαμορφώθηκε, λόγω τῶν κλιματικῶν συνθηκῶν, ποὺ ἐπικρατούσαν στὴν τότε περίοδο, τὰ ὀφειολιθικὰ πετρώματα, ποὺ βρισκόντουσαν σὲ διάφορα μέρη αὐτῆς, ὑποστήκανε λατεριτίωση, σὲ συνέχεια τῆς ὁποίας προκύψανε σταδιακὰ βωξίτες. Ἀπὸ αὐτοὺς πληρωθήκανε πολυάριθμα καρστικὰ ἔγκοιλα (δολίνες κλπ.) καὶ κυρίως στὴ μονάδα Πατέρα-Μάνδρας (Εἰκ. 3, 9).

3. Μὲ τὴν Κενομάνιο θαλάσσια ἐπίκλυση, τὸ μεγαλύτερο μέρος τῆς καρστικῆς ἐκείνης ἐπιφάνειας μὲ τοὺς βωξίτες της ἀπολιθώθηκε ἀπὸ τὶς θαλάσσιες ἀποθέσεις. Στὰ τμήματα αὐτῆς, ποὺ δὲν ὑποστήκανε ἐπίκλυση, ἡ καρστοποίηση ἐξακολούθησε.

4. Κατὰ τὴν Ἀλπικὴ ὀρογένεση λόγω πτυχώσεων, μεταπτώσεων κλπ. ἡ Προαλπικὴ καρστοποιημένη βωξιτοφόρα ἐπιφάνεια διασπάστηκε καὶ τὰ ἀποκομμένα τμήματα αὐτῆς βρίσκονται σήμερα σὲ διάφορα ὕψη καὶ μὲ διαφορετικὲς κλίσεις.

Σὲ μερικὰ σημεῖα, ὅπως στὸ ψηλότερο τμήμα τοῦ βουνοῦ Πατέρα, περίπου 1.000 μ. πάνω ἀπὸ τὴ θάλασσα, ἔχουμε λόγω διαβρώσεως ἐμφάνιση τῆς ἀπολιθωμένης Προαλπικῆς καρστοποιημένης ἐπιφάνειας μὲ διασωζόμενα πάνω σ'αὐτὴ λείψανα βωξιτῶν (Εἰκ. 10).

Ἡ μελέτη ὅμως τῆς προαλπικῆς ἐπιφάνειας, κυρίως τῶν ἐπίγειων μορφῶν (δολινῶν κλπ.) ἀλλὰ κάποτε καὶ μερικῶν ἐπι-ὑπόγειων, εἶναι εὔκολη στὰ πολυάριθμα λατομεῖα βωξιτῶν, δυσκολότερη ὅμως σχετικὰ καὶ στὶς ὑπόγειες στοὲς ἐκμεταλλεύσεως.

Τὸ Μεταλπικὸ ἀσβεστολιθικὸ τοπίο (κὰρστ) μέχρι τῆς ἀπομονώσεως τῆς ὀρεινῆς Β. Ἀττικῆς.

1. Μὲ τὴν κατὰ τὸ Ἀνώτερο Ἠώκαινο ἔξαρση τοῦ χώρου, στὸν ὁποῖο βρίσκεται ἡ Β. Ἀττική, ἀρχίζει νέος κύκλος καρστοποιήσεως.

Κατὰ τὸ μεγάλο χρονικὸ διάστημα μέχρι τοῦ Ἐλβέτιου περίπου, λόγω τῆς ἐπίγειας διαβρώσεως διαμορφώθηκε μιὰ χαρακτηριστικὴ ἐπιφάνεια (Α). Ἀπὸ τὴν ὑπόγειο ἐξάλλου διάβρωση, ἡ ὁποία ἀπὸ τὴν κλιμακωτὴ σημαντικὴ ἔξαρση προχώρησε πολὺ σὲ βάθος, διαμορφώθηκαν ἀξιόλογα ὑπεδαφικὰ καρστικὰ δίκτυα ἀπὸ στοές, θαλάμους κλπ.

2. Σὰν συνέπεια τῶν τεκτονικῶν ἐπιδράσεων ἡ παλιὰ ἐκείνη καρστοποιημένη ἐπιφάνεια σχετικῆς κυρίως ἐπιπεδώσεως (Α), διαρρήχθηκε καὶ τεμαχίστηκε. Τὰ τεμαχισμένα τμήματα αὐτῆς βρίσκονται σήμερα σὲ διάφορα ὕψη. Τὰ σὲ μεγαλύτερα ὕψη λίγα λείψανά της συναντᾶμε σήμερα στὸ ψηλότερο μέρος τῆς Πάρ-

νηθας στὴ ράχη Καραμπόλα (Γκρούπες κλπ.) — Ὄρνιο, καθὼς καὶ στὸ ψηλότερο μέρος τοῦ Κιθαιρώνα.

Τὰ περισσότερα ὅμως καὶ πιὸ ἀξιόλογα βρίσκονται σήμερα σὲ ὕψη μεταξὺ 950-1150 μέτρων γύρω ἀπὸ τὸ ψηλότερο μέρος τῆς Πάρνηθας (Πλατύβουνο (Εἰκ. 2, 4), Μόλας, Ξεροβοῦνι, Φλάμπουρου - Μαυροβούνι - Κεραμίδι - Κούμπουλα). Βρίσκονται ἐπίσης στὰ ψηλότερα σημεῖα τοῦ Πατέρα (Ἔλατου, Μακρὺ ὄρους) καὶ ἀνατολικὰ τοῦ Κιθαιρῶνα στὴν Πάστρα - Λεστόρι (Εἰκ. 10).

3. Λείψανα παλιᾶς καρστοποιημένης ἐπιφάνειας ἐπιπεδώσεως συναντᾶμε καὶ σὲ ὕψη μεταξὺ 700-800 μέτρων βόρεια τῆς Πάρνηθας (Δρίζας, Σαλονίκι-Πατήματος) καὶ δυτικὰ αὐτῆς (πέρα ἀπὸ τὸ ἀρχαῖο φρούριο Φυλῆς). Ὑπάρχουν ἐπίσης καὶ στὸν Πατέρα. Δὲν ἀποκλείεται, ἀρκετὰ ἀπ' αὐτά, νὰ εἶναι τμήματα νεώτερης ἐπιφάνειας σχετικῆς ἐπιπεδώσεως (Β).

Σὲ ἀκόμα νεώτερη ἐπιφάνεια σχετικῆς ἐπιπεδώσεως (Γ) δὲν ἀποκλείεται ν' ἀνήκει ἡ μεταξὺ Πατέρα καὶ τοῦ ὑψίπεδου Δερβενοχωρίων ἔντονα καρστοποιημένη (κυρίως ἀσβεστολιθικὰ φαράγγια καὶ κοιλάδες Δάρδεζας, Σαρανταπόταμου, Κόκκινου κλπ.) περιοχὴ (ὑψόμετρου 400-600 μ.)

4. Ἐκτὸς ἀπὸ κάποια ἐπιφάνεια στὰ ψηλότερα σημεῖα τοῦ Πατέρα, ἐπὶ τῆς ὁποίας βεβαιώνονται λείψανα βωξίτου παλιότερης Προαλπικῆς ἐπιφάνειας, ποὺ ἐπανεμφανίστηκε λόγω διαβρώσεως, οἱ Μεταλπικὲς παλιὲς ἐπιφάνειες καρστικῆς ἐπιπεδώσεως Α-Γ εἶναι πιθανότατα ἡλικίας Ἐλβέτιου (ἡ Α ἴσως λίγο παλιότερης).

Ἐξέλιξη τοῦ Μεταλπικοῦ κὰρστ μετὰ τὴν ἀπομόνωση τῆς ὀρεινῆς Β.Ἀττικῆς.

1. Μὲ τὸ σχηματισμὸ τοῦ Ἀθηναϊκοῦ λεκανοπέδιου, ποὺ ἔγινε κατὰ τὸ Ἐλβέτιο καὶ ἀργότερα τῶν λεκανοπεδίων τῆς Ἐλευσίνας, Μεγαρίδας-Ἀλκυονίδας καὶ Νοτιοβοιωτικοῦ, καθὼς καὶ τοῦ μέτριου ὕψους ὑψιπεδοειδοῦς τῆς Διακρίας, ἀπομονώθηκε ἡ ὀρεινὴ Β. Ἀττική.

Σὰν συνέπεια τῆς ἀπομονώσεως αὐτῆς, καθὼς καὶ τῆς σταδιακῆς ἐξάρσεως ἡ ὑπόγεια καρστικὴ διάβρωση προχώρησε σταδιακὰ ἀρκετὰ σὲ βάθος, ὅπως καὶ ἡ ἐκβάθυνση τῶν ἀσβεστολιθικῶν φαράγγων καὶ γενικὰ τῶν κοιλάδων. Ἀπὸ τοῦ Ἀνωτάτου Μειοκαίνου — ἀρχὲς Πλειοκαίνου (Ποντίου βαθμίδας) ἔχει κιόλας διαμορφωθεῖ στὶς γενικὲς αὐτῆς γραμμὲς ἡ ἀνάγλυφη ὄψη τῆς ὀρεινῆς Β. Ἀττικῆς.

2. Στὸ μεσαῖο μέρος τῆς ὀρεινῆς Β. Ἀττικῆς ἔχουν σχηματισθεῖ δύο ἀξιόλογοι σχετικὰ (λίγο περισσότερο τῶν 50 τετρ. χλμ. καθεμιὰ) καρστικὲς λεκάνες (poljes), ἐκείνη τῶν Δερβενοχωρίων (ὑψ. πάνω ἀπὸ 500 μ.) ἀπὸ διάβρωση ἀσβεστιτικῶν πετρωμάτων ἀντίκλινου καὶ ἡ ἄλλη τῆς Οἰνόης (ὑψ. κάτω τῶν 400 μ.) ἀπὸ διάβρωση κυρίως μὴ ἀσβεστιτικῶν πετρωμάτων συγκλινοειδοῦς (Εἰκ. 6).

3. Ἀπὸ τοῦ Κατωτέρου Πλειοκαίνου (Ποντίου) ἀρχίζουν ν' ἀποκτοῦν ἀξιόλογο σχετικὰ βάθος μερικὲς κοιλάδες καὶ νὰ διαμορφώνονται οἱ σπουδαιότερες

ἀσβεστιτικὲς φάραγγες (canyons), ὅπως ἐκείνες στὰ ρέματα Γιαννούλας (Κλειστῶν) (Εἰκ. 2, 4, 7), Μαυρορέματος (Εἰκ. 8), Σαρανταπόταμου, Κόκκινου κλπ.

Ἀπὸ τὶς ἐπιφανειακὲς καρστικὲς μορφὲς οἱ ἀσβεστολιθικοὶ μικρόλακκοι (dolines) ἀφθονοῦν σὲ πολλὰ ἐπιπεδοειδὴ τμήματα, κυρίως τῶν ψηλότερων τῆς Πάρνηθας, τοῦ Πατέρα καὶ τῆς Πάστρας-Κράπθι, διαφόρων μεγεθῶν καὶ τύπων καὶ σὲ διάφορα στάδια ἐξελίξεως, ἀρκετὲς δὲ ἔχουν καὶ καταβόθρα. Οἱ μὲ μέτριες διαστάσεις ὅμως ἀσβεστολιθικοὶ λάκκοι (uvalas) δὲν εἶναι πολλές.

Ἐπιδράσεις ἐπὶ τῆς ἐξελίξεως τοῦ Μεταλπικοῦ κάρστ.

1. Οἱ τεκτονικὲς παραμορφώσεις ἀπὸ συμπιέσεις (compressions) καὶ ἀπὸ τεντώματα (detensions) στὴ ζώνη τῆς Αἰγαίας λιθοσφαιρικῆς πλάκας, στὴν ὁποία βρίσκεται ἡ Β. Ἀττική, ἐπιδράσανε ἀξιόλογα στὴν ἐξέλιξη τῆς καρστοποιήσεως σ' αὐτήν.

Ἔτσι οἱ ἐξάρσεις στὴ Β. Ἀττική, ποὺ προκλήθηκαν ἀπὸ συμπιέσεις εὐνόησαν πολὺ τὴν σὲ βάθος ἐπέκταση τῆς καρστοποιήσεως καὶ σχηματίστηκαν ἔτσι πολὺ ἀξιόλογα ὑπόγεια δίκτυα ἀπὸ στοές, θαλάμους κλπ. καθὼς ἐπίσης καὶ ἐκβαθύνσεις τῶν ἀσβεστολιθικῶν φαράγγων.

2. Οἱ μεταβολὲς στὸ βασικὸ ἐπίπεδο διαβρώσεως, ποὺ ὀφείλονται κυρίως στὴν πλήρωση τῶν βαθύτερων μερῶν τῶν γύρω ἀπὸ τὴν ὀρεινὴ Β. Ἀττική βαθύπεδων ἀπὸ ἀποθέσεις (λιμναίες κλπ), ἀλλ' ἐπίσης καὶ στὶς τεκτονικὲς διαταράξεις εἶχαν ἀξιόλογη ἐπίδραση, ἰδιαίτερα στὴν ὑπόγεια καρστοποίηση καὶ ἐπὶ τῶν ἀσβεστολιθικῶν φαράγγων.

3. Πολὺ ἀξιόλογες ἦσαν ἐπίσης καὶ οἱ ἐπιδράσεις ἀπὸ τὶς κλιματικὲς διακυμάνσεις. Περισσότερο σημαντικὲς ἀπὸ αὐτὲς ἦσαν οἱ προερχόμενες ἀπὸ μεταβολὲς ἀπὸ ὑγρότερο κλίμα, ὁπότε εἴχαμε ἐπίταση τῆς ἐπίγειας καὶ ὑπόγειας καρστοποιήσεως σὲ ξηρότερο, ὁπότε εἴχαμε μείωση αὐτῆς καὶ ἀντίστροφα. Λιγότερο ὅμως σημαντικὲς ἦσαν οἱ ἐπιδράσεις ἀπὸ μεταβολὲς ἀπὸ ψυχρότερο κλίμα σὲ θερμότερο καὶ ἀντίστροφα, ἰδιαίτερα στὴν ὑπόγεια καρστοποίηση.

4. Ἐπιδράσεις ἀπὸ μεταβολὲς τῆς στάθμης τῆς θάλασσας, πολὺ ἀξιόλογοι στὶς παράκτιες περιοχὲς τῆς Μεσογείου κατὰ τὸ Τεταρτογενές, δὲν φαίνεται νὰ ἦσαν αἰσθητές, ἐκτὸς μόνο στὰ δυτικότερα τῆς ὀρεινῆς Β. Ἀττικῆς πρὸς τὶς ὁποῖες ἡ θάλασσα κατὰ τὸ Τυρρήνιο βρισκότανε κοντά τους (χερσόνησο Περαχώρας κλπ.)

Μερικὲς τελικὲς παρατηρήσεις.

1. Τὸ ἀσβεστολιθικὸ τοπίο τῆς ὀρεινῆς Β. Ἀττικῆς εἶναι σχεδὸν συνεχὲς μὴ διακοπτόμενο, παρὰ μόνο ἀπὸ στενὲς λωρίδες ἢ ἀπὸ ἄλλα σχήματα ὄχι ἐκτεταμένων ἐμφανίσεων πετρωμάτων, ποὺ δὲν καρστοποιοῦνται.

Ὁ ἀξιόλογος χωρικὸς διαφορισμός, ποὺ παρατηρεῖται στὴν καρστοποίηση ἀλλοῦ ἐντονότερος καὶ ἀλλοῦ ἀσθενέστερος κλπ. ὀφείλεται κυρίως:

α) στὸ μεγαλύτερο ἢ μικρότερο χρονικὸ διάστημα ἀπὸ τὴ διάβρωση τῶν ὑπερκείμενων τῶν ἀσβεστιτικῶν πετρωμάτων, ποὺ δὲν καρστοποιοῦνται.

β) στὸ εἶδος τοῦ ἀσβεστόλιθου, δολομιτικοῦ ἀσβεστόλιθου κλπ.

2. Τὸ ἀσβεστολιθικὸ τοπίο τῆς ὀρεινῆς Β. Ἀττικῆς εἶναι στὸ μεγαλύτερό του μέρος ἀρκετὰ ἐξελιγμένο, σὲ διαφορετικὸ ὅμως βαθμὸ σὲ κάθε τμήμα αὐτοῦ. Σὲ μερικὰ δὲ ἀπὸ αὐτὰ παρατηρεῖται μεγάλη ἀφθονία ὁρισμένων τύπων καρστικῶν μορφῶν (δολινῶν κλπ.).

Μόνο τοπικά, ὅπως γιὰ παράδειγμα στὴν περιοχὴ Δερβενοχωρίων, ὅπου ἡ διάβρωση ἔχει προχωρήσει μέχρι τῶν ὑποκειμένων τῶν ἀσβεστολιθικῶν πετρωμάτων μὴ ὑποκειμένων σὲ καρστοποίηση πετρωμάτων, παρουσιάζεται ὑπὸ τύπο ὁλοκάρστ.

Στὸ μεγαλύτερο μέρος αὐτοῦ εἶναι ἀκόμη μεροκάρστ.

3. Τέλος, μποροῦμε νὰ ποῦμε ὅτι ἡ ὀρεινὴ Β. Ἀττική, ἐκτάσεως περίπου 1.200 τ. χλμ., ἀποτελεῖ πεδίο πολὺ πρόσφορο γιὰ πολλὲς ἔρευνες καὶ μελέτες, ποὺ θὰ ἀναφέρονται τόσο στὴν ἐπιφανειακή, ὅσο καὶ στὴν ὑπόγεια καρστοποίηση.

Ἀπὸ τὶς ἔρευνες καὶ μελέτες δέ, ποὺ ἀναφέρονται στὴν ὑπόγεια καρστοποίηση, εἶναι εὐνόητο,ὅτι βοηθεῖται ἡ διευκρίνιση τῶν συνθηκῶν τῆς σπηλαιογενέσεως σὲ περιοχὲς μὲ ἀπολιθωμένες ἢ ὄχι καρστικὲς ἐπιφάνειες, ποὺ ὅμως ἐπηρεάστηκαν ἔντονα ἀπὸ ἐπιδράσεις τεκτονικές.

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