THE GEOLOGY - PETROLOGY OF THE ISLAND OF SKIATHOS *

BY

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1. ABSTRACT

The paper deals with the geology, mineralogy and petrology of the island of Skiathos.

The island of Skiathos is the western island of N. Sporades archipelago in the Aegean Sea and geologically belongs to the Pelagonian isopic zone. The eastern part of the island consists of high grade metamorphic rocks and belongs to the Pelagonian massif. The western part consists of low grade metaporphic rocks and belongs to the Central Euboean saddle.

The high grade metamorphic rocks consist of schists, schistose gneiss and gneiss which have been derived from sedimentary rocks metamorphosed under the condition of the amphibolite — cordierite facies. The low grade metamorphic rocks consist of marbles dolomites, slates, phyllites and calc-silicate marbles, which were metamorphosed under the condition of the greenschist facies.

The igneous rocks are devided into two groups. One occurs either at the contact of the dolomites with the crytalline basement or into the dolomites and consists of basic tuffs and porphyritic andesites. The other occurs in the flysch and consists of serpentinized peridotites, diabases and spilitic diabases.

Regarding the origin of the middle — upper Triassic — lower Jurassic dolomites it is concluded that they are of syngenetic origin (Chilingar - Bissel - Fairbridge, 9) especially the type in which the calcitic material is sybstituted by dolomitic, simultaneously with its sedimentation.

2. INTRODUCTION

2. 1. Previous geological work in Skiathos.

The first information available about the geology of the island comes from A. PHILLIPSON (30), J. PAPASTAMATIOU - G. MARINOS (27, 28) F. FRECH (10), C. RENZ (31), C. KTENAS (17). All the above geologists have limited their work to the recording and to the description of the various rocks of the island, but noone has attempted to set the island in one of the internal isopic zones of Greece (See fig 4 Sketch map showing the isopic zones of the Hellenides and their structural relationships after Aubouin. 1,3).

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* FERENTINOS, G. C., 1972, Ph. D. Thesis, Patras University, Greece.

2 2. Main aim's of the author's research

The object of my study was to determine in which of the internal isopic zones of Greece the island of Skiathos lies. Therefore the island was investigated from stratigraphical, structural and magmatic aspects. The facies, phases, and the relative ages of the metamorphic and igneous rocks which occur on the island,as well as their inter - ıelationships were defined and determined. During the same mapping period the gradual dolomitization of a horizon of marble into dolomite was investigated. So by the comparison of the geological evolution of the island with the geological evolution of the isopic internal zones the island was located in the zone in which it might lie-

3. THE GEOLOGICAL STRUCTURE OF THE ISLAND OF SKIATHOS

3.1. Situation - Topography

The island of Skiathos is the western island of the N. Spoıades archipelago in Aegean sea. It is situaded between Thessaly and Euboea. The exact position of the island is latitude 39° 10', longitude 23°28'.

The island of .Skiathos is approximately 55 square kilometre in area, it is hilly and its highest hills Stavros and Karaphlitzanaki occur on the N.E. part of the island.

The morphology of the island is the result of its structure and the action of the external agents on its rocks and it is determined :

a.a. by a range of elongated hills. The axis ot these hills strike N — S and N.W. — S.E. and the created topography is in accordance with the general strike of the rocks.

b.b. by a series of narrow gorges and narrow valleys through which water runs to the sea. The narrow gorges flow E-W and the narrow valleys N-S. From the field work it was deduced that the origin of the narrow gorges is due to the continuous action of the running water on the other hand the narrow valleys are situated on fault lines and are of tectonic origin.

The ridge of the hills in the east part of the island consists of limestones intersected by dolinens.

Three of these dolinens are found at Kambies and they are of Karst origin. They are a result of the subsidence of the roofs of caves as infered from the breccia which can be seen along the sides of the dolinens.

3.2. Geology

3.2.1. Stratigraphy

The field work has shown that the island of Skiathos as well as the nearby island Mikros and Megalos Tzougrias, Marangos, Arkos, Tripiti, Aspronisos consist of metamorphic and igneous rocks. The rock sequence (in ascending order) is :

a. High grade metamorphic rocks (Crystalline basement) consisting of a series of schists, schistose gneiss and gneiss in which occur lenses of amphibolites and garnet mica schists.

b. Low grade metamorphic rocks (Mesozoic formation of the alpine cycle) consisting of

— Marbles — Dolomites with porphyritic andesites and basic tuffs of middle Triassic — lower Jurassic
— Limestones with rudists of upper Cretaceous
— Flysch associated with basic eruptive rocks

The crystalline basement of the island consists of alternating beds of schists, schistose - gneiss and gneiss forming parallel bands. From this observation that is, the frequency of variation from one to another, as well as from their mineral constituents and their chemical composition we conclude that this crystalline basement derives from the matamorphism of sediments whose facies and chemical composition varied horizontally and vertically during sedimentation.

Considering the age of the crystalline basement which is closely accossiated with the problem of the age of the Pelagonian massif the present work has not shed any further light, because during the field work no fossils were found. Nevertheless we can accept that the age of the crystalline basement must be Pre-triassic because it is covered transgressively by Triassic dolomites.

Indeeed G. MARINOS (19, 20) in his geological studies on E. Orthry and N. Euboea concluded that Permian rocks, either sedimentary, or fossiliferous metamorphic beds occur within the Pelagonian massif.

The crystalline basement of the island of Skiathos is covered by Mesozoic formations which have ubdergone low grade mataporphism and they consist of the following strata (in ascending order) :

a. Marbles - Dolomites of middle Triassic - lower Jurassic

During the field work fossils not found, however J. PAPASTAMATIOY - G. MARINOS (27, 28) have found megalodon in the nearby island of Skopelos lying east of Skiathos. The above geologists assume that these two dolomites are the same and so determined the age of the dolomites as middle Triassic - lower Jurassic.

The system of marble - dolomite, ranges from white to gray in colour and is severely fractured. Dolomites break in rhombohedra by hammering and through weathering gives red or brown soil. The lower beds of the sequence consist of marbles and the upper beds of dolomites. The transition from marbles to dolomites in some places is gradual, in others sharp. Sometimes the marble is not seen and the metamorphic basement is covered directly by dolomites.

The system of marbles - dolomites is covered unconformably either by upper Cretaceous limestones or by sedimentary clastic formation of flysch phase. This system occurs mainly in the following localities : In the hill (h. 117 m.) west of the hill Aghios Phanourios (See fig. 1), in Akra Plakes (See fig. 2) in Bourtzi, in Playa in Katavothra, and in Kechries.

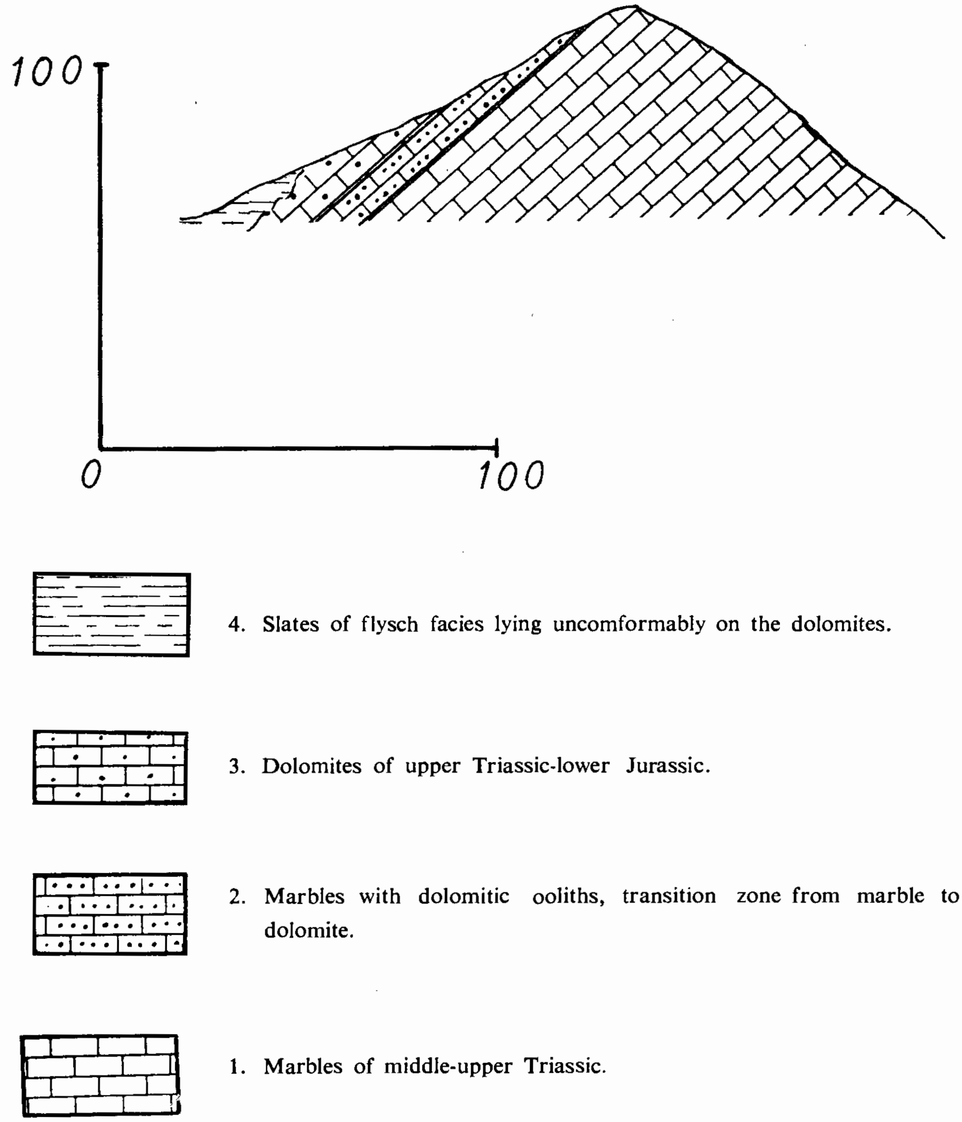


Fig. 1. Section through the hill (height 117) west of Aghios Phanourios.

From the observations at the above exposures it can be concluded :

— The contact between the crystalline basement and Triassic dolomites is not of tectonic origin. The absence of mylonite and the gentle dip of the contact surface reject the possibility of a thrust or fault contact.

— Lack of characteristic geological evidence, that indicates transgression, for instance basal conglomerate or different strike of the beds on opposite sides.

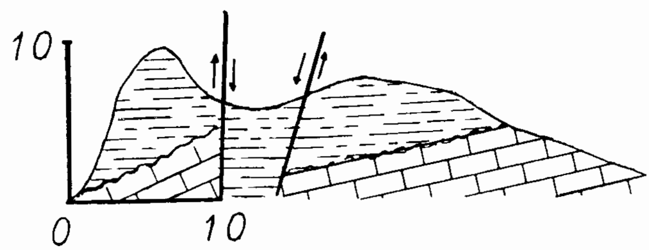
— Criteria that indicate transgression are :

i. Dolomites rest upon a surface of undulating relief carved in the metamorphic basement.

ii. Dolomites rest upon the different members of the crystalline basement in different places.

iii. The abrupt contact between the crystalline basement and dolomites which pass into marbles in the deeper parts.

b. Upper Cretaceous limestones. The Playa hill consists of limestones which in some localities lying transgressively on the metamorphic basement because of



States of flysch facies lying unconformably on the marbles with fold axis striking E-W and dipping 20° to the west.

Marbles of middle-upper Triassic age striking N-S and dipping E-W.

Fig. 2. Section through the Akra - Plakes.

the entire erosion of dolomites and in other localities lying transgressively on the dolomites.

The limestones are well bedded. At the bottom of the sequence it is thin-bedded and gradually becomes tabular. Towards the west side of the summit it becomes unbedded with hippurites. It is a rudist reef facies.

c. Flysch

Flysch occupies the mazor part of the east side of the island. It is composed of sedimentary clastic formations. These clastic formations consist of two different petrographical types.

— Argillaceous slates with limestones lenses and psammitic banks.

— Alternate layers of gray to black limestones, marly limestones, psammites and banks of marbles and phyllites.

The first type of these clastic formations is more extended and in some places passes gradually into limestone lenses because of the gradual change of the phase vertically and horizontally.

These limestones lenses are thin-bedded, the beds average 5-7 m.m. in thickness and they consist of calcite, quartz, talc and other green minerals. Except for

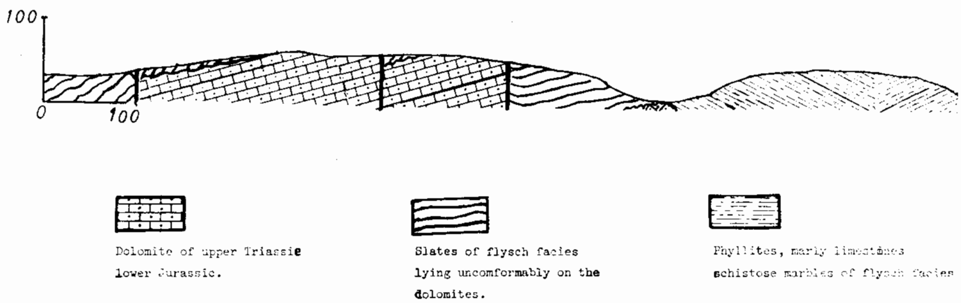


Fig. 3. Peninsula Marangos. Section trending N.NE - S.SW.

these lenses, igneous bodies (diabases, peridotites spilites) with chert occur in the slates. These igneous bodies constitute an ophiolitic group which with the argillaceous slates, compose a geological unity as it is suggested from their geological appearance that is the diabase (dolerite) and the peridotites occur between the slates as sills and lenses, the cherts and the spilites are well bedded and intercalated with the slates as well as poorly foliated and folded. Consequently we should be accepted that during the sedimentation of flysch flows of magmatic material took place.

The second type of these clastic formations has not the same extension and appears in the Marangos peninsula and in Akra Sozon. In Marangos (See fig 3) it is composed of alternate well - layered gray limestones, pale marly limestones, lime phyllites and banks of white schistose marbles. In Akra Sozon it is composed of pale marly limestones and alternate layers of blacky limestones and psammites.

The flysch either overlies the dolomites or the metaporphic basement but never comes in contact with the upper - Gretaceous limestones. Because of this appearance of the clastic formation, the absence of fossils and of the existence of the ophiolites ; the question therefore arises «are these formations flysch or schist of Jurasside age ; like the chert schists formation of Axios and Subpelagonian zones ?». Evidence from the area itself is not coclusive but such evidence as is available from the geology of the nearby regions : a The islandof Skopelos where the chert schist facies is entirely lacking and the Triassic dolomites are covered transgressively by upper Cretaceous limestones (J. PAPASTAMATIOU 26), b. The Mt Pelion where the chert schist is entirely lacking and the Triassic dolomites are covered transgressively by flysch with ophiolites (A. TATARIS 33) c. The assumption that it is not possible for the Cretaceous limestones to have been deposited where the Jurassic chert schist hac been eroded.

All these evidence strongly suggests that these clastic formations are flysch, the sedimentation of which started at the same time as the sedimentation of the upper Cretaceous limestones.

3. 2. 2. Structure

From the above it is deduced that the island of Skiathos is composed of two completely different units.

One consists of metamorphic rocks. The other consists of slightly metamorphosed alpine sediments. It is also concluded that in the structure of the island of Skiathos orogenic and epeirogenic movements were involved which affected the two geological units of the island.

Concerning the structure of the crystalline basement, which is the same as the structure of the Pelagonian massif, nothing could be added because of the absence of evidence of stratigraphical details, also preexisted tectonic pattern were redirected and destroyed by the alpine faulting and folding cycle which took place during the Tritogene. From G. MARINOS (19, 20) researches in Orthry, N. Euboea and Atalanti is pointed out that both the Hercynian and the Alpine folds affected the crystalline basement. Some big faults occuring in this area trending N - S, N.N.W. - S.S.E. and smaller ones trending E - W may be due to the post - alpine epirogenic movements because their directions coincide with the direction of those faults occuring in the younger unit.

Concerning the structure of the Alpine unit we have observed two transgressions and two breaks. The first transgression took place during the Triassic and dolomites were deposited on the crystalline basement. The exact time of this trangression is difficult to define in Skiathos because of the absence of fossils but from the researches of J. PAPASTAMATIOU (26, 27) G. MARINOS (19, 20, 21) C. RENZ (32), in the surrounding areas, it is decuded that the transgression started in the upper Triassic. The commencement of the second transgression started in the Senonien and limestones and flysch were deposited on the upper Triassic - lower Jurassic dolomites.

The first break began in the middle Jurassic as is suggested from the absence of upper Jurassic and lower Createceous. The exact time of the second uplift and the beginning of the prolonged erosion until now could not be determined because of the absence of fossils in the upper layers of flysch. But the lack of Miocene, Pliocene and Pleistocene strata proved that it took place not later than Oligocene.

The eastern part of the island is the limb of an anticline whose axis strikes N.W. - S.E. This limb is complicated by minor folding and forms an anticlinorium.

The faults which occur in the eastern part of the island are divided into two sets. The one set trending E - W and the other is oriented in a N. NW - S. SE, N - S aud N. NE - S.SW direction. It is not possible to determine the age of these faults because of the lack of evidence. But it is believed that they belong to the set of faults which were involved in the formation of the Aegean Sea during the Pliocene and Pleistocene. Along these faults with the help of erosion were formed valleys. Three of these valleys running in a N - S, N. NE - S. SW direction devided the island in three parts. In these valleys during the holocene the sea came in and formed lagoons. Remnants of these lagoon after the regression of the sea are the Strofillia and Limni.

3. 2. 3. Magmatism and Volcanism

The geology and the tectonics of a region are closely connected with its magmatism.

After the detei mination of the facies and the age of the different horizons, the horizons will be connected with the igneous bodies which occur within them. Regarding the structural appearance of the igneous rocks of the island these are divided into two main groups.

The first group consists of dykes and sills which sometimes cut accross the dolomites and the metamorphic rocks, and some times lie between the dolomites and the crystalline basement. They are composed of basic tuffs (which have been laterilized and are purple in colour) and of basic porphyritic, andesites. Characteristic of the basic tuffs is the sericitization of the feldspars, and for the porphyritic andesites the decomposition of the hornblende in quartz, chlorite and magnetite (Fe_3O_4).

From their appearance and from their mineralogical and textural features it is deduced that in the beggining of the upper Triassic trangression slight volcanic activity occured in a shallow shef sea environment. J. PAPASTAMATIOY and G. MARINOS (27) have noticed volcanic activity of the same type in the nearby island of Skopelos. Volcanic activity of this age is unusual in Greece but it is more usual in Yugoslavia CIRIC - CARAMATA (8).

The second group is an ophiolitic complex with chert, which consists of peridotites, diabases (dolerites) and spilites. This together with the clastic formations constitute the flysch facies, as has already been said. Consequently we shoul daccept that the eruption of this magmatic material took place from Senonian to Paleocene(;) when the first folding began. Therefore regarding the time of the evolution of the geosyncline, this ophiolitic complex is classified in syntectonic magmatic activity, (J. AUBOUIN 1).

3.3. Rewiew of the Greek isopic internal zones and discussion of the position of Skiathos in these zones.

The island of Skiathos, as has already been said consists of two geological units. One occupies the western part of the island and belongs to the Pelagonian massif, because of the features of the rocks of which it is composed. The other occupies the eastern part of the island and consists of Alpine sediments.

As it is shown in fig 4 the eastern part of the island could lie in one of the following isopic zones.

1. Vardar* (Axios zones)	—	furrow
a. Almopian zone	—	furrow
b. Paicon zone	—	ridge
c. Peonian zone	—	furrow
2. Pelagonian zone	—	ridge
3. Sub-pelagonian zone	—	Correspond to the external southehwestern margin of the Pelagonian ridge.

By comparing the already known geological evolution of Skiathos with the geological evolution of these zones and by accepting as characteristic of each zones the following features :

1. The upper Triassic transgression over the metamorphic basement in the Sub - Pelagonian zone and in the Central Euboean saddle of the Pelagonian zone (AUBOUIN, J. - GUERNET, C. 2; AUBOUIN, J. BRUNN, J. et al 3; GUERNET, C. 11, 12; MARINOS, G. 19, 20, 21).

2. The homogeneity and the continuity of sedimentation of dolomites from middle Triassic to upper Jurassic (Kimmeridgian) in the Sub - Pelagonian zone and in the Central Euboean saddle (AUBOUIN, J. GUERNET, C. 2; GUERNET, C. 11, 12; COUMANTAKIS, J. 15, 16; MARINOS, G. 19, 20, 21; PAPASTAMATIOU, J. 26).

3. The upper Cretaceous transgression occured during the Cenomanian in the Central Euboean saddle, and during the Santonian - lower Kampanian transition. in Kassidiaris, W. Orthy, and during Campanian in Elatia of Locris of Sub - Pelagonian zone (AUBOUIN, J. BRUNN, J et al. 3).

4. The commencement of flysch sedimentation began during the Maastrichtian in the Vardar, Pelagonian and sub - pelagonian zone, but began earlier, and simultaneously with the sedimentation of limestones, in the east Orthry (G. MARINOS 19, 20, 21).

5. The metamorphic basement unconformably is overlying by upper Cretace-

* Vardar zone was defined by Kosmat (1924), it was divided by Mercier (23) into three completely independent zones (See Fig. 5). Mercier's definition is followed in this work.

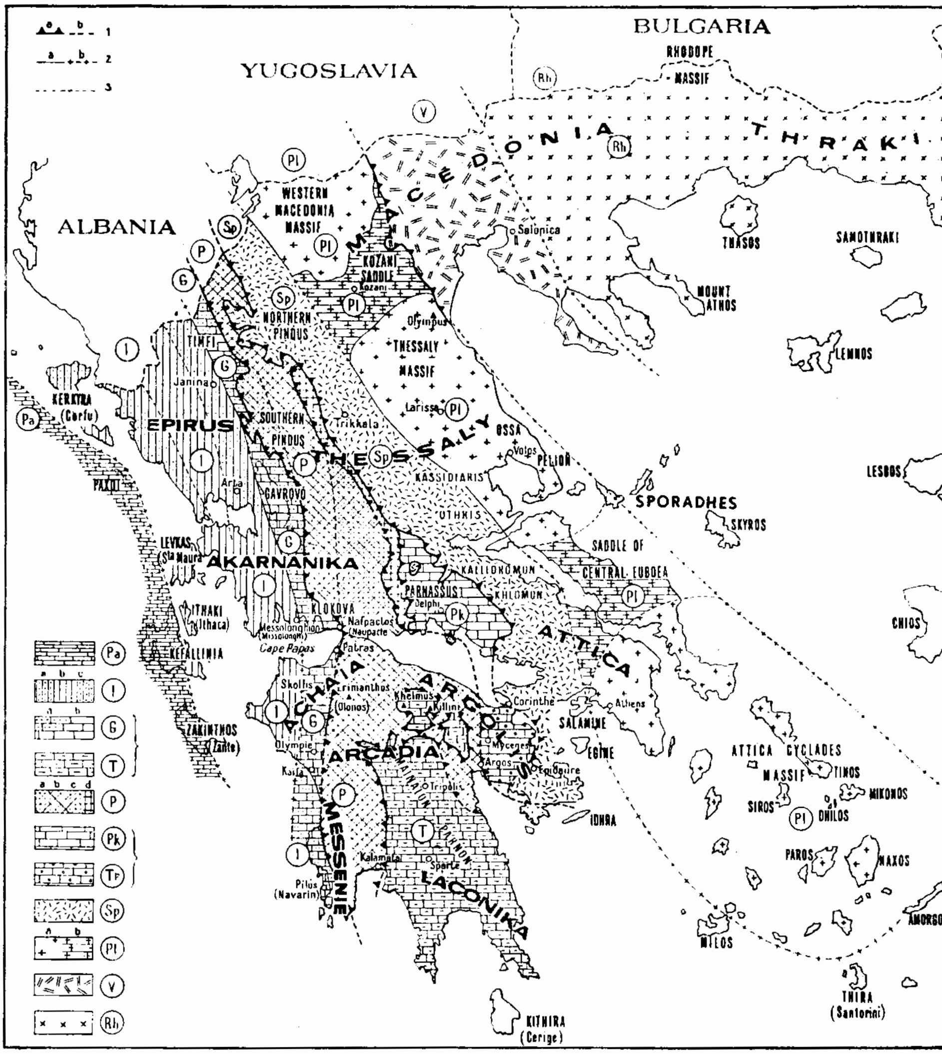


Fig. 4. Schetch-map showing the izopic zones of the Hellenides and their stractural relationship (after Aubouin et al 1963)

Pa	= pre Apulian zone
I	= Ionian zone
G-T	= Gavrovo zone and Tripolitza zone
P	= Pindus zone
PK-Tk	= Parnassus zone and Trapezona zone
Sp	= sub-Pelagonian zone
Pl	= Pelagonian zone a = basement b = sedimentary cover
V	= Vardar zone
Rh	= Rhodope zone

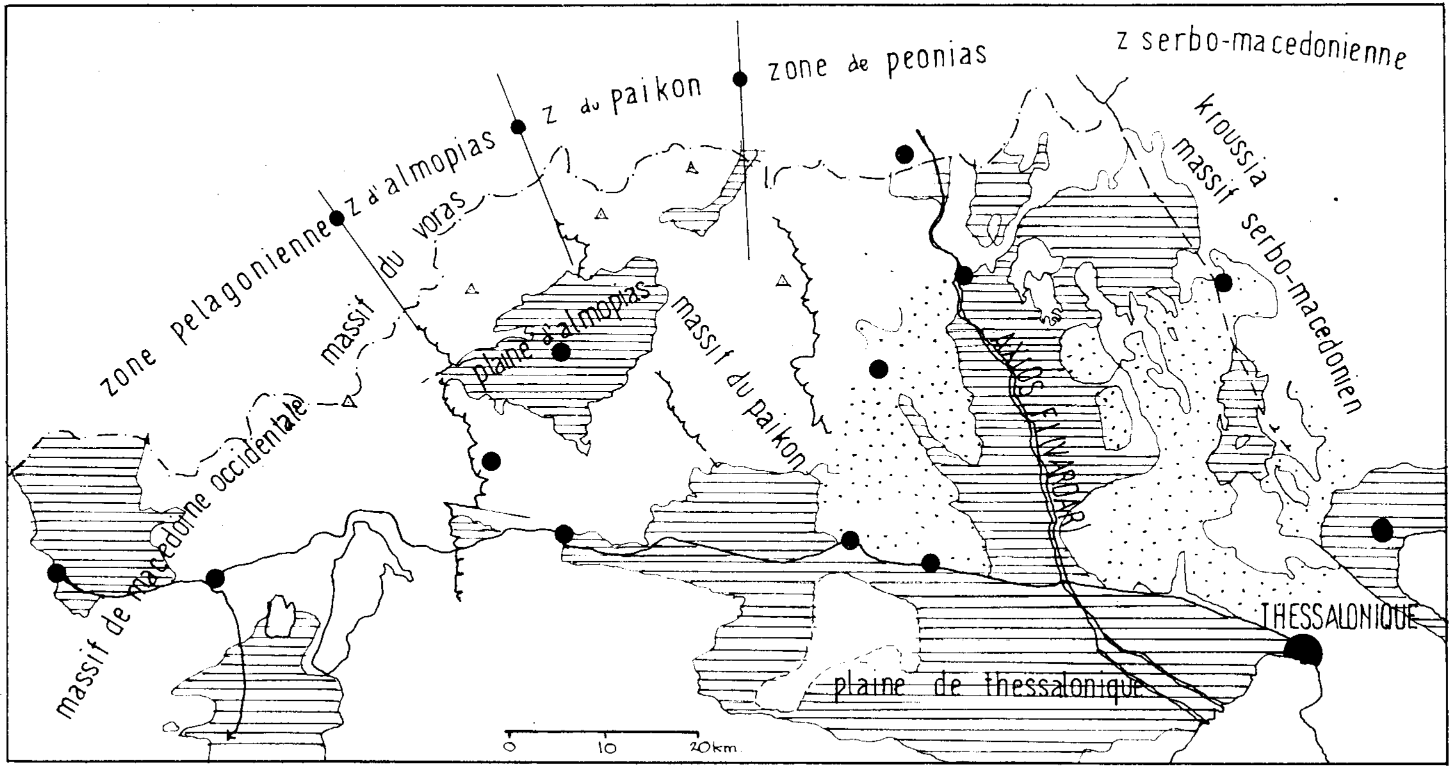


Fig. 5. Schetch-map showing the structural relationships of the three independent zones Vardar zone consist (after Mercier) of:
a. Peonian zone and pre - Peonian subzonc b. **Paicon** zone c. Almopias zone

ous limestones only in the Pelagonian zone (GODFRIAUX , I. 13, 14, MERCIER, J. 22, 23).

We conclude that the eastern part of Skiathos lies on the east slope of the Pelagonian zone and more accurarely in the Central Euboean Saddle.

4. PETROLOGY

4.1. Petrography

The study of the selected material took place in the laboratory of Geology at the Patras University under the supervision of its director Prof. Dr. ATHANASIOS PANAGOS as well as in the laboratory of Applied and Economical - Geology of Technical University of Athens where the hand samples and the thin sections are retained.

A comprehensive selection of all the rock types and their variations throughout the area was collected for sectioning. The thin sections were studied under the microscope and also under the universal stage for the more accurate determination of the minerals.

For accuracy and clarity as well as convenience of discussion a distinction is made between the rocks of Skiathos on basis of their origin.

Thus the rocks of Skiathos are classified as :

1. Metamorphic
2. Igneous.

4.1.1. Metamorphic Rocks

The present classification of the metamorphic rocks is based on their quantitative mineralogical composition as well on their texture.

The rocks of the island of Skiathos are classified by their texture into :

slates : fine grained rocks with perfect planar foliation (slaty cleavage). They are products of low grade regional metamorphism and are derived from pelits, clay shales, quartz psammites and other clastic formations.

Phyllites : fine grained and very finely schistose rocks. The grain size is finer than schists. The cleavage surfaces show a lustrous sheen due to mica, sericite and chlorite which with quartz constitute the main mineral constituents.

Schists : Strongly foliated and commonly lineated rocks, with a 20% maximum amount of feldspar. The individual mineral grains can be recognised megascopically. They arə a typical product of medium to high grade regional metamorphism.

Gneiss : Coarse discontinuously banded quartzofeldspathic rocks with ill - defined foliation they are products of high grade regional metamorphism.

Marbles : Metamorphic rocks consisting predominantly of fine to coarse grained calcite and or dolomite.

It is generally accepted that the above rock types are formed under wide limits of pressure and temperature. For every defined range of pressure and temperature each group according to its chemical composition consists of mineralogical assemblages acorresponding to a metamorphic facies.

The concept of Metamorphic facies was by ESCOLA (35). In 1939 he formulated the following definition «A certain metamorphic facies comprises all rocks exhibiting a unique and characteristic correlation between chemical and mineralogical composition, in such a way that rocks of a given chemical compositon have always the same mineralogical composition and differences in chemical composition from rock to rock are reflected in systematic differences of their mineralogical composition».

F. TURNER (34) gave the following definition «A metamorphic facies includes rocks of any chemical composition and hence of widely varying mineralogical composition, which have reached chemical equilibrium during metamorphism under a particular set of physical conditions» and in 1960 he gave with Verhoogen the most comprehensive account of facies See TURNER, F. - VERHOOGEN, (34).

In 1961 MIYASHIRO (35) introduced the concept of metamorphic facies series and noted that each individual metamorphic area is characterised by a definite facies series.

In 1967 H. WINKLER (35) gave another tabulation of metamorphic facies.

a. Rocks of high grade metamophism

The western part of Skiathos is composed, as has already been said, of high grade metamorphic rocks which consist of schists, schistose gneiss and gneiss with lenses of amphibolites and garnet - mica schists.

These rocks are brownish to brown - reddish and greenish in colour. This colour is due not only to their mineralogical composition but also to their alteration.

These rocks mainly consist of the following minerals :

Quartz : It forms the major constituent in all the petrographical types except for the garnet mica schists.

Muscovite : It occurs in the same proportion as quartz and it is the predominant micaceous mineral.

Biotite : It is commonly interleaved with muscovite but because of its instability there is in a lesser amount than muscovite.

Feldspars : They consist of microclines and plagioclases which generally varies from oligoclase to andesine. The An content in Plagioclase was determined by U Stage methods, by the symmetrical extinction methods and by the maximum extinction angle in section vertical to the plane (010).

Cordierite-: It is the only one of the exclusively metamorphic silicates which is found in all the petrographical types.

Garnets : They are of almandine composition.

Amphiboles : They consist of the green hornblende and occur only in the amphibolites and the hornblende - schists.

The geological appearance of the system schists, schistose gneiss and gneiss that is, the frequency and the small size of the textural and mineralogical variants as well as the inter - relationship made recording the formation difficult in a map 1 : 50.000, so the system has not been separately mapped and could only be distinguished regarding the local distribution of the following rock types.

M u s c o v i t e s c h i s t s. Those studied consist of the mineral assemblage Quartz - muscovite - biotite - cordierite - garnet - chlorite. The rocks - occur on the north end of the inlet of Aghia Heleni along the shore. The rocks are foliated lepidoblastic to medium (grained) granoblastic. They are brownish and sometimes, greenish because of the existence of chlorite. Chlorite occurs as disoriented flakes which shows its secondary derivation from biotite. It is of Penninite composition. Cordierite occurs in large amounts between the crystals of quartz.Characteristic is the smooth interlocking contact between its crystals and quartz crystals. It was formed through the reaction of Muscovite + Chlorite + Quartz $\rightarrow$ cordierite + biotite + H_2O as is pointed out from the absence of K - Feldspars.

Garnet occurs in small irregular grains. It is well fractured and the fractures are filled by penninite and quartz. It is of almandine composition as is deduced from the refractive index $N = 1.83$ and its brown colour (macroscopically) and flesh colour (microscopically).

H o r n b l e n d e s c h i s t s . Those studied consist of the mineral assemblage green hornblende — plagioclase — quartz — muscovite — biotite — clinozoisite. The rocks occur in the path between Aghios Antonios and 100 m. to the east of Panagia Kounistra. The rocks with a foliated texture are greenish in colour. Amphiboles are represented by green hornblende.

Feldspars occur either as medium grained crystals or as aggregates of very much smaller crystals. The An content is from 10% to 25%. They are filled with crystalline inclusions of clinozoisite and flakes of white mica.

M i c a c o r d i e r i t e s c h i s t s. Those studied consist of the mineral assemblage, quartz — cordierite — muscovite — biotite — plagioclase — clinozoisite — epidote — garnet. The rocks appear as a dark brownish layer between the schistose gneiss. The layer averages 1 to 1.5 m in thickness. Under the microscope the rocks show mineral banding with alternating bands of quartz — cordierite and muscovite — biotite. As accessory minerals in these bands occur some plagioclase clinozoisite, epidote and garnet.

T r e m o l i t e t a l c s c h i s t. Those studied consist of the mineral assemblage tremolite - talk. The rock occurs as a lenticle on the schistose gneiss of the Kalamaki peninsula and on the side of the road which leads to Kanapitza. It is brown - greenish in colour, well foliated and with a soapy feeling. Under the microscope it shows a nematoblastic texture.

G n e i s s. Those studied consist of the mineral assemblages : (a) feldspar-quartz — muscovite — biotite — epidote — clinozoisite and garnet. (b) quartz oligoclase — muscovite — cordierite. The rocks are massive and occupy a large part of the system schists — schistose gneiss and gneiss. They are dark beige, greenbeige, brown and green in colour due to the Kaolinitization of the feldspars, the chloritization of the biotite and the forming of Fe - oxides. It is granoblastic in texture.

Feldspars consist of microclines, perthites, and plagioclases. The plagioclases are oligoclases in composition.

Biotite usually represented by bontanite. Bontanite is a biotite rich in T_1O_2. During bontanites decomposition the T_1O_2 settled along the pinacoid of biotite as long accicular crystals of rutile forming equilateral triangle.

Along the fault — line zones of the island as along the road from Skiathos to Koukounaries, from Koukounaries to Mandraki and from Troulos to Aselinos Augen gneiss occur. These rocks are greenish in colour and they consist of poprhyroblasts of feldspas which in some places are up to 3 or 4 cm. in diameter, quartz and small well bent flakes of muscovite. Weathered surfaces exposed on hillsides are roughly pitted due to different weathering of their mineralogical constituents. The feldspars consist of microclines, perthites and oligoclases. The size of feldspar porphyroblasts as well as the fact that the porphyroblasts are fractured indicated that movement of alkalis took place along the fractures.

G a r n e t - m i c a s c h i s t. Those studied consist of the mineral assemblage : muscovite — biotite — chlorite — garnet — quartz. The garnetiferous rocks occur on the Mandraki inlet, on the Karavotrakisma half a kilometre to the east of Lake Strofilia, which compose the top of the hill (100 m) and on other places. They are always surrounded by a thin layer which is silverishreddish in colour and which consists of muscovite - biotite (which is altered in penninite) and rarely by a few crystals of garnet. They are compact, well foliated and spotted by large brown crystals of garnets (up to 1,5 cm).

Muscovite occurs as anhedral crystals and flakes in aggregates, it is well oriented. Along the cleavage surfaces the flakes are brown in colour due to the occurence of hydrous iron oxides.

Biotite occurs in small amounts because of its instability. The alteration of biotite is so extensive that it does not occur in some thin sections. Garnets occur as porphyroblasts 5 - 10 mm in diameter, they are fractured and the cracks are filled by quartz and chlorite. They are almandine in composition as is seen by its refractive index and its flesh colour under the microscope.

Chlorite comes from the alteration of biotite and occurs in large disoriented flakes. It is penninite in composition.

The absence of the feldspars, the occurence of quartz in small amounts and sometimes its absence gave rise to a lot of questions about the origin of this rock. But the rest of its mineralogical composition in connection with its chemical composition suggests that it came from a sediment rich in Al_2O_3, K_2O and poor in S_iO_2 which was metamorphosed under the condition of Amphibolite - Cordierite facies.

Amphibolites. Those studied consist of the mineral assemblage : green hornblende - feldspars (plagioclase) — cordierite — quartz — biotite — muscovite — clinozoisite magnetite.

This rock occurs at Styles. It is greenish in colour, without foliation because of the small amounts of the micaceous minerals and the slight orientation of the amphiboles crystals.

b. Rocks of low grade metamorphism.

These rocks occur in the eastern part of the island and consist of marbles - dolomites, slates, phyllites and calc - silicate marbles.

Marbles and dolomites. This system occurs on Akra Plakes, Bourtzi, Aghios Phanourios, on the slopes of Playa and on the hill (height 117 m) west of Aghios Phanourios. The lower layers of the system consist completely of marbles. They are either foliated and their foliation is parallel with their bedding, or massif and thick tabulated. They are white to greyish in colour.

Under the microscope they are thin grained and granoblastic in texture. The crystal of calcite are anhedral in constrast to the dolomite crystals in the dolomites, which are subhedral. Their size is 0.0025 to 0.0037 mm. The crystals exhibit the rhombohedral cleavage but neither undulose extinction nor multitwinning is exhibited. In the upper layers of the marbles occur dolomitic coliths which range in size from 0.3 to 1.0 cm. in diameter. They are white and milky in colour. The ooliths have a remnant of calcite in the centre, they have scratches which show movements in the bottom of shallow sea water. They are well bedded and the cement material is calcitic. In the upper layers dolomitic ooliths increase more and more and finally the calcite marbles pass into dolomites.

In the thin sections which were studied neither the marble layers nor the dolomite layers appear to contain periclase, brucite or $Mg\ SO_4$. It is known that periclase is formed through the high grade metamorphism of the dolomites and $MgCO_4$ is formed during the dedolomotization through the reaction $CaCO_3\ MgCO_3 + CaSO_4 \rightarrow 2CaCO_3 + MgSO_4$.

From the absence of brucite and periclase it is deduced that (1) the marbles metamorphosed under conditions of low grade metamorphism, this agrees with the small size of the calcite crystals. (2) the marbles were not formed from the metamorphism of dolomites but from the metamorphism of limestones.

The absence of $MgSO_4$ rejects also the case, which the system consisting only of dolomites and the marbles were formed by the dedolomitization of the lower strata of the system and the formation of limestones in the beginning, and afterwards by the metamorphism of limestones to marbles.

Due to the scratches of the dolomitic ooliths and to the existence of calcite remnants in the centre of the ooliths to the fact that the ooliths are well bedded and that the cementing material is calcitic and also from the geological observation that dolomites occur closer to the coast than the limestones of the same age through which they pass into the open sea, it is deduced that the dolomites belong to the syngenetic dolomites after Chilingar, Bissel, Fairbridge (9) which were formed through the sedimentation of calcitic material and its simultaneous substitution by dolomite.

S l a t e s : Those studied consist of the mineral assemblage : quartz - sericitebiotite — muscovite — feldspars — hematite. These rocks are well foliated and their mineral content cannot be recognised megascopically. They are brownish, greyish - brown and brownish — black because of the organic material which is included in them.

At Stygeron, Myrties and Lechouni well metamorphosed beds of sandsone occur in the slates consisting of quartz — sericite — feldspars — muscovite. At Lechouni the quartz crystals are highly recrystallized and form porphyroblasts with undulose extinction and biaxal figure. From this fact which shows that the porphyroblasts come from the coalescence of smaller quartz crystals as well as from the fact that the porphyroblasts are disoriented and from the observation that this exposure occurs near a peridotite, we conclude that the peridotite affect a slight contant metamorphism to this bed of sandstone.

P h y l l i t e s. Those studied consist of the mineral assemblage sericite - quartz - calcite - limonite. They occur on Marangos and on Akra Sozon. They are thin grained and well foliated rocks. Under the micoscope the lepidoplastic texture was observed.

C a l c - s i l i c a t e m a r b l e s. Those studied consist of the mineral assemblages:

calcite — quartz.
calcite — quartz — albite — talc — Sericite
calcite — quartz — albite — talc — tremolite
calcite — talc — tremolite
calcite — quartz — cordierite — sericite and some crystals of muscovite — biotite.

They occur as small and large lenses in the shale mainly in Lalaria, Karaphlytzanaki and Prophiti Elias. They are white greyish greenish brown depending on their mineralogical composition.

They are thin bedded, the beds average 5 - 7 mm in thickness. Each bed consists mainly of calcite crystals with scattered anhedral crystals of quartz. Usually calcite is the most predominant of all the minerals but sometimes quartz forms elongated thin aggregates, which extend in layers along the bedding planes. Also along the bedding planes occur talc, chlorite, tremolite, cordierite and the opaque minerals hematite and coveline.

The calcite crystals are anhedral and of the same size as those occuring in the marbles - dolomites. In some localities where aggregates of green minerals predominate the calcite crystals are larger and in general the more the aggregates of the green minerals are found the larger the size of the calcite crystals is.

From the above it is concluded that the flysch sediments do not occur under their normal appearance. So the argillaceous sediments appear as slates, the marly sediments appear as phyllites, the sandstones as gneiss and the limestones as calcsilicate marbles.

The clastic formation of flysch consist of dedrital material which comes from the Pelagonian massif, except for the small flakes of the sericite which are formed in phyllites and slates and for the green minerals in calc - silicite marbles which are a product of regional metamorphism.

The changes are due to the mechanical causes during the folding, which took place immediately after the sedimentation of flysch.

The clastic formation of flysch was metamorphosed under conditions of the greenschist facies. The above conditions regarding the slates and the phyllites made only textural and structural changes in the rocks and not mineralogical changes because the grains of which the slates and the phyllites consist do not react under these conditions. Regarding the calcsilicate rocks except for the mineral orientation made also mineralogical changes. The formation of all these new minerals is explained if we accept that the quartzo - calcic sediments were either rich in Mg, Fe and Si or enriched during the passage of hydro - thermal solutions rich in Mg, Fe, Mn, Ca and coming from the ultrabasic magma.

4.1.2. Igneous rocks

a. Upper Triassic effusion.

As has already been said these effusions consist of pophyritis andesite and basic tuffs.

Porphyritic andesite occurs 250 m to the south of the Kechries monastery and near the path which leads from Aghios Antonios to the Kerhries monastery.

This porphyritic andesite consists of phenocrysts of hornblende, biotite and feldspar in a ground mass of quartz epidote and magnetite. Hornblende occurs in large crystals well altered.

The alteration products of the hornblende are chlorite, epidote, quartz and magnetite.

Biotite occurs in lesser amounts than hornblende and it is altered into chlorite and magnetite.

Feldspars seldom occur and they are altered into sericite. Magnetite perhaps is entirely of secondary origin but its partial primary origin, cannot be excluded.

Chlorite consists of prochlorite and penninite. Prochlorite comes from the alteration of hornblende and penninite comes from the alteration of the biotite.

Basic tuffs occur 500 m from Kechries in the path between Aghios Antonios and Kerchries. Also there is another outcrop near the first one 50 m to the north. These tuffs are very fine grained and reddish - mauve in colour because of the oxidation of their femic minerals. They consist of phenocrysts of fedspar and quartz.

The feldspars are completely altered to sericite. The grounmass consists of mainly well oriented sericite. Some crystals of magnetite which occur in the groundmass are probably of primary origin.

b. Syntectonic ophiolitic emission (ophiolite complex)

This ophiolite complex occurs in the northern part of the island and appears in the flysch. It is developed along an arc, which starts from the Limani of Nikotsara, passes by the Evagelistria, Krio Pigadi, Prophites Elias, Neos aghios Apostolos, Panagia Kardasi and ends in Akra Kastro.

The exposures are small in area and some of them do not differ from the surrounding rocks.

They consist of the following petrographical types :

Serpentinized peridotite.
Diabase (dolerite)
Spilitic diabase.

Serpentinized peridotites. Under this name three small exposures are included 10 to 15 m^2 in area. These exposures differ with regard to their mineralogical assemblege. They are complete serpentinised periodotites of which there are not any remnants of the primary ferromagnesian minerals, because of the decomposition of all the primary minerals the type of peridotite from which they are derived could not be determined. Attempts to determine the type of periodotites, from their textures also failed.

On the basis of their mineralogical assemblage the serpentinized peridotites are classified into the following types : (The names of these types are derived from the place in which they occur).

Sinodari types
Revma Lechouni type 1
Revma Lechouni type 2

Sinodary type. The rock is yellowish green in colour and is cut by a system of thin magnesite veins.

Under the microscope the main minerals are antigorite, serpophite and chrysotile and in lesser amounts magnetite, magnesite, talc and garnets.

Revma Lechouni type 1. The rock is whitish green in colour, is massif and hard because of its silification. Under the microscope the main minerals are garnets, serpentines and brucites.

Garnets are the main minerals and are different from the garnets which occur in the Sinodari type. They are pyrope in composition as it is determined by the refractive index 1.71 - 1.72 and are yellowish beige in colour. The crystals appear as an aggregate without crystal outlines. This mass is well corroded and its space is filled by large crystals of serpentine (Prehnite). Along the cleavage planes of the serpentine crystals small crystals of brucite are formed. This mass is also cut by a system of veins which are filled by large crystals of brucite and prehnite.

Prehnite occurs in large subhedral crystals either as veinlets or as platy grains filling the space between the garnet crystals.

Brucite occurs as plates with hexagonal outlines, sometimes filling the fractures of the rock and sometimes formed along the cleavage planes of prehnite.

Revma Lechouni type 2. The rock is deep green to greenish in colour. It is massif and hard because of its silification.

The main minerals are garnets (Pyrope in composition) serpentine and chlorite.

D i a b a s e. Northwest of the Sinodari fountain and in the path which leads to Lechouni a small sill occurs. It is massive, foliated and deep green to green in colour. The only mineral which is distinguished megascopically is epidote. Under the microscope the following minerals are determined : Amphiboles are either of primary origin and are formed during the cooling of the magma or of secondary origin and are formed during the metamorphism. The amphiboles of the primary origin occur in large crystals and consist. of the green hornblende. The amphiboles of secondary origin occur as oriented flakes and consist of actinolite.

Feldspars. They form a framework into which the amphibole crystals fit. Feldspars crystals are not determinable because of the decomposition. Quartz, epidotes and magnetite are of secondary origin and come from the decomposition of green hornblende.

S p i l i t i c D i a b a s e s : This rock occurs in Krio Pigadi, Pirgi Pharmakolyptras, in the path from Evagelistria to aghios Haralambos. They occur as well foliated and folded sills. It is difficult to distinguish them fro mthe surrounding slates.

Those studied consist of the mineralogical assemblage : feldspars-biotite-chlorite — actinolite — epidote and magnetite. Veinlets of calcite, biotite and quartz also occur.

Feldspars are the main mineral. Those studied show some remnant of their ophitic texture. The feldspars are albite in composition as is determined by the lack of polysynthetic twinning low refractive indices, less than that of the balsam and (+) 2V a 70 - 82. Biotite occurs either in thin flakes well oriented in the mass of the rocks, which are completely altered into chlorite, or appear in veinlets along the the cleavage of the rocks.

4 2. Petrochemistry

Six chemical analyses (See table 1) of the most characteristic petrographical types were made for the petrochemical study of the selected rocks.

TABLE 1.

	1(974)	2(629)	3(636)	4(985)	5(634)	6(787)
SiO_2	51.55	37.60	72.80	53.27	47.60	58.55
Al_2O_3	18.70	34.85	17.95	19.84	18.36	19.20
Fe_2O_3	3.20	3.55	1.17	3.22	10.64	2.55
FeO	6.70	7.10	0.43	6.20	1.90	1.43
MgO	5.53	3.65	1.16	4.78	6.10	4.82
MnO	0.023	0.17	0.016	0.01	0.14	0.03
CaO	9.20	0.25	0.22	6.62	8.80	2.18
Na_2O	1.24	0.62	0.99	1.74	0.96	1.90
K_2O	1.03	6.16	3.80	0.60	1.05	4.70
TiO_2	1.40	1.00	0.00	1.04	1.40	0.52
P_2O_5	—	—	—	—	—	—
SO_3	0.12	0.01	0.05	0.04	0.02	0.08
CO_2	0.01	0.03	0.01	—	0.02	—
H_2O	1.30	5.00	1.45	2.53	3.00	4.03
H_2O	—	—	—	—	—	—
TOTAL	99.98	99.99	99.94	99.84	99.99	99.94

1. Amphibolite
2. Garnet mica schist
3. Muscovite gneiss
4. Diabase
5. Porphyritic andesite
6. Basic tuff.

Three of the analysed samples belong to the high grade metamorphic rocks, one belongs to the syntectonic magmatic rocks, which were metamorphosed under a condition of low grade metamorphim and the two last belong to the upper Triassic - lower Jurassic effusion and metamorphosed under a condition of low grade metamorphism.

The aims of the chemical study were firstly, to determine the primary rocks from which the metamorphic rocks came and secondary to determined the physical conditions which have affected the primary rocks and have turned them into metamorphic rocks.

The study of the chemical analyses of the first three samples on the one hand, is based on the facies diagram, so the corresponding thin sections were studied by modal analyses, which were carried out with a Swift automatic point counter. On the other hand it is based on the petrochemical calculation by Niggli (BURRI, C. 5). The chemical study of the last three samples is based only on the petrochemical calculation after Niggli.

4. 2. 1. Petrogenesis and metamorphic facies Methods of representation

A correct graphical representation of a mineral paragenesis is possibly only if the number of components consisting the minerals does not exceed four, because only four components can be represented in space at the corners of a telrahedron. Nevertheless Eskola by means of suitable selection and restriction allows the representation of most rocks in a triangular representation. The first observation is «Silica must be present in excess (quatz is a constituent of many metamorphic rock then only those minerals with the highest possible SiO_2 content can be formed, consequently the amount of S_iO_2 has no influence on the mineral assemblage and need not to be represented graphically». The second is «The restriction of the elements by the creation of groups». So at the one corner of the triangle defined as A. that portion of Al_2O_3 is plotted (more exactly $Al_2O_3 + Fe_2O_3$ because F^{3+} and Al^{3+} can be substitute each other), which is not combined with Na and K. The second corner is defined as C = CaO and the third one as F = (Fe, Mg, Mn) 0.

Accessory constituents are disregarded in the graphical representation and so before calculating the A, C, F values the amounts of $(Al,Fe)_2O_3$, CaO and (Fe, Mg)0 contained in the accessories are substracted.

As a first approximation, the scheme for calculating the A, C, F ratios (after making the correction necessary on account of the accesories) may be summarized as follows :

$$A = [Al_2O_3] + [Fe_2O_3] - [Na_2O] + [K_2O]$$

$$C = [CaO] - 3{,}3\ [P_2O_5]$$

$$F = [MgO] + [MnO] + [FeO]$$

In this diagram the K, Na — silicates as well as the undersaturated minerals cannot be represented, so H. WINCLER suggests using also the A′ F K diagram. In this diagram C - Minerals are represented together with mineral containing (Mg^{1+}, Fe^{1+}) and (Al^{3+}, Fe^{3+}). In calculating the A′ F. K. values of a rock the analysis is corrected with respect to the accessories.

The general calculation scheme is :

$A = [Al_2O_3] + [Fe_2O_3] — [Na_2O] + [K_2O]$ — 1/3 of the [CaO] contained in grossularite/andradite),
— 3/4 of the [CaO] contained in the zoisite/epidote),
— the [CaO] contained in anorhite),
— twice the [CaO] contained in margarite).

$K = [K_2O]$

$F = [FeO] + [MgO] + [MnO]$

The above ratios are applied to the rocks of Skiathos as follows : Modal analysis number 1 (974)[1] Amphibolite.

The sample (974) consists of the following minerals and in the fol lowiehtwg percentages :

Hornblende	52 %
Quartz	18.4 %
Clinozoisite	11.2 %
Muscovite	8.1 %
Biotite	3.26%
Plagioclase	2.96%
Cordierite	1.82%
Hematite	2.26%

Therefore A, C, F and A′, F, K values are modified as follows:

a. A.C.F. diagram

$A = [Al_2O_3] + [Fe_2O_3] — [Na_2O] — 3 [K_2O] — [F_2O_3]$

oligoclase muscovite accessories

133 + 4 — 4 — 29 — 14 — = 140

$C = [CaO] = 164$

$F = [MgO] + [MnO] + [FeO] — ([MgO] + [FeO])$

biotite

134 + 9 + 43 — 7 — 6 = 224

These values were added and recalculated as a percentage of the total weight so we have A = 26.4% C = 30.9% F = 42.7%

1. The numbers in the parentheses correspind to the thin sections of the analysed rocks.

b. A, F K diagram

$A' = [Al_2O_3] + [Fe_2O_3] - [Na_2O] - 3[K_2O] - 3/4\,[CaO] - [Fe_2O_3] - [CaO]$

oligoclase muscovite clinozoisite anorhite

$183 + 4 - 4 - 29 - 36 - 14 - 6 = 98$

$K = [K_2O] = 18$

$F = [MgO] + [MnO] + [FeO] - ([FeO] + [MgO])$

Hornblende

$137 + O + 93 - (110 + 109) = 11$

and by the recalculation of these values in perentage we have A' = 77.2% K = 14.15% F = 8.65%.

Modal analysis number 2 (629) Garnet - mica schists.

The sample 629 consists of the following minerals and in the follow weight percentages :

a. Muscovite	48.5 %
b. Peninite	22.8 %
c. Quartz	11.5 %
d. Almandine	7.95%
e. Hematite — Ilmenite	8.2 % and 1,89 %

Therefore A, C, F and A', F, K values modified as follows.

a. A.C.F. diagram

$A = [Al_2O_3] - 3\,[K_2O]$

Muscovite

$341 - 3.66 = 143$

$C = [Cad] = 4$

$F = [MgO] + [MnO] + [FeO] - [FeO]$

ilmenite

$90 + 2 + 99 - 13 = 178$

and by the recalculation of these values in percentage we have A = 44% C = 1.2% F = 54.8%

b. A'.F.K. diagram

$A' = [Al_2O_3] - 3\,[K_2O]$

muscovite

$341 - 3.66 = 143$

$K = [K_2O] = 66$

$F = [MgO] + [MnO] + [FeO] - [FeO]$

ilmenite

and by the recalculation of these values in percentage we gave A' = 37% K = 17% F = 46%.

Modal analysis number 3 (636), Muscovite gneiss.

The sample 636 consists of the following minerals and in the follow weight percentages

a. Quartz	= 39.4 %
b. Oligoclase	= 9.93%
c. Muscovite	= 28.4 %
d. Cordierite	11.17%

Therefore A,C,F and A', F, K values modified as follows.

a. A.C.F. diagram

$$A = [Al_2O_3] + [Fe_2O_3] - [Na_2O] - 3\,[K_2O]$$

oligoclase muscovite

$$176 + 8 - 16 - 120 = 48$$

$$C = [CaO] = 4$$

$$F = [MgO] + [FeO] + [MnO]$$

$$28 + 4 + O = 32$$

and by the recalculation of these values in percentages we have A = 57.1% C = = 4.75% F = 38.15%.

b. A' F. K diagram

$$A' = [Al_2O_3] + [Fe_2O_3] - [Na_2O] - [CaO] - 3\,[K_2O]$$

oligoclase anorthite muscovite

$$176 + 8 - 16 - 4 - 120 = 44$$

$$K = [K_2O] = 40$$

$$F = [MgO] + [FeO] + [MnO]$$

$$28 + O + 4 = 32$$

and by the recalculation of these values in percentage we have A' = 37% K = 34.5% F = 24.6%.

The above calculated A, C, F and A', F, K values are plotted on the A.C.F. and A'.F.K. diagram (See fig 6) showing the chemical composition of various magmatic and sedimentary rock after H. WINKLER (35).

By means of the above A. C. F. and A.F.K. diagram it is deduced the following :

(a) The amphibolites 1 (1974) plots within the marls containing 35 - 65% carbonate and andesites - basalts common field, but the existence of the cordierite in the mineral assemblage of the the amphibolite reject the possibility of the igneous derivation.

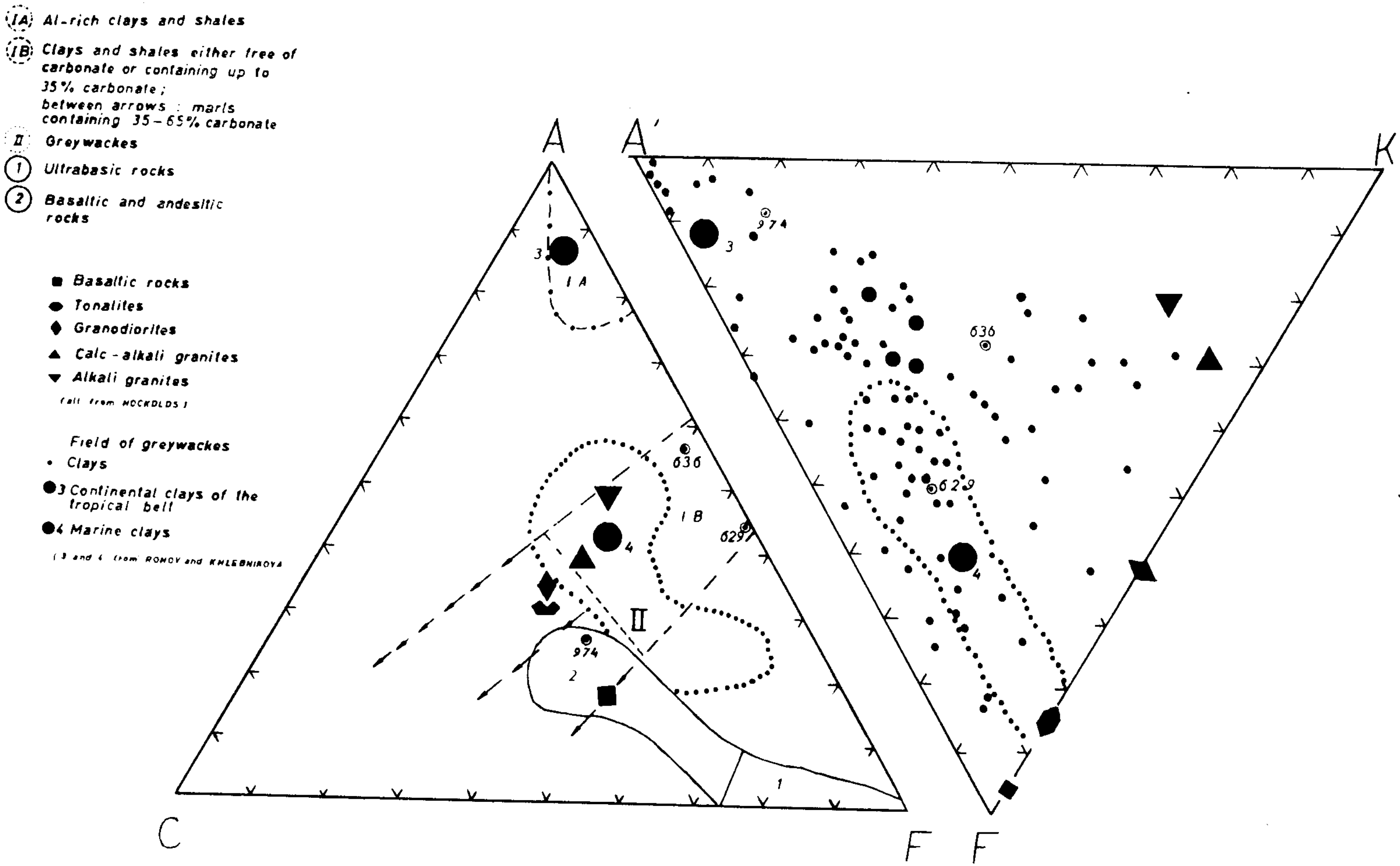


Fig. 6. The chemical composition of various magmatic and sedimentary rocks plotted on an A.C.F. and A'.F.K. diagram. After Winkler. The plots correspond to the following rocks of Skiathos:
1 (974) Amphibolite 2 (629) Garnet mica schist 3 (636) Museovite gneiss.

(b) The Garnet mica schists 2 (629) plots within the clays and shales free of carbonate or containing up to 36% carbonate field.

(c) The Muscovite gneiss 3 (636) plot within the clays and shales field but lies near the greywackes field.

When the above calculated A,C,F, and A′, F, K values were plotted against the A.C.F. and A′, F, K diagrams and by comparing them with the diagrams which have been constructed for most metamorphic facies and subfacies on the basis of

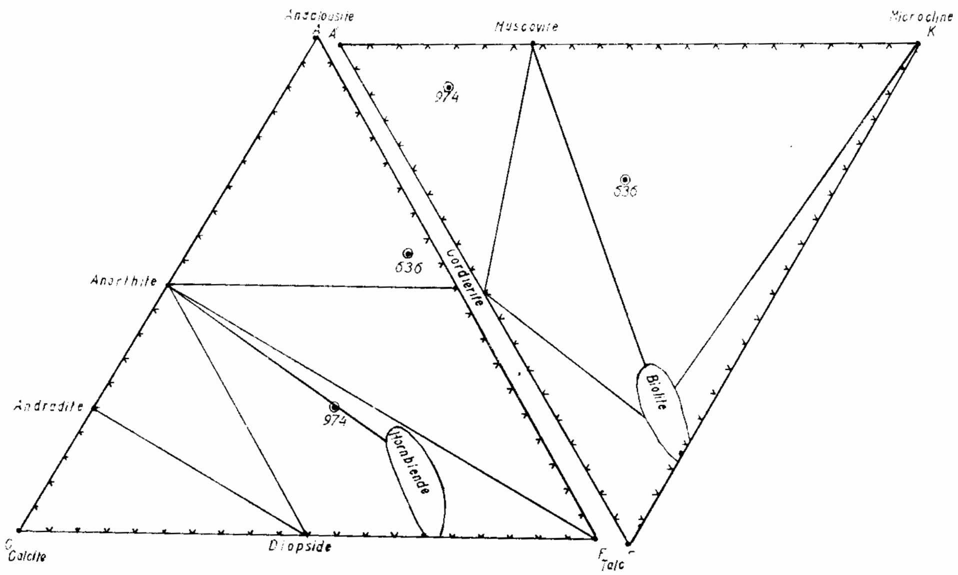


Fig. 7. Andalusite-cordierite-muscovite subfacies of the cordierite-amphibolite facies of Abu Kuma type metamorphism (WINKLER, H. 35)
3 (636) Gneiss 1 (974) Amphibolite.

petrographical observations. It is deduced that the observed mineral assemblages can be formed only if the primary rocks metamorphosed under the condition of the cordierite-amphibolite facies of Abukuma metamorphic series, WINKLER (35) and especially under the condition of the andalusite - cordierite - muscovite for the am phibolites and gneiss and the sillimanite - cordierite - muscovite - almandine subfacies for the Garnet - mica schists.

Some differences between the observed mineralogical composition and the expected one from the A.C.F. and A′.F.K. digrams are easily explained.

So in the amphibolities 1 (1974) the observed mineral assemblage is «Hornblende—plagioclase—cordierite—muscovite—biotite—clinozoisite — quartz and the expected one from the diagrams A.C.F. and A' F.K. (See fig. 7) is Hornblende — diopside — plagioclase cordierite — muscovite — andalusite — quartz. As regards biotite and clinozoisite the difference is due to the instability of the plagioclase and hornblendes which alter to biotite and clinozoisite. Regarding the diopside and andalusite the difference is explained if we observed that the plotted point in the A.C.F. diagram lies on the anorthite — hornblende line and so plagioclase and hornblende were formed instead of diopside, and the formation of andalusite is rejected. On the other hand the plotted point in the diagram A′ F.K. lies close to the andalusite and muscovite line, which indicates that andalusite and muscovite should

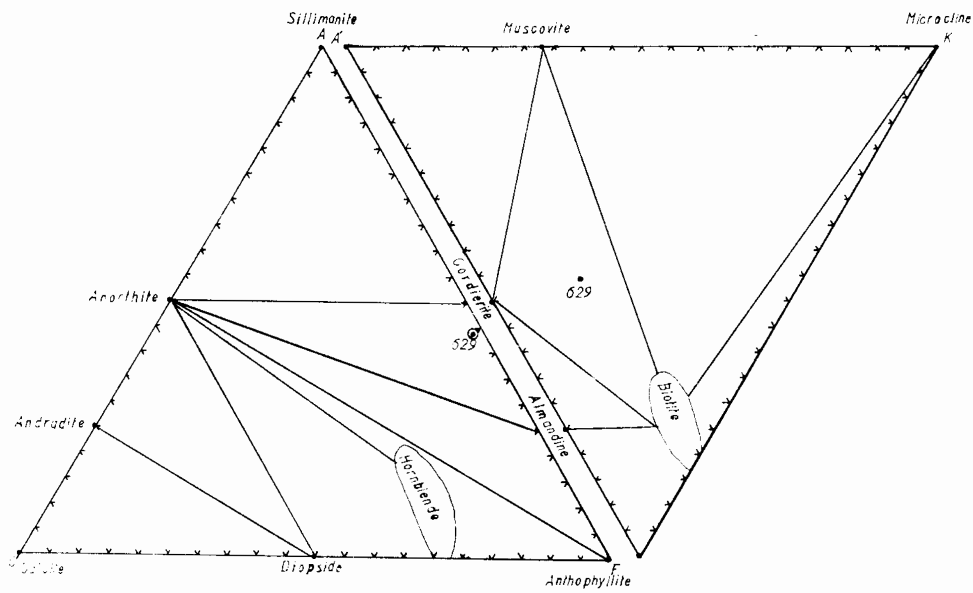


Fig. 8. Sillimanite-cordierite-muscovite-almandine- subfacies of the cordierite-amphibolite facies of Abu Kuma type metamorphism (WINKLER, H. 35)
2 (269) Garnet mica schist.

mainly have been formed and in a lesser amount cordierite, but because the parent sediment was an Mg - rich, cordierite was formed instead of andalusite.

In the muscovite - gneiss 3 (636) the observed mineral assemblage is «Plagiolase - cordierite - muscovite - quartz and the expected one from the A.C.F. and A′-F-K- diagram (See fig. 7) is Plagioclase-cordierite—muscovite — biotite — antalusite—K Feldspars— Quartz. The difference regarding the andalusite is explained if we observe that the plotted point in the diagram A.C.F. lies within the triangle andalusite — plagioclase — cordierite but close to the cordierite apex and in the line cordierite - plagioclase, so that the formation of andalusite is rejected. On the other hand in the diagram A′, F, K the plotted point lies on the line muscovite - biotite and closer to the muscovite so the only mineral which is formed is muscovite.

In the Garnet - mica - Schist 2 (629) the observed mineral assemblage is muscovite — penninite — almandine quartz and that which is expected from the A.C.F. and A′ F.K. diagrams (See Fig 8) is cordierite almandine — plagioclase — muscovite — biotite — quartz. The difference regarding penninite is due to the complete alteration of the biotite to penninite. The difference regarding the cordierite and the plagioclase is explained if we observe that the plotted point in the A.C.F. diagram lies on the line cordierite almandine which prohibits the formation of plagioclase. On the other hand in the diagram A′, F. K. the plotted point lies closer to the line muscovite — biotite and so muscovite biotite was formed instead of cordierite.

4. 2. 2. Petrochemical Calculation by Niggli

In order to confirm the origin of the metamorphic rocks more accurately and to determine the Normal magma to which the upper — Triassic extrusion and the syntectonic submarine flow belong, the Niggli numbers si, al, fm, c, alk, k, c/fm, $C + 2alk\ T = al - alk,\ y = \frac{Zalk}{Zalk + K}$ were estimated (see table 2).

TABLE 2.

Niggli's Numbers

	1(974)	2(629)	3(636)	4(985)	5(634)	6(787)
si	132.82	95.28	426.76	150.10	117.47	203.76
al	28.33	51.90	61.97	32.83	26.67	39.33
fm	41.79	35.90	16.91	41.62	46.07	35.77
c	25.39	0.60	1.41	19.97	23.26	7.95
alk	4.49	11.60	19.71	5.58	4.00	16.95
K			0.71			
c/fm	0.60	0.016	0.083	0.48	0.50	0.22
c + alk	29.88	12.2	21.12	25.55	27.26	24.90
T = al — alk	23.84	40.3	42.26	27.25	22.67	22.38
$y = \frac{2alk}{2alk + c}$			0.96			

1 (974) Amphibolite

2 (629) Garnet mica schist

3 (636) Muscovite gneiss

4 (985) Diabese

5 (634) Porphyritic andesite

6 (787) Basic tuff

Regarding the amphibolites 1 (974) it was observed (a) that the SiO_2 content is in the gabbrodiorites limits and it's CaO content is quite high — (b) Either the igneous or the sedimentary origin of the amphibolite is possible as it is shown from the diagram of fig. 9, 10, and 11.

Regarding the gneiss 3 (636) it was observed (a) That the SiO_2 content is very high (72%) and the Niggli Number si = 426.76 is particularly close to many of the

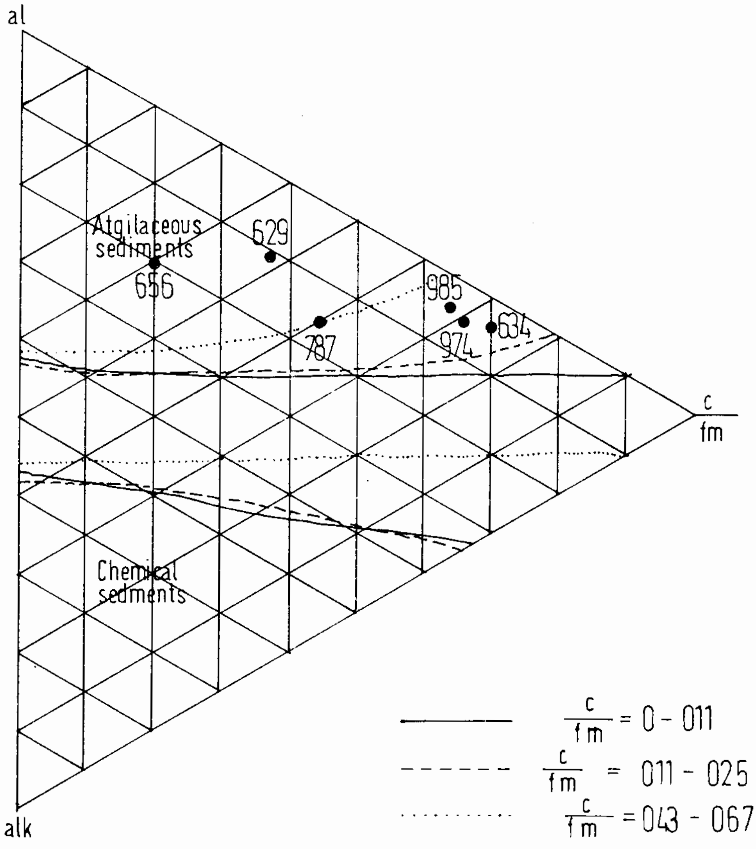


Fig. 9. Cross-sections I, II, IV of the al-fm-c-alk tetrahedron of Niggli system.

1 (974) Amphibolite
2 (629) Grnet mica schist
3 (636) Muscovite gneiss
4 (985) Diabase
5 (634) Porphyritic andesite
6 (787) Basic tuff.

corresponding numbers of the gneiss in the Pelion and Argiropoulion (GEORGIADIS, A. 6, 7; PANAGOS, A. 24; PAPASPYROU, S. 29) district. (b) the content in femic (Fe, Mg) and in CaO is very low. This agrees with the mineralogical composition of the gneiss with an adundance of leucocratic minerals and a lack of melanocratic minerals. (c) the sedimentary origin as is pointed out from the diagrams of the fig. 9, 10, 11. It is especially seen from the diagram of the fig. 9 that the gneiss come from sediments rich in Al and poor in Alk, from the diagram of the fig. 10 from sediments poor in CaO and from the diagram of the fig. 11 from sedients rich in Si.

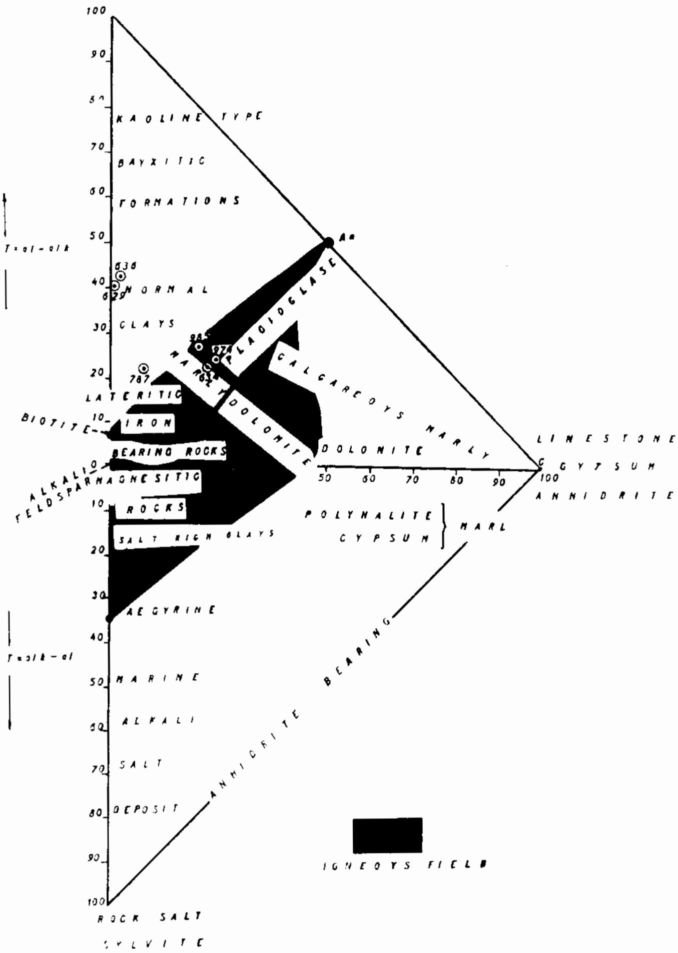


Fig. 10. Location of the igneous field and the main sedimentary rocks in the triangle + T — (—T) — c.

After P. Niggli, F. De Quervain and R. V. Winterhaltez.
The rocks correspond to the following rocks of Skiathos.

1 (974) Amphibolite	4 (985) Diabase
2 (629) Garnet mica schist	5 (634) Porphyritic andesite
3 (636) Muscovite gneiss	6 (787) Basic tuff.

Regarding the garnet mica schists 2 (629) characteristic is the low content in S_iO_2. These rocks come from sedimentary parent rock which is rich in al and poor in Si and Ca as pointed out from thediagram of the fig. 9, 10, 11.

Regarding the upper triassic extrusions and the syntectonic ophiolitic emission, it was observed :

a) from the diagram of fig. 12 that the diabase and the porphyritic andesite is alk poor and Ca normal, the basic tuff is alk and c poor.

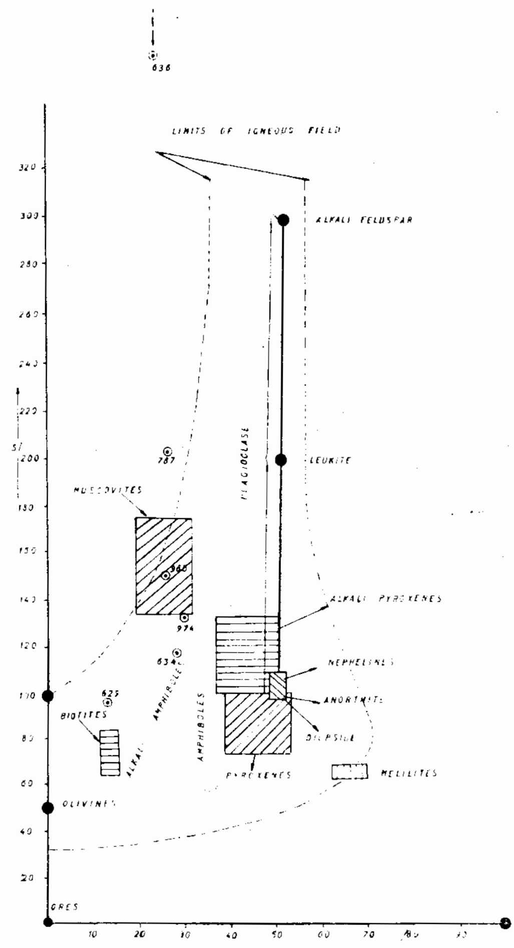


Fig. 11. Illustration of thc igneous field and the important rocks forming minerals in the si — (c + alk) diagram. After C. Burri and P. Niggli (1941).

The plots correspond to the following rocks of Skiathos :

1 (974) Amphibolite	4 (985) Diabase
2 (629) Garnet mica schist	5 (634) Porphyritic andesite
3 (636) Muscovite gneiss	6 (787) Basic tuff.

b) from the diagram of fig 13 the diabase and the porphyritic andesite are classified as to the semi - femic normal magma, the basic tuff is classified as to the Pera - femic normal magna.

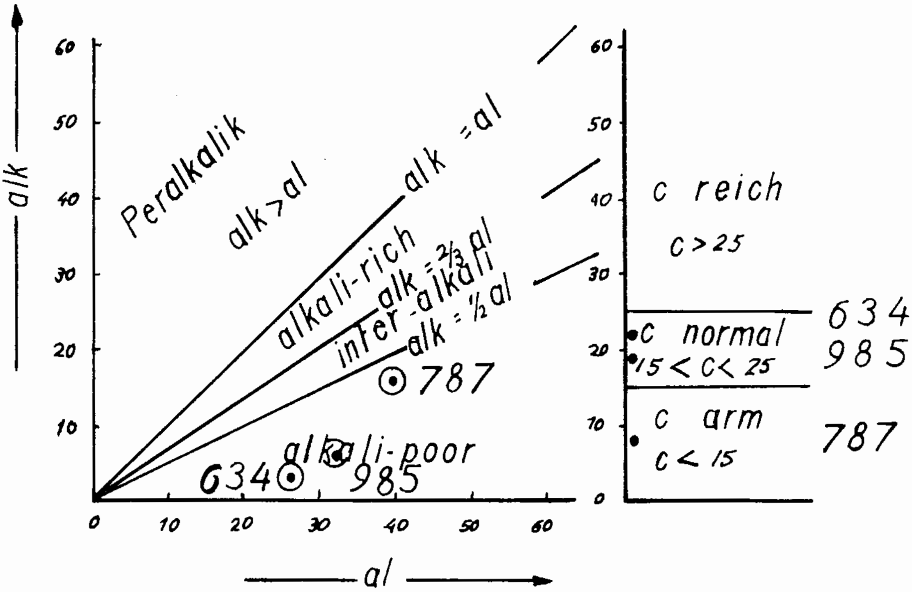


Fig. 12. Classification principles of Magma's after C. Burri and P. Niggli (1945).
The plots correspond to the following rocks of Skiathos.
4 (985) Diabase 4 (634) Porphyritic andesite 6 (787) Basic tuff.

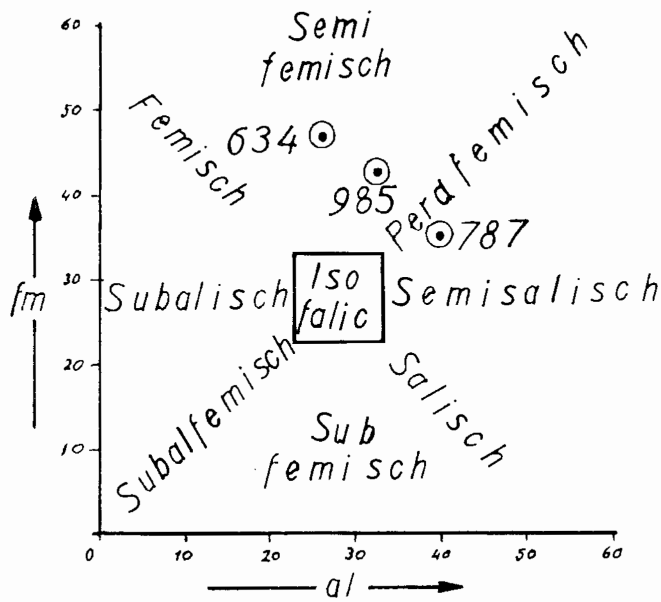


Fig. 13. Classification principles of magmas. After C. Burri and P. Niggli (1945).
The plots correspond to the following rocks of Skiathos :
4 (985) Diabase 5 (634) Porphyritic andesite 6 (787) Basic tuff.

ΠΕΡΙΛΗΨΙΣ

Τὰ ἐκ τῆς διεξαχθείσης γεωλογικῆς καὶ πετρολογικῆς μελέτης τῆς νήσου Σκιάθου συμπεράσματα συνοψίζονται εἰς τὰ κάτωθι :

1. Ἡ νῆσος Σκιάθος συνίσταται τόσον ἐκ μεταμορφωμένων ὅσον καὶ ἐκ μαγματικῶν σχηματισμῶν.

2. Οἱ μεταμορφωμένοι σχηματισμοί, ἀναλόγως τοῦ βαθμοῦ μεταμορφώσεως καὶ τῆς ἡλικίας, διακρίνονται εἰς προτριαδικοὺς καὶ μετατριαδικούς.

Οἱ προτριαδικοὶ σχηματισμοὶ ὑπάγονται εἰς τὴν Πελαγονικὴν μᾶζαν καὶ ἀποτελοῦν τὸ μεταμορφωμένον ὑπόβαθρον τῆς νήσου. Συνίσταθται ἐκ μαρμαρυγιακῶν σχιστολίθων — γνευσιοσχιστολίθων — γνευσίων. Ἐντὸς αὐτῶν ἀπαντῶνται τόσον φακοὶ ἀμφιβολιτῶν ὅσον καὶ φακοὶ γρανατιτικῶν μαρμαρυγιακῶν σχιστολίθων. Οἱ σχηματισμοὶ αὗτοι προῆλθον ἐκ τῆς καθολικῆς μεταμορφώσεως ἰζημάτων πηλιτικῆς, ἀργιλλοψαμμιτικῆς καὶ μαργαϊκῆς συστάσεως, ὑπὸ συνθήκας πιέσεως καὶ θερμοκρασίας ἀντιστοιχούσας εἰς τὴν ἀνδαλουσιτικὴν - κορδιεριτικὴν καὶ σιλλιμαντικὴν - κορδιεριτικὴν - μοσχοβιτικὴν - ἀλμανδινικὴν ὑποφάσιν (τῆς ABUKUMA σειρᾶς).

Οἱ μετατριαδικοὶ σχηματισμοὶ ὑπάγονται εἰς τὸ βύθισμα Κ. Εὐβοίας καὶ συνίστανται ἀπὸ δολομίτας - μάρμαρα, σχίστας, φυλλίτας καὶ σιπολίνας. Οἱ σχηματισμοὶ οὗτοι φέρουν ἐκδήλους τοὺς χαρακτῆρας μεταμορφώσεως τῆς πρασινοσχιστολιθικῆς φάσεως.

3. Οἱ μαγματικοὶ σχηματισμοὶ διακρίνονται εἰς ἐκείνους οἱ ὁποῖοι εὑρίσκονται ,κατὰ τὴν ἐπαφὴν τοῦ κρυσταλλοσχιστώδους ὑποβάθρου πρὸς τοὺς δολομίτας, εἴτε ἐντὸς τῶν δολομιτῶν καὶ εἰς ἐκείνους οἱ ὁποῖοι εὑρίσκονται ἐντὸς τοῦ φλύσχου. Οἱ μὲν πρῶτοι εἶναι βασικοὶ τόφφοι καὶ πορφυριτικοὶ ἀνδεσῖται, οἱ δὲ δεύτεροι εἶναι σερπιντινιώμενοι περιδοτῖται, διαβάσαι καὶ σπηλῖται.

4. Ἡ στρωματογραφικὴ διάρθρωσις συνοψίζεται ὡς ἑξῆς : Σχιστόλιθοι - Γνευσιοσχιστόλιθοι - Γνευσιοι μετὰ φακῶν ἀμφιβολιτῶν καὶ γρανατιτικῶν μαρμαρυγιακῶν σχιστολίθων. Τριαδικοϊουρασικὴ σειρὰ δολομιτῶν - μαρμάρων, κειμένων ἐξ ἐπικλύσεως ἐπὶ τῶν προηγουμένων.

Ἄνω Κρητιδικοὶ ἀσβεστόλιθοι καὶ φλύσχης. Τοῦτο διότι εἰς ἄλλας μὲν θέσεις ἐπικαλύπτεται ὁ δολομίτης ἐξ ἐπικλύσεως διὰ δολομιτικῶν ψηφιδοπαγῶν καὶ ἀσβεστολίθων, εἰς ἄλλας δὲ ἀποκλειστικῶς διὰ φλύσχου. Ὡς ἐκ τούτου δεχόμεθα ταυτόχρονον ἰζηματογένεσιν κρητιδικῶν ἀσβεστολίθων καὶ φλύσχου.

5. Ἡ Παλαιογεωργραφικὴ ἐξέλιξις τῆς περὶ ἧς ὁ λόγος περιοχῆς ἔχει ὡς ἑξῆς :

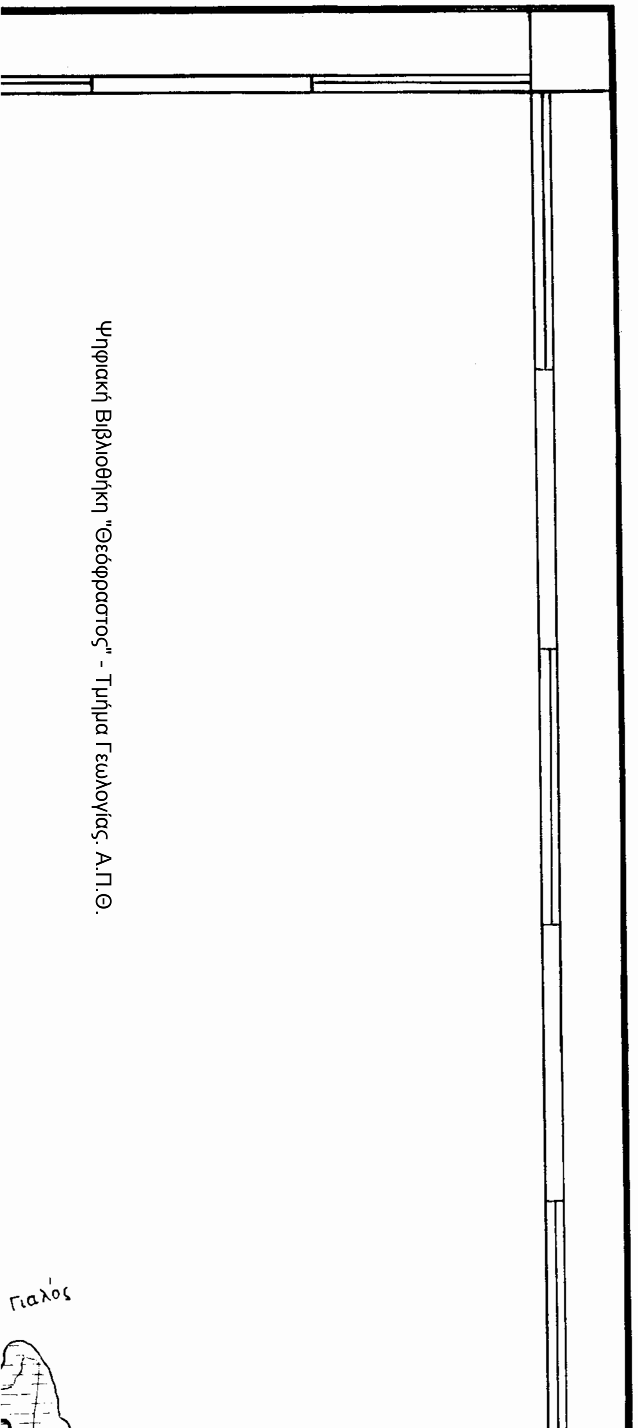
Κατὰ τὴν διάρκειαν τοῦ Μέσου καὶ Ἀνωτέρου Τριαδικοῦ (ἴσως καὶ Ἰουρασικοῦ), αὕτη ἀπετέλει θαλάσσιον χῶρον μικροῦ βάθους ἢ τεναγώδη παραθαλασσίαν περιοχήν, εἰς τὰ ἀβαθὴ μέρη τῆς ὁποίας ἀπετέθησαν δολομῖται καὶ εἰς τὰ βαθύτερα μάρμαρα. Συγχρόνως πρὸς τὴν ἔναρξιν τῆς ἰζηματογενέσεως τῶν δολομιτῶν, ἐξεδηλώθη ἡφαιστειότης, ἀποτέλεσμα τῆς ὁποίας ἦτο ἡ δημιουργία τῶν βασικῶν τόφφων καὶ τῶν πορφυριτικῶν ἀνδεσιτῶν. Ἀκολούθως ἡ θαλασσεύουσα

GEOLOGICAL MAP OF SKIATHOS

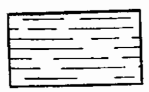
SCALE 1:50.000

L E G E N D

METAMORPHIC ROCKS

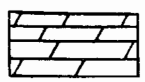


Low grade metamorphic rocks

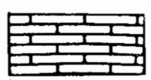


Flysch of upper Cretaceous (senonian) - Oligocene (?).
It is composed of clastic sedimentary formations.
These formations consist of :

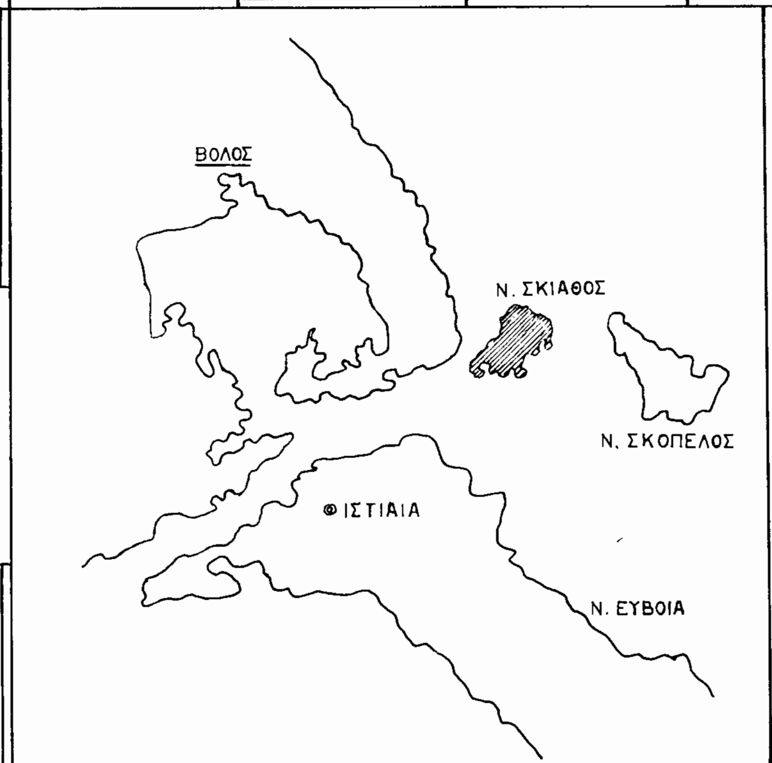
- Argillaceous slates with limestones lenses and psammitic banks.
- Alternate layers of grey to black limestones, marly limestones, psammits phyllites banks of schistose marbles.



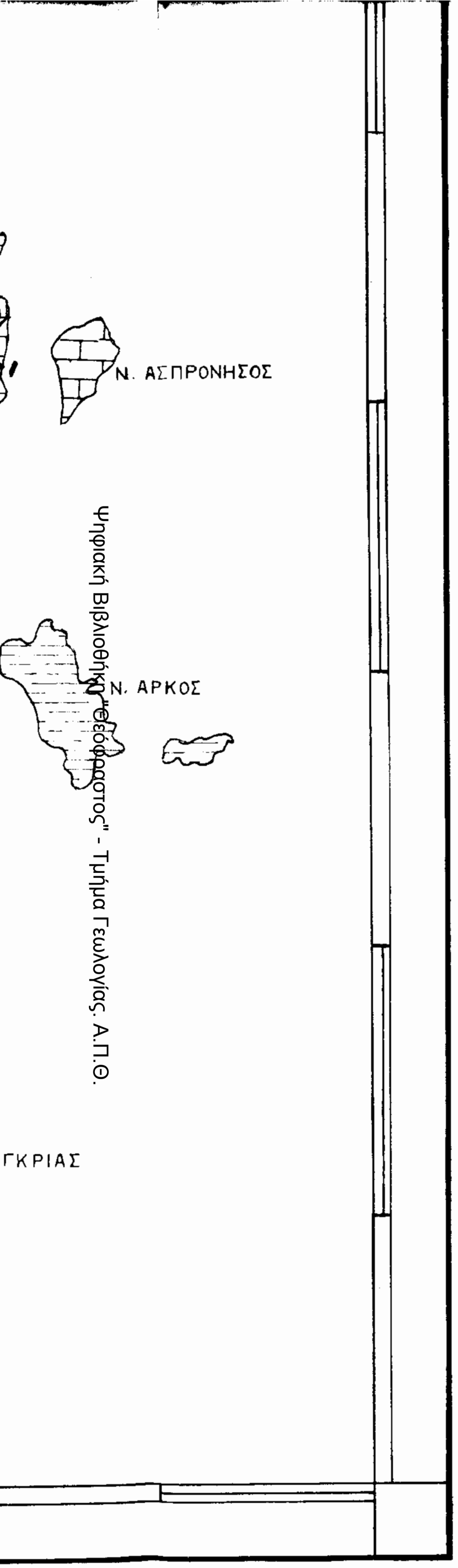
Limestone's lenses with chert intercalations within the previous slates.



Limestones with Hippurites Colliciatus of upper Cretaceous (Senonian). They are lying in some localities transgressively on the metamorphic basement and in other localities on


ΒΟΛΟΣ
Ν. ΣΚΙΑΘΟΣ
Ν. ΣΚΟΠΕΛΟΣ
ΙΣΤΙΑΙΑ
Ν. ΕΥΒΟΙΑ

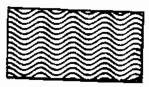

Άκ. Κάστρο
ΛΑΛΑΡΙΑΣ
Λιμ. Νικοτσάρα
Ακ. Σώζων
Μ. Αγ. Χαραλάμπους
Μέγας Γιαλός
Μ. Ευαγγελιστρίας



vely on the metamorphic basement and in other localities on the dolomites.

Marbles Dolomites with porphyritic andesites and bassic tuffs of middle Triassic - lower Jurassic. These rest uncon-formably on the crystalline basement and is covered transgres-dively either by upper Cretaceous limestones or by flysch.

High grade metamorphic rocks.



Pre-Triassic crystalline basement consisting of alternating bands of schists - schistose gneisses-gneisses with lenses of amphibolites and garnet mica schists.

IGNEOUS ROCKS

Porphyritic andesites and basic tuffs of upper Triassic - lower Jurassic.

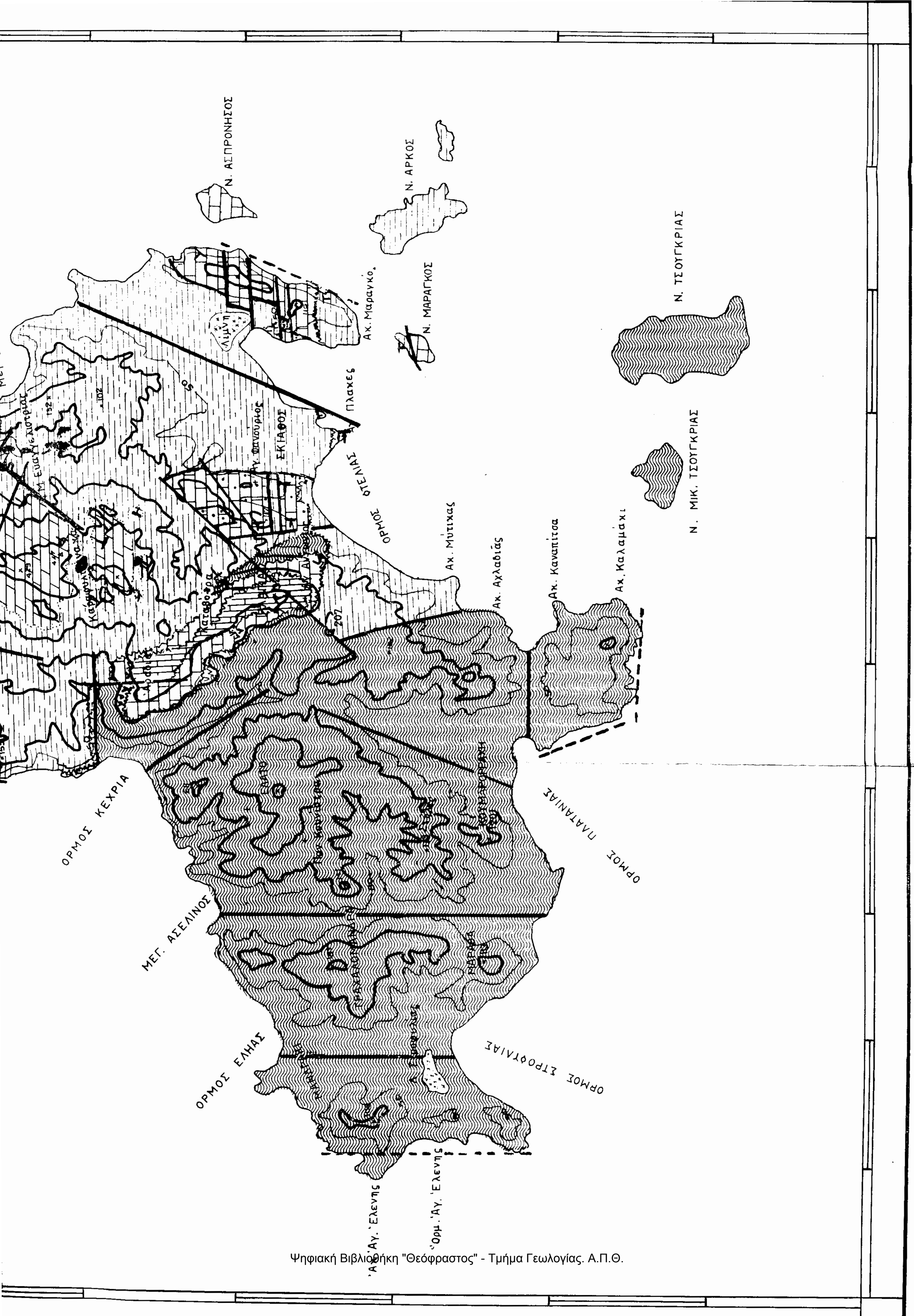
Ophiolitic complex with chert of Senonian Palaeocene (?). It is consist of serpentinized peridotites ,diabases and spilitic diabases. These occur on the slates of the flysch facies.

Strike and dip of the beds

Visible fault

Probable fault

Uncomformity


Ν. ΑΣΠΡΟΝΗΣΟΣ
Ν. ΑΡΚΟΣ
Ν. ΜΑΡΑΓΚΟΣ
Ακ. Μαραγκο
Ν. ΤΣΟΥΓΚΡΙΑΣ
Ν. ΜΙΚ. ΤΣΟΥΓΚΡΙΑΣ
Λίμνη
Πλάκες
ΣΚΙΑΘΟΣ
Αγ. Φανούριος
Ακ. Μύτικας
Ακ. Αχλαδιάς
Ακ. Κανάπιτσα
Ακ. Καλαμάκι
Καταβόθρα
ΟΡΜΟΣ ΚΕΧΡΙΑ
ΜΕΓ. ΑΣΕΛΙΝΟΣ
ΟΡΜΟΣ ΕΛΗΑΣ
ΟΡΜΟΣ ΠΛΑΤΑΝΙΑΣ
ΟΡΜΟΣ ΣΤΡΟΦΥΛΙΑΣ
Ακ. Αγ. Ελένης
Όρμ. Αγ. Ελένης

περιοχὴ ἀνεδύθη καὶ ἀπετέλεσεν χέρσον, μέχρι τῶν ἀρχῶν τοῦ 'Ανωτ. Κρητιδικοῦ. Ὁ ἀκριβὴς χρονολογικὸς ἐντοπισμὸς τοῦ ὀρογενετικοῦ τούτου συμβάντος δὲν εἶναι δυνατὸν νὰ ἐπιτευχθῇ ἐλλείψει ἀπολιθωμάτων. Κατὰ τὰς ἀρχὰς τοῦ Ἄνω - Κρητιδικοῦ (Σενώνιον) ἡ περιοχὴ κατεκλύσθη καὶ πάλιν ὑπὸ τῆς θαλάσσης, ἐντὸς τῆς ὁποίας ἀπετέθησαν κατὰ θέσεις ἀσβεστόλιθοι καὶ φλύσχης.

6. Ἀπό γεωτεκτονικῆς ἀπόψεως ἡ νῆσος Σκιάθος ἐντάσσεται εἰς τὴν Πελαγονικὴν ζώνην.

ACKNOWLEDGMENT

The research for this thesis was carried out at the laboratory of Geology at Patras University, under the supervision of Prof. ATHANASIOS PANAGOS, who suggested the topic, read the paper critically and has given a great deal of advice on points of appıoach and interpretation.

I wish also to thank Prof. J. Papastamatiou director of the laboratory of Applied and Economical Geology (Technical University of Athens) where a considerable portion of this work was done and who visited the island during the summer 1968. I express my special gratitude to Prof. John Melentis (Salonica University) for his interest, guidance and encouragement throughout the course of this work and also to Dr. A, J. Barber (Chelsea College, London University) for having read the English translation of this thesis.

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The numbers in the parentheses correspond to the thin sections of the analysed rocks.