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A reinterpretation of the geology of the Atticocycladic massif (Greece)

Atikosikladik masifinin (Yunanistan) jeolojisine yeni bir yaklaşım

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ÖZ : önceleri Atikosikladik Masifinin topografyasının erozyona bağlı olarak geliştiği sanılırdı. Ancak, ayrıntılı saha çalışmaları, topografyanın tektonik kontrolünde geliştiğini ve geniş açılı iki fay takımının dalınılan yönünde kaymaları sonucu oluştuğunu göstermiştir.

Çeşitli kayaç tiplerinin yanyana bulunması, önceki çalışmacıları, nap yapılarının ve büyük uyumsuzlukların varlığı düşüncesine sevketmiştir. Bu yazı daha önce açıklanamayan bu gibi karmaşık yapıların varlığının ve değişik kayaçlann birarada bulunmasının, anılan geniş açılı fayların yavaş hareketleri ile ilgili olduğunu açıklayabilmek amacıyla hazırlanmıştır. Bu önemli fay takımlarının varlığını kabul etmek, Atikosikladik Masifinin yapısını anlayabilmeyi olabildiğince basitleştirmektedir.

Bu faylar geniş yaydıma sahip olup, her ikisinin de düşey hareket miktarları oldukça fazladır. İki fay takımının birbiri üzerindeki hareketinden dolayı, bu önemli fayların oldukça uzun olan çizgisel izleri, hava fotoğraflarında doğrudan doğruya görülememektedir.

ABSTRACT : The topography of the Atticocycladic massif has previously been assumed to be primarily the result of erosion. However detailed field work has shown that the topography is tectonically controlled and is the reuslt of small dispslip displacements on two sets of high angle faults.

In order to account for the juxtaposition of the various rock types in the field, previous workers have invoked the existence of nappe structures and major unconformities. In this paper the existence of such structures is questioned and it is suggested that these juxtapositions can be accounted for by relatively small movements on high-angle faults. The recognitin of these important fault sets considerable simplifies the structure of the Atticocycladic massif.

These faults are widespread and it is thought that a considerable amount of vertical movement is associated with tehm. These important faults are not immediately apparent on the areal photographs because movement on the two sets inhitbits the formation of long linear fault traces.

INTRODUCTION

Considerable debate has been focudes on the sturcture and stratigraphy of the metamorphie rocks of Attica (the mainland of the Atticocycladic massif) and the whole area (fig. la). Inter-pretations put forward by previous workers fall into three categories, (1) existence of unconformities (27 existence of nappes and (3) existence of both unconformities and nappes.

All these interpretations will be questioned in this paper.

Previous Interpretations Of The Geology of Attica

Lepsius (1893) was the first to map Attica systematically. He lpresented a stratigraphic sequence, which with a few modifications still holds today. (Table 1)

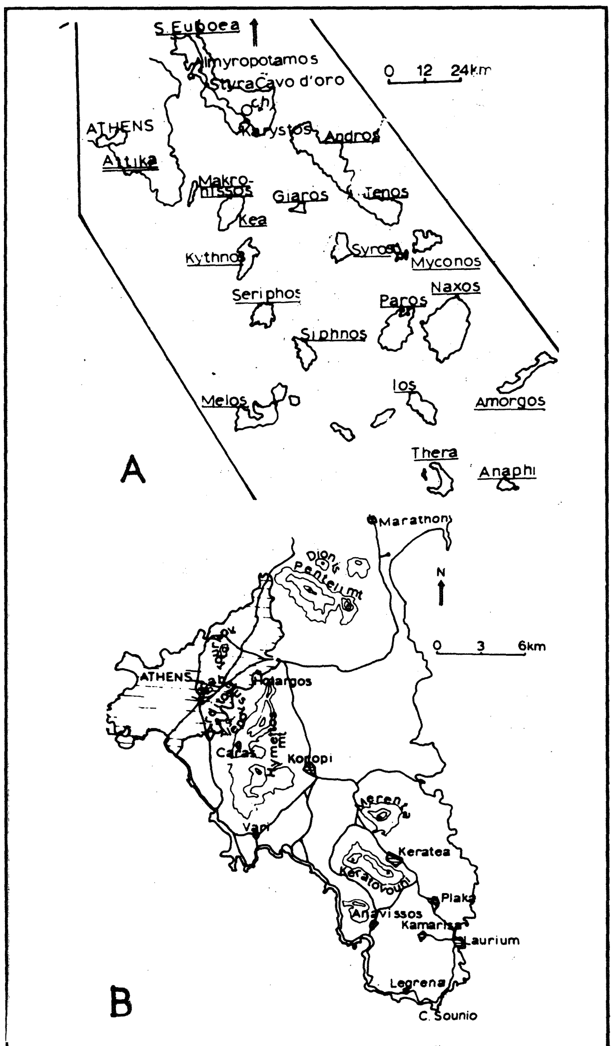
In the metamorphie rocks, which he considered to be of Precambrianage, he distinguished the following sequence of rocks from lowest to highest: "Vari schists", "Pirnari dolomites", "Lowest marble", "Kaesariani schists" and "Upper merble". These are overlain unconformably by Jurassic to Cretaceous Limestones.

The "Athens schists" lie unconformably over these rocks consist of calcschists, chlorite sahists, quartzites, limestones and (in the area of Laurium? metavolcanic rocks. It is worth noting that some of the limestones, Lepsius described, are tectonically brecciated marbles.

Kober (1929) introduced the concept of nappe tectonics to the area, comparing Attica with the Alps. He believed that there was a resemblanca between the geology of Attica and that he had noted in a region of the Alps where a window exists through the Pennine nappes, he distinguished three series: The Lower and upper Attica series and the beotian series (Tablo 1). The Lowest Attica series and tyhe Beotian series (Tablo 1). The lowest Attica series cansists of metamorphie rocks, including: "Mica-schists", "Marbles and dolomites", the "Vari schists" and the "Penteli gneiss" (see Table 1.)

He assumed, that, the " Lowest Attica series was overlain unconformably by the "Caras formation" of Cretaceousage. The "Caras formation" was overthrust by the "Athens schist" and a limestone that makes up the foothills of mount Hymettos (Toblo 1) and includes the Arditos and Alepovonuni hills (Fig. lb). He also considered that the "Athens schists" and the limestone hills were in turn overthrust by the Beotian series which consists of Cretaceous to Jurassic limestones and outcrop on the Acropolis and the Lycabetus hills in Athens.

Marinos and Petrascheck (1956) modified Lepsius's model for the area around Laurium and recognised two seystems, one autochthonous the other allochthonous (Tablo 1). The autochthonous system consists of metamorphie rocks, comprising, the "Lower marble" (including schist intercallations) the "Kaesariani schists"



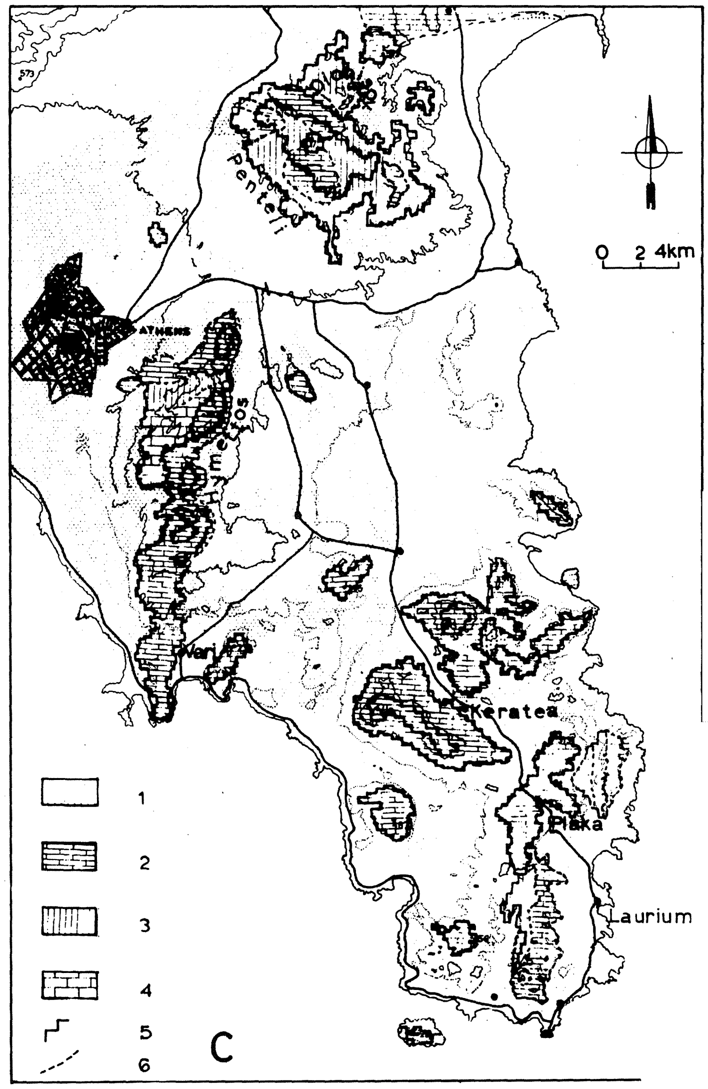


Figure I (a) The Atticocycladic massif, the studied area (b) A map of Attica showing the localities referred to in the text (c) A simplified geological map of Attica (post-Alpine sedimets and intrusive rocks ate not included) 1 = "kaesariani schists", 2 = "upper marble", 3 = "kaesariani schists", 4 = "lower marble", 5 = Non linear faults (represented by two sets of faults, see text) 6. Geological boundaries.

and the "Upper marble". The allochthonous or "Phyllitic seystem" comprises semimetamorphic rocks, calcaschists, chloritic schists, quartizites, marbles, limestones and metavolcanic rocks.

To support their views they put forward the following argument:

1. The "Phyllitic system " overlies all the other units. (Fig 2).
2. Both systems are technically brecciated.
3. The metavolcanic rocks of the "phyllitic system" in Laurium have no conduit in the autochthonous system.
4. The "lineations" (they do not specify which ones) in these two seystems have different orientations.

Geologists of the "Compagnie Française des Mines de Laurium[11] (they will be referred to as "French geologists" in the text) reverted to Lepsius's interpretation. They distinguished the following series: (Table 17.

1. The "Kamarisa series" which comprises the "Lower marble" overlain unconformably by the "subordinate marbles", "Kamarisa schists" and "upper marble".
2. The "Plaka series" overlies unconformably the "Kamarisa series". The former comprises limestones, marbles and schists (Table 1).
3. Both the "Kamarisa" and "Plaka series" are overlain unconformably by the "Athens schists" or the "Athens series".

The tectonic model of Attica presented by Marinos & Petraschek (1956) is based on work around Laurium in

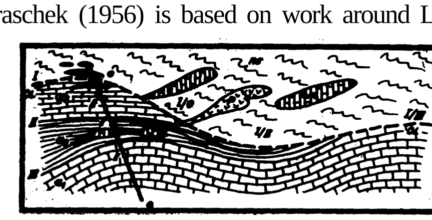


Figure 2 Schematic interpretation of the geology ot Attica (After Marinos & Petrascheck 1956). *(SL_X =* "lower marble", a_2 "kaesariani schists", a_3 = "upper marble", ns = allochthon phyllitic system.

Lepsius (1893)	Kober (1929)	Marinos & Petrascheck (1956)	Internal reports of Comp. Fr. des Mines de Laurium	This paper
[Cretaceous] Upper limestone (Lycabetus) Athens schists ang. unconformity - [Jurassic L.Cretaceous] Lower limestone -ang. unconformity - [Precambrian] Upper marble Kaesariani schists Lower marble Pirnari dolomites Vari schists	[Boeotian series] Lycabetus Acropolis & Tourkouvouni formation [Jurassic Cretaceous] -overthrust - [Upper series of Attica] Athens schists Alepovouni and Arditos limestones [U. Trias L. U. Jurassic] overthrust - Caras formation [M. U. Cretac] ang. unconformity - [series of Attica] Micaceous schists Marble and dolomites [Trias Lias] Vari schists Penteli Gneiss [Trias Palaeoz.]	[Allochthon system] Phyllitic system (marbles, quartzites, calc. schists) - overthrust - [Autochthon system] [Trias? Jurassic?] Upper marble Kaesariani or Kamarisa schists Lower marble with schist intercallations	[Allochthon system] Athens schists -unconformity - [Plaka series] Upper Plaka limestone " " schists Middle " limestone Lower " schists -ang. unconformity - [Autochthon system] [Kamarisa series] Upper marble Kamarisa schists Subordinate marble - ang. unconformity - Lower marble	Flysch —lat. trans.→ Ath. schists [Maestric. Senonian] Upper limestone —lat. transition— Upper marble [Cenomanian U. Jurassic] Schist chert formation —lat. trans.— or Kaesariani or Kamarisa schists [Jurassic] Lower limestones —lat. trans.— Lower marbles [Trias]

Table 1 Previous and present autyhors'interpretations of the stratigraphy of Attica.

southern Attica. Katsikatsos (1977) working on the whole of Attica and S. Euboiea supports their model but, in addition, considered that the relatively unmetamorphic rocks of northern Attica were themselves thrust over the sequence proposed by Marines and Petrascheck (table 1). He also recognised Cretaceous fossils in a limestone in the Kamarisa region. He took that limestone to be unmetamorphosed and therefore suggested thet it rested unconformably on the metamorphosed rocks of the region.

Fotakis-Tsipouras & Hawkins (19827 made minor modifications to the of the French geologists and suggested an additional member the "Anavissos unit".

Papadeas (in press) working in the Marathon area, distinguished various marbles and schists ranging from Pre-Carboniferous to upper Cretaceous in age. He rejects the idea of nappes but recognises two important unconformities.

Finally Marino s et al (1971, 1974) working in the area around Athens suggest that all the outcropping pelitoclastic rocks and the Cenomanian limestones that make up the "Athens schists".

Whilst plreparing the geological map of the Athens area (Athens & Piraeus sheet) Gaitanakis (1981) follawed Kober's model (Table 17 which interprets the Cenomanian limestones as relics of a nappe which overlies the "Athens schists" which are of Maestrichtian age.

Present Author's Interpretation

Detailed field work by the present author has revealed numerous high angle-faults, dipping between 65°-90°, the significance of which had previously been overlooked. They occur as members of two sets and have experienced small dip-slip displacements (0-50cm) associated with the differential uplif which has occurred in the area. This has resulted in the formation of dome-like structures (Fig. 3b).

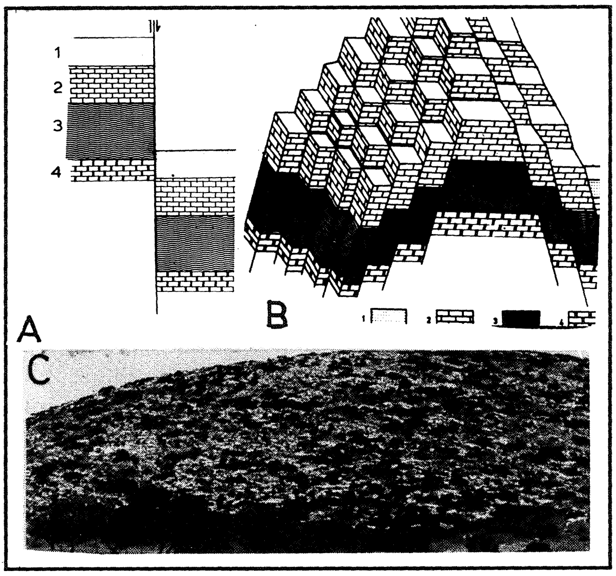
Previously the "upper" and "lower marbles" (table 1) were distinguished from each other by their thicknesses, the "upper marble" has a thickness of 100 m (proved by borehole data) and it is estimated that lower marble has a minimum thickness of 500 m.

However, it is apparent, that, if the region is cut by numerous high angle faults, offsets on these faults may result in the relatively thin "upper merble" having a vertical thickness considerably greater than 100m (Fig. 3b, c, d, &e). If-these faults, are not recognised the marble would be 'mistaken for the thick, 'lower marble". Thickness, therefore should not be used to distinguish the two marble urlits.

Interpretations /and reinterpretations of pervious structural sections and structures will now be presented in the light of these high-angle faults.

The model presented by Marinos and pletrascheck (1956) for the structure of Attica is summarised in Fig. 2 and shows the "Athens schists" (called phyllitic system by Marinos and Petrascheck) separated from the other rock units by a major cross cutting thrust. The basis for this model was the recognition in the field of the "phyllitic system" being in contact with successively lower units. (Fig. 2).

Their evidence can, however, be reinterpreted. For example* they observed the "phyllitic system" (recognised by the present author as the "Athens schists"[4]) overlying a thick marble whick they assumed to be the lower marble. In fact, it is the "upper marble" thickened by the process described above and illustated in fig. 3b. Work by the lpresent author shows that the "Athens schists" overlie the "upper marble" conformably and where the contact can be seeen in the field it is generally transitional and not tectonic. However, movement on these high angle faults often obscures this relationship and brings the "Athens schists" into direct contact with the underlying units Fig. 3a



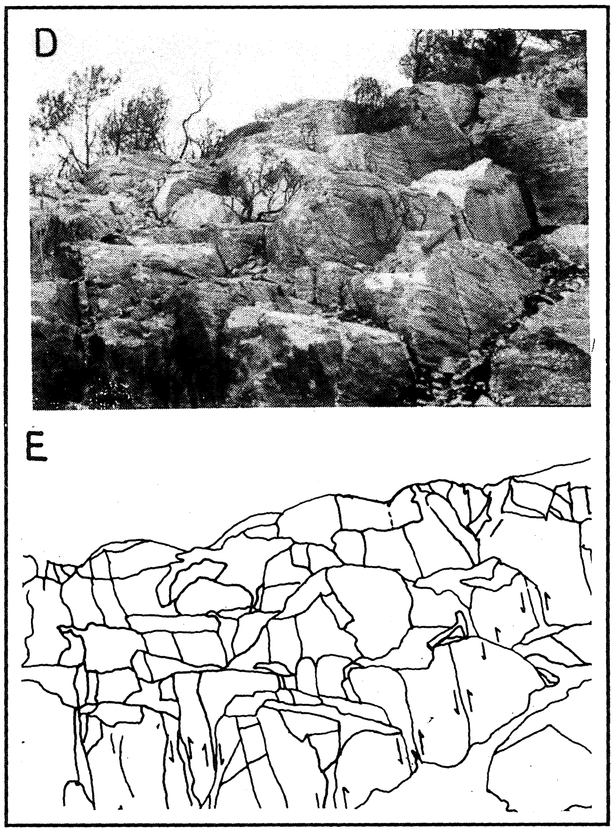


Figure 3 (a) The 'Athens schists" in direct contact with the lower units due to faulting (1 = "Athens schists", 2 = "Upper marble", 3 = "Kaesariani schists", 4 = Lower marble), (b) A dome-like horst structure due to small dip-slip movements on high angle faults, (cd A photograph of a domelike structure of upper marble near Keratea. (d) Detail of dome-like structure,

In western Keratovouni, Lepsius (18937 described the occurrence of alternations of marble and semi-metamorphosed schists, (the "Pirnari dolomites"), which he considered to underlie the "lower marble". Marinos and Petrascheck (1956) considered them to represent schist intercallations within the "lower marble" (Fig 4a & b). Both these interpretations are, however, inconsistent with the topography which does not reflect this (Fig. 4c).

Field work, by the present authyor shows that the bands of schist shown in Fig. 4a & d overlies down-thrown blocks of marble. The fault scarps can be clearly seen in the field, Fig. 4a, d & e. Fortunately, the two major schist units of the area, the "Athens schists" which is only semi-metamorphosed and the "Kaesariani schists", which exhibits green sechist facies can be distinguished easily in the field. Lepsius (1893) and Marinos & Petrascheck (1956) considered the schists in Fig. 4a & d to be either below or part of the "Lower marble". They were, therefore, perplexed by its low grade of metamorphism. Indeed Marinos (1942) tried to explain this anomaly by suggesting it was the result of retrogression. However the anomaly no longer exists when it is realised that the schists are the semimetamorphosed "Athens schits" brought down by movements on the high angle faults. (Fig. 4f).

The "Vari schists" which outcrop in the Vari area (Fig. 1 b & 5) were recognised and named by Lepsius (1893) who considered them to be the lowest unit in Attica (Table 1) The V. schistsare semimetamorphic rocks and on the basis of field evidence, he considered that they lay under a dolomitic marble, Fig. 5a. Unfortunately the contact between the two rock types is obscured by detritus. However a quarry section (Fig. 6) near Koropi (Fig. 1 b) shows clearly that the semimetamorphic rocks are down-faulted against the marble. The two rock units have been brought into Juxtaposition by movements on high-angle faults and the structure of the area is similer to that in Fig. 3b. On the basis of these observations the present author considers that the Vari schists are stratigraphically equivalent to the "Athens schists" and the dolomitic marble equivalent to the "upper marble".

The "Caras formation" (Table) 1) was considered to be a succession of limestones and schists. The present author considers tyhat the alternation of limestones and schists is the result of movements on numerous high angle-faults and that the limestone is equivalent to the "upper marble" and the schists, stratigraphically equivalent to the "Athens schists".

A typical section of the "Athens schists" hasbeen described from the area of Plaka (Fig. lb) by Lepsius (1893) and Marinos and Petrascheck (1956). They conclude that marbles and limestones are embedded in the "Athens schists" (refered to as the "Phyllitic system" by! Marinos & Petrascheck (1956) see Fig. 2.

The French geologists mapped the Plaka area in more detail and distinguished an alternation of limestones and schists with an unconformity between the "Uppei: Plaka limestone" and the "Athens schists" (table 1 Fig 7a, b & c).

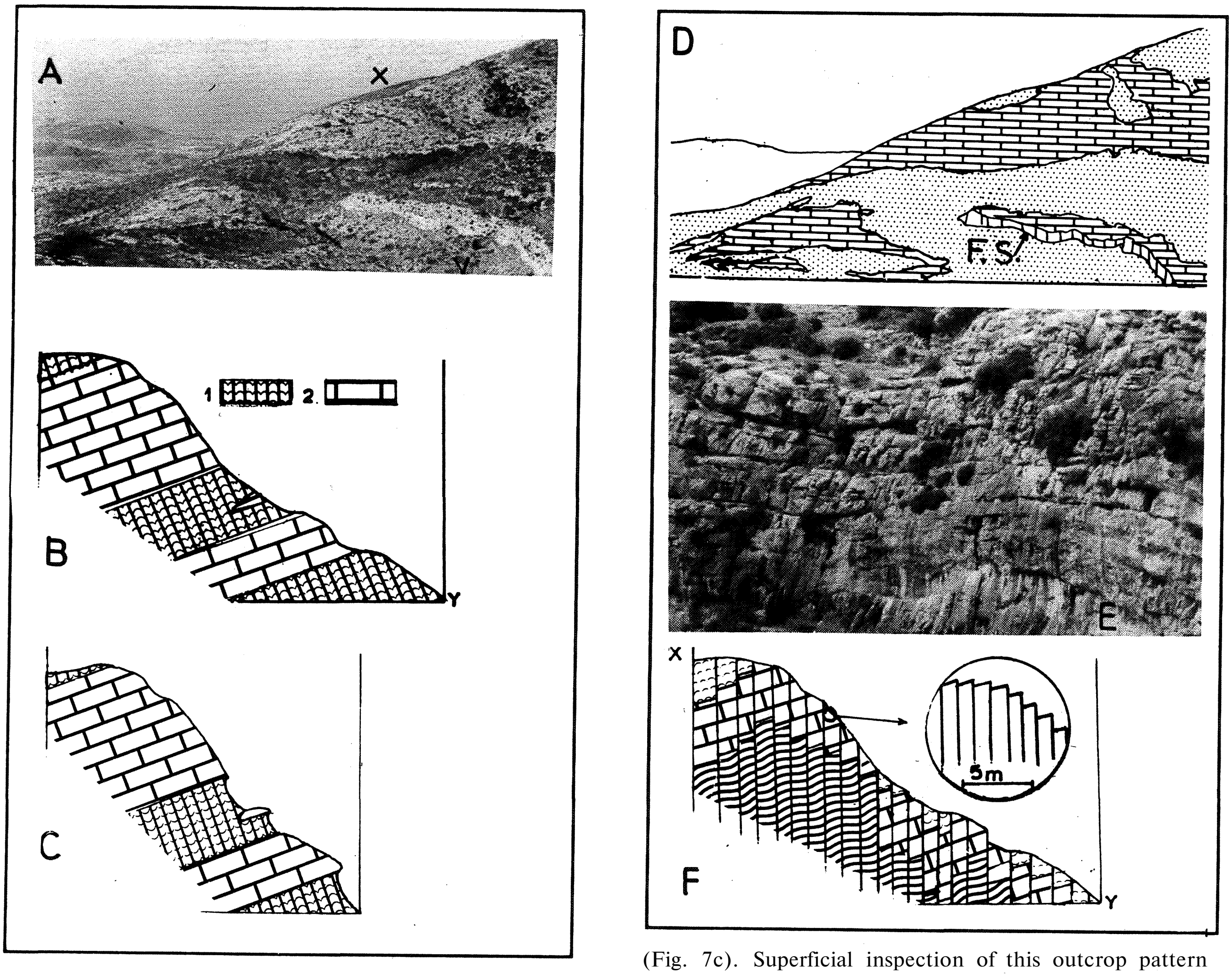


Figure 4 (a) A panoramic view the western Keratovouni area (b) A geological profile (x y) according to previous workers. (c7 The expected topography if b was the case (d) A line diagram of a (key as in Fig. lc) F.S. = fault scarp (3) details of the fault scarp, (f) present author's interpretation. The inset depicts the effect of small movements on numerous high angle faults on the topography, (key as in Fig. 3a).

Field work by the present author has shown that these limestones are tectonically brecciated marbles. This brecciation is almost certainly the result of movement on the high-angle faults and there is no doubt that the repetition of limestones (marbles) and schists is due to these same movements and does not reflect an original sedimentary succession. (Fig. 7d). The conclusion of the plresent author is that the "limestones" are equivalent to the "upper marble" and the repetition of marble and schist by faulting also occurs in the western Keratovouni area.

It is interesting to note that although the French geologists mapped the individual limestones in the Plaka area as separate units, it is sometimes possible in the field to show that the limestonis are in fact the same (Fig. 7c). Superficial inspection of this outcrop pattern would indicate the existence of isoclinal folds. However, detailed field observations show that the outcrop pattern is, in fact the result of faulting on the two sets of high angle faults. (Fig. 7d).

In the Legrena valley (Fig. lb) previous workers (Lepsius, 1893, Marinos & Petrascheck, 1956 the French geologists and others) have described an "upper marble" unit and a "lower marble" (A & B of Fig. 8a) separated by the "Kaesariani" or "Kamarisa schists" (C in Fig. 8a). In addition they recognised marble intercalations in the "Kaesariani schists" and estimated the thickness of the "Kaesariani schists" at this locality to be 300 m. Which was compatible with the thickness obtained from the borehole data. The French geologists suggested that an unconformity existed between the lower marble and the "Kamarisa schists" which locally include the "subordinate marble" (see Table 1)

Detailed field work, however, has shown that the two marbles (A & B Fig 8a) are the same and have been "Separated" by erosion which has exposed the underlying "Kaesariani schists". Near the village of legrena the two outcrops A and B become one (Fig. 8a). Marinos and petrascheck (1956) recognized that in the Legrena area the two were in contact and considered this to be the result of lateral discontinuities in the Kaesariani schists.

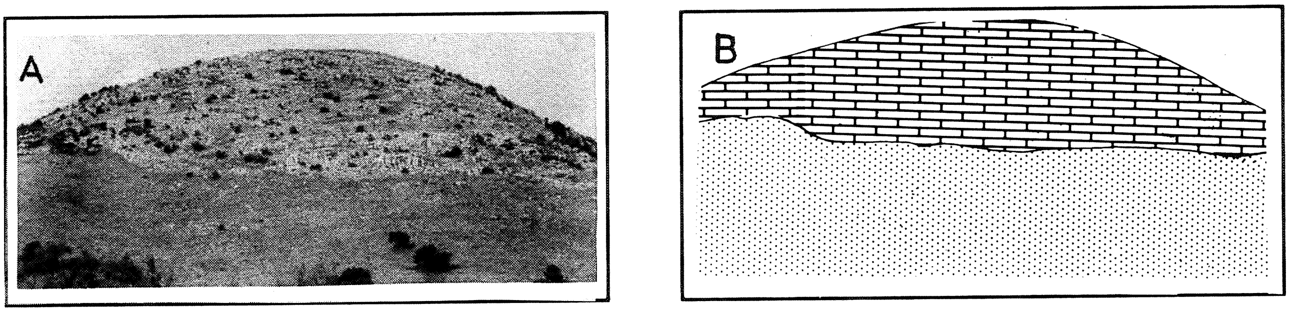


Figure 5 (a) The Vari schists lying topographically lower than the marble, (b) A line diagram of a_f (key as in Fig. lc).

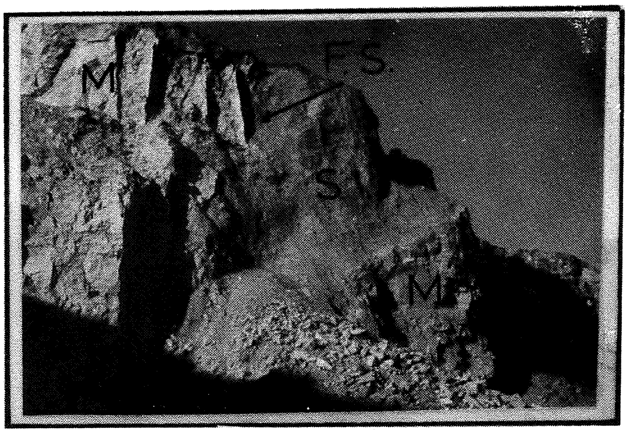
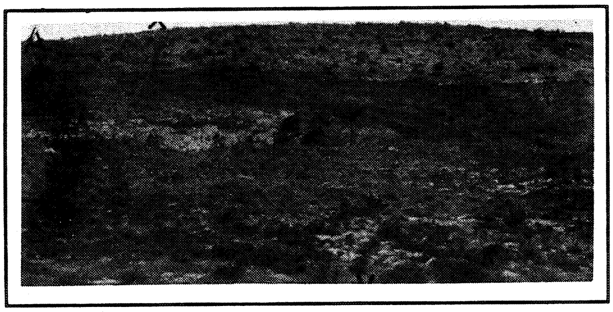
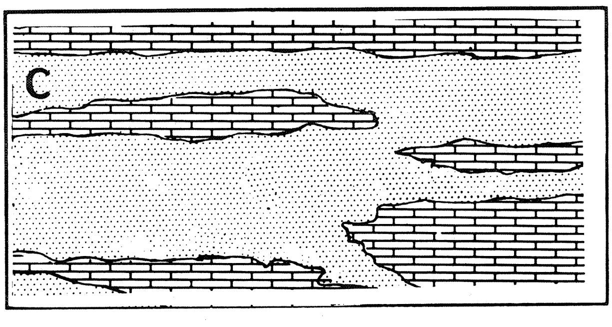


Figure 6 A quarry section reveals that Vari schists overlie the marble. M = marble S = schists F.S. = fault scarp.

The present author's interpretation of the area is shown schematically in Fig. 8b. It can be seen that the marble intercallations in the Kaesariani schists mentioned by previous workers are in fact remnants of the "upper marble" preserved in down faulted blocks. The "subordinate marble" (Table 17 recognised by the French geologists in a mine near Kamarisa (Fig. lb) is overlain by Kaesariani schists and is interpreted by the present author to represent a horst block wlock which has raised the "lower marble into the Kaesariani schists".

The same phenomenon can be observed at mount Penteli (Fig. lb) where Lepsius (1893) described a succession from "lower marble", "Kaesariani schists to marble" which was unconformably overlain by the "Athens schists" (Table 1). A different succession for the area was proposed by Kober (1929) (table 17 who considered the two "Penteli gneiss" are overlain by "marbles and dolomites" which in turn are overlain by mica-schists.





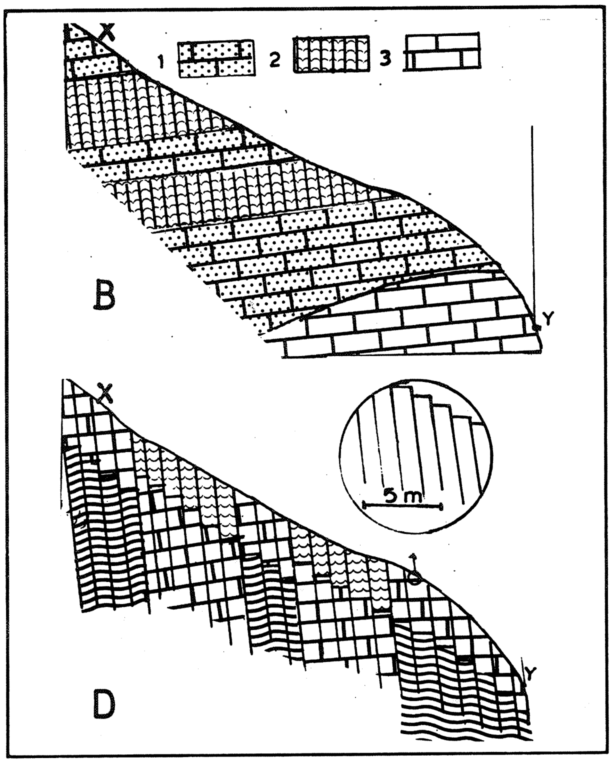


Figure 7 (a) A photograph of the Plaka area, (b) A profile according to the French geologists interpretation 1 = Plaka limestones, 2 = Plaka schists, 3 = Camarisa upper marble, (c) A line diagram of a, (key as in Fig. lc). Beyond the photographed area the two marbles are linked, (d) Present author's interpretation, (the inset depicts details of the ture topography), (key as in Fig. 3a).

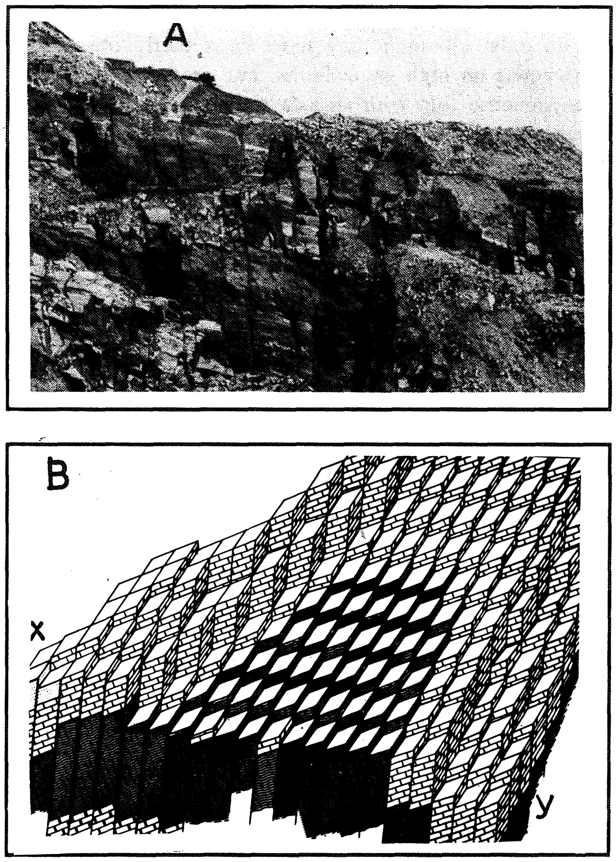


Figure 8 (a) The eastren slope of the Legrena Valley, (b) A model of the present author4s interpretation of the geological structure of the area (key as in Fig. 3a).

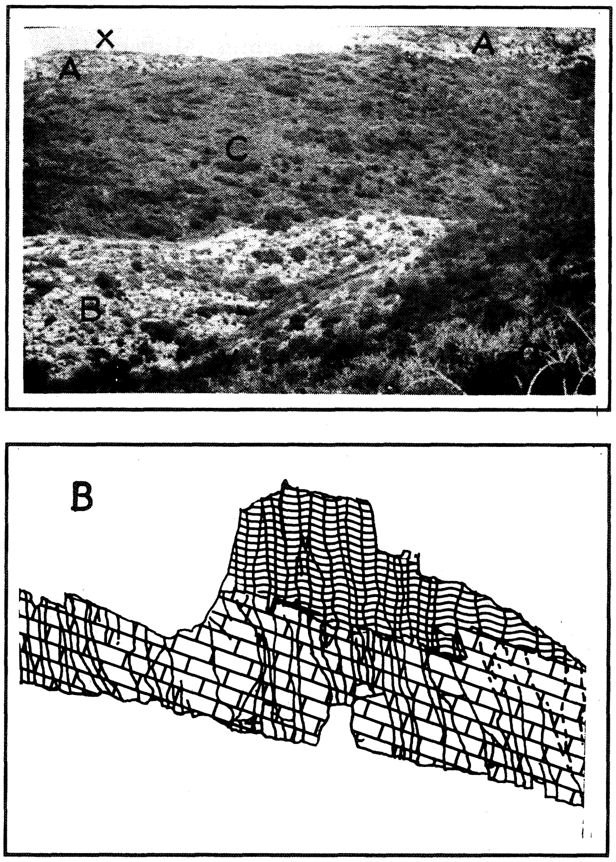


Figure 9 (a) The 'upper marble" overlying the Kaesariani schists in a quarry at Penteli. Note the numerous high angle faults, (b) A line diagram of a, (key as in Fig. 3a).

Fieldwork by the present author has shown that what Lepsius called "Lower marble" is in fact the "Upper marble" which, because of movements on the high-angle faults, is now thickened by the process described in Fig. 3b. However in a quarry section (Fig. 9) this marble can be clearly seen to rest on tolp the "Kaesariani schists".

In view of the reinterpretation of the geology of Attica in terms movement on high-angle faults, the reader may begin to question the outcropping of the "lower marble", suspecting that it represents downfaulted upper marbla thickened by the lprocess shown in Fig. 3b. however, it does outrop in the area around Dionysovouni (Fig. 107 and in the northern part of Hymettos mountain (Fig. lb), where it has been justaxposed against the "upper marble" by high angle faulting. This is shown in Fig. 11.

The main rock units of Attica i. e. the "lower marble", "Kaesariani schists", "upper marble" and the "Athens schists" show considerable lateral variations in both lithology and metamorphic grade. Gaitanakis (1981) described a lateral transition from the semi-metamorphosed "Athens schists" to flysch of Maestrichtian age. *jK* similar transition has been found by the present author in the region north of mount Penteli. He olso observed a lateral transition from "Kaesariani schists" to clastic sediments in the Holargos area of Athens.

It will be reacalled from table 1 that the limestone making up the Acropolis and other hills around Athens was thought to be either a limestone intercallation within the "Athens schists" (Lepsius) or the klippen of a lateral transition from "Kaesariani schists" to clastic sediments in the Holargos area of Athens.

It will be recalled from table 1 that the limestone making up the Acropolis and other hillis around Athens was thought to be either a limestone intercallation within the "Athens schists" (Lepsius) or the klippen of a nappe, thrust over the "Athens schists" (Kober).

The present author's interpretation of the geology of the Athens area is shown schematically in Fig. 11. It is argued that all the limestone hills the area are dome-like, up-faulted blocks of Cenomanian limestone ("upper marble") which underlie flysch containing Senonian to Maestrichtian fossils and which is equivalent to the "Athens schists". In addition the "upper marble" overlies clastic sediments which are thought by the author to be strati-graphically equivalent to the "Kaesariani Schists".

The lateral transition from the metamorphic roks of southern Attica to the relatively unmetamorphosed sediments in the area around Athens is supported by fossils.

occssionally found preserved in the metamorphic rocks, for example, in the. Kaesariani schists, Marinos (1948) has found fossils of probable Jurassic age. Cenomanian to aptien fossils have been found in the upper marble (e. g. Leleu & Neumann, 1969, Papadeas 1970, Katsikatsos 1977 and Senonian to Maestrichtian fossils have been recorded from "Athens schists" Marinos et al. 1971, 1974, Gaitanakis 1981).

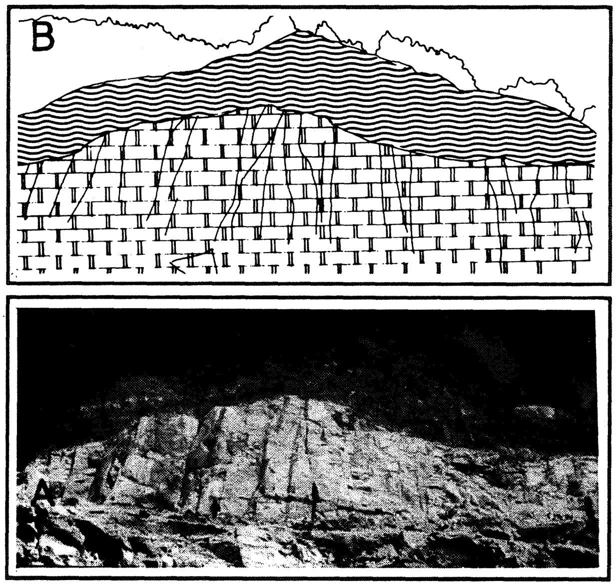


Figure 10 (a) A quarry section at Dionyssovouni showing the lower marble in stratigraphic contact with the underlying Kaesariani schists, (b) A line diagram of a, (key as in Fig. 3a).

The structural pattern of the main rock units of Attica are shown in Fig. 11 and the author has redefined these units as follows.

"Lower marble" is a marble unit which is sometimes dolomitised and whick show lateral colour variations- It underlies the "kaesariani schists". The "Kaesariani schists" is a unit including metamorphosed (greenschist facies) clastic, calcite rich rocks, with vertical and lateral variation in lithology. It also includes serpentinised ultrabasic rocks. This is overlain by the "Upper marble", which exhibits lateral variation and in places in places is dolomitised and ankeritised. This unit underliec the "Athens schists" which include semimetamorphic calcite rich rocks (Including calcshists), chloritic schists, quartzites, altered spilites and (in the schists, quartzites, altered spilites and (in the Laurium area) metavolcanic rocks.

It is worth noting that the general succession listed above is locally found in a reverse order. This is due either to folding or a combination of faulting and slipping as illustrated in Fig. 12.

Although the emphasis of this paper has been to show how small dip-slip movemets on two sets of high angle faults can account for much of the present distribution and juxtaposition of rock types, in Attica and that it is not necessary to invoke the existence of nappes and major unconformities, there is a little doubt that large folds do exist although they have been partly obscured by movemets on high angle faults. For example, a large scle asymmetric fold with an axisHrending approximately NE runs along the Hymettos mt. and extends to mount Penteli.

The Geology of South Euboea

S. Euboea (Fig. la) consists of metamorphic rocks, marbles and schists. Previous workers (Katsikatsos, 1977, Bavay & Romain-Bavay, 1980) have suggested the existence of two or three nappes which rest on an autochthon, the Almyropotamos series. Katsikatsos (1977) described two nappes (1) the Styra and Ochi series (an alternation of marbles and schists) and (2) the relatively ummetamorphosed sedimets of northern Euboea. In addition Katsikatsos includes a marble unit in the area of Almyropotamos in the northern part of S. Euboea in which he found Triassic fossils (Megalodon) to be part of the autochton. Bavay and Romain-Bavay (1980) described two more successive nappes overlying the allochthonous Ochi series.

Fieldwork by the present author indicates that the rock units in S. Euboea are stratigraphically equivalent to those in Attica. He recognises the "Athens schists", the "Upper marble" and the "Kaesariani schists". The lower marble does not orop out on the island and all the marbles are "upper marble". This is supported by the fossils found by Katsikatsos (1969) in these marbles which range from Up. Jurassic to Cenomanian in age.

Triassic fossils have been found by Katsikatsos (1969) in blocks of marble in the northern part of S. Euboea. However these blocks are not in situ and probably belong to the lower marble and were deposited onto the "upper marble" in the manner shown in Fig. 13.

The alternation of marbles and schists recognised by various previous workers (including Katsikatsos, 1977, Bavay & Romain-Bavay, 1980) were considered by them to be a primary alternation (Fig. 14). It is argued by the present author that author that this is not so and that the "alternation" are actually repetitions of the beds (Upper marble and Athens schists) by movemets on high angle faults in exactly the same way as was described earlier in this paper for the area of western Keratovouni (Fig. 4).

Dip-slip movement on high angle faults does not effect the dip of the beds. Displacements of inclined strata and subsequent erosion can give rise to a topography identical to that associated with a dipping, sequence of alternating competent and incompeted rocks, Fig. 15. Examples of topography associated with the model shown in Fig. 15i can be found in the Cavo d'oro and the Ochi mountain areas, Fig. la.

The Geology of Cyclades

The stratigraphic succession of Attica (Lower marble Kaesariani schists, Upper marble, Athens schists) together with the tectonic control of topography described above, seems to extend all over the Cyclades (Fig. la). Field reconnaisance on theCycladic islands shows that they are dome-like structures of the Kaesariani schists and the Upper marble with relics of the Athens schists.

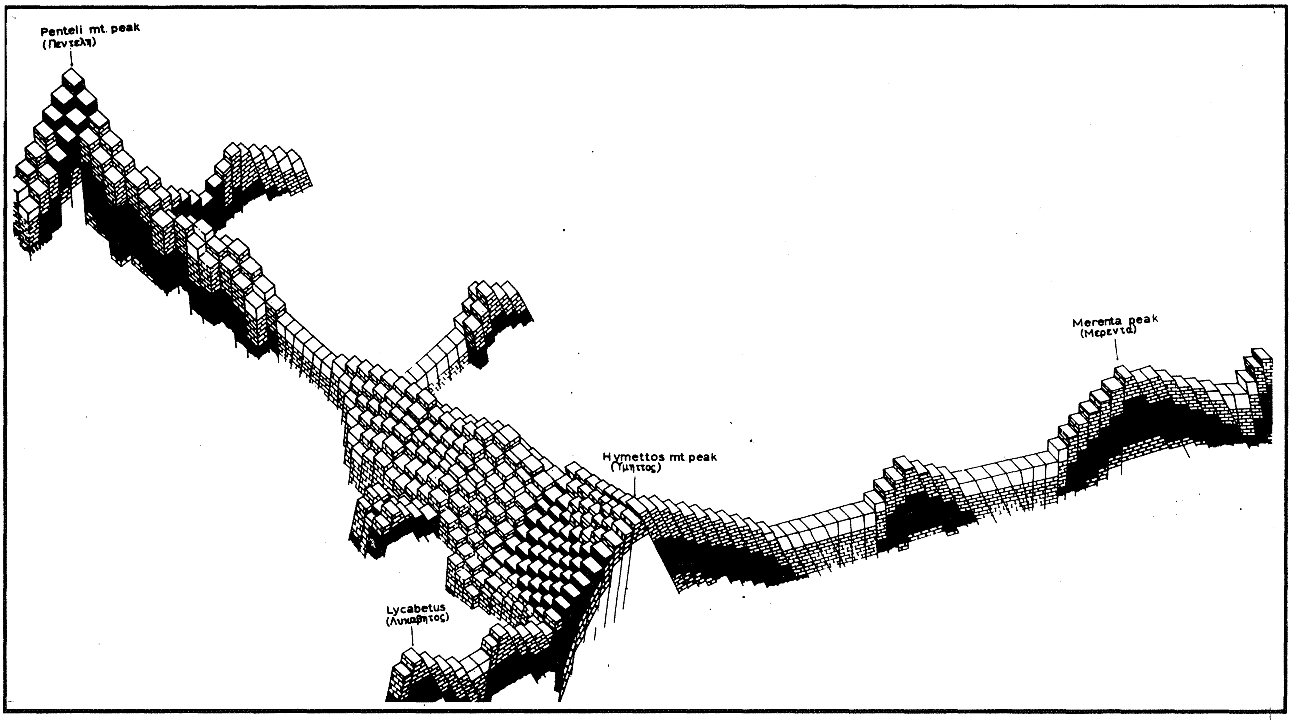


Figure 11 Schematic representation of the structure of Attica, (key as in Fig. 3a).

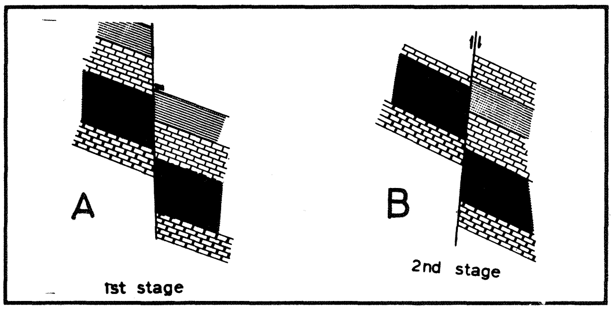


Figure 12 (a) Faulting causing the lateral Juxtaposition of the 'Athens schists" against the originally underlying "upper marble", (b) Subsequent slipping of parts of the 'upper marble" into the "Athens schists" resulting in a local reversal of the succession. (The slipped Athens schists on the downthrown side of the faults have been removed by erosion, key as in Fig. 3a).

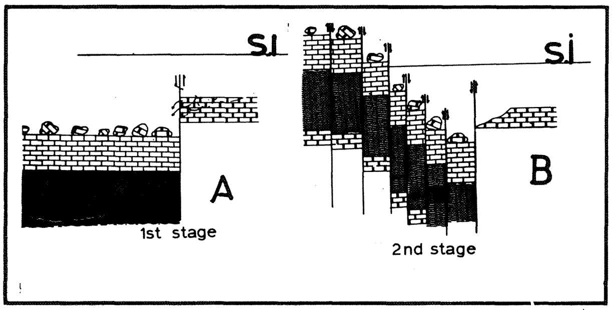


Fİgure 13 (a) Submarine faulting brings the 'lower marble" to a higher level than the upper marble. Erosion (or simple slippage) places blocks of the "lower marble" over the "upper marble", (b) shows the effect of movement on high angle faults on a, (key as in Fig. 3a).

SUMMARY

There is considerable evidence that the rocks of Attico-cycladic massif have undergone and are still experiencing differential uplift, for example, raised beach deposits occur at many localities and on Kea, indicate an uplift of 80m. Conversely many archaeological sites are now below sea level. (Marinos, 1971, Caskey, 1971).

Having established that numerous high angle faults exist in the area and that considerable dip-slip displace ments have occurred on many of them it is tempting to suggest that they are associated with differential uplift On a regional scale. Further support for this association comes from the observation that high angle faults cut even the youngest(quaternary) marine deposits which now outcrop. Only the terrestrial quaternary deposits remain relatively unfaulted.

The fault surfaces very considerably in appearance from fresh and barren fractures to fractures infilled with mineral such as calcite. In addition the exhosed fault scarps range from fresh sharp features to highly weathered and eroded steps.

The formation of "domes" and "basins" by movemets on two sets of high-angle faults rather than the more usual tectonic proccess of folding may account for the much more irregular distribution and geometry of these structures. In addition, the use of minor structures

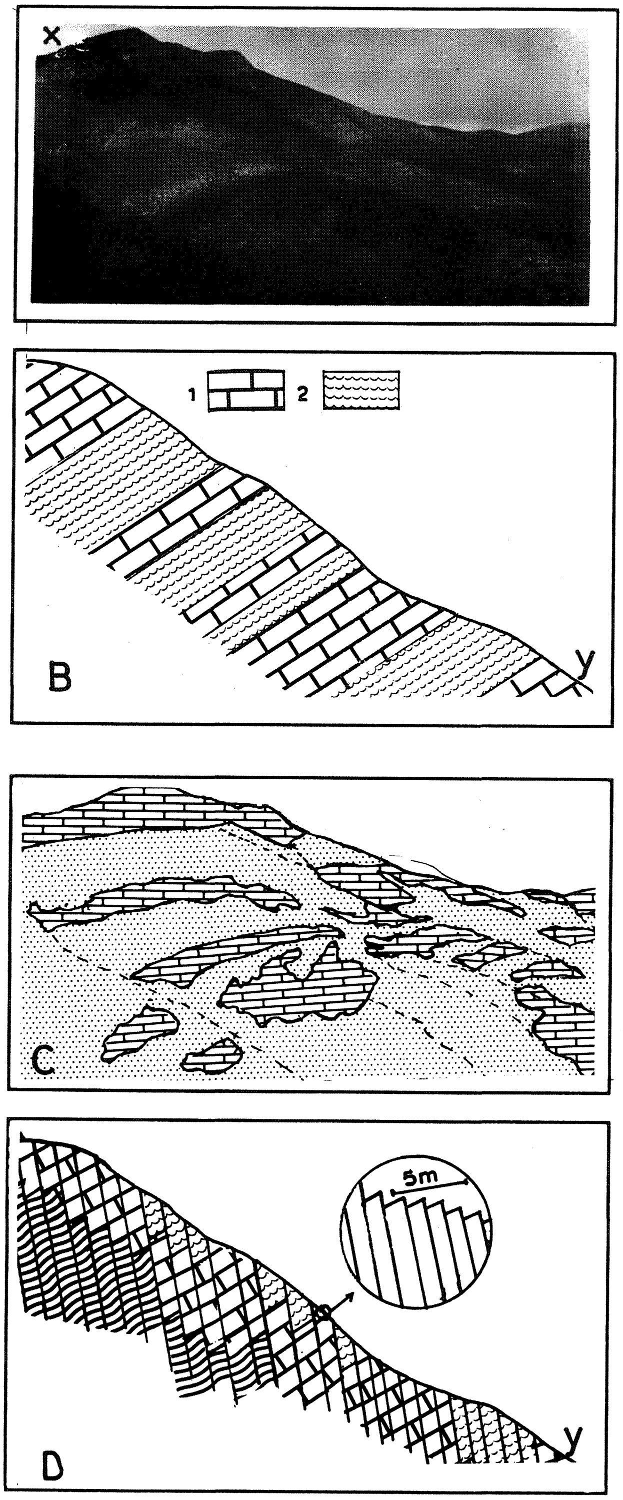


Figure 14 (a) A panoramic view of a "false alternation of marble and schists in the Styra area, (Fig. la).
(b) A profile based on other workers' interpretation of a.
(c) A line diagram of a, (key as in Fig. lc).
(d7 Present author's interpretation. The inset depicts details of teh topography, (key as in Fig. 3a7.

(dip of bedding, orientation of minor folds, for example) to predict the position of major fold closures will, of course, be invalid if the minor structures are separated from the closure by one or more high angle faults.

It will be noted that erosion of the dome like horst structures shown schematically in Fig. 3b will result in older rocks being found at topographically higher sites thyan younger rocks.

If it is not recognised that small movemets on high-angle faults are responsible for the local change in elevation of the different rocks, it becomes necessary to postulate nappe structures or major unconformities to account for their juxtaposition and distribution.

If it is not apparent that repetition of strata has occurred by movement on high-angle faults then the unwary geologists may interpret the repetition as being of sedimentary origin.

In the authors opinion the high-angle faults are not due to a regional extension but are the brittle response of the over rocks to folding at depths.

Geological Mapping of a Technically Controlled Topography

Geological mapping of an area such as the Atticacycladic massif which is dominated by two sets of closely spaced high angle-faults presents certain problems particularly if no suitable marker horizons are present. Not all the faults can be represented on the maps particularly if the maps are 1: 50, 000 or more. In such terrain it is first necessary to recognise the type of tectonic setting and then to map in representative faults. Dome structures whick are the result of movement on high angle faults can be distinguished on map from the domes formed by folding, by the technique used in Fig. lc. The small faults drawn on this diagram represent a group of faults with the same orientation and the same sense of movement. Because the topography of these regions is controllled by faulting, the positioning of these representative faults on the map will commonly be subparallel to prominent topographic slopes.

Conclusions

The juxtaposition of the rock units of the Atticocycladic massif can be explained by small movements on numerous high angle dip-slip faults. It is unnecessary to postulate the existence of nappes or major unconformities. It is thought that differential uplift is responsible for the formation of these high-angle faults.

It is suggested that stratigraphy and structure of many other areas, where the full implications of these high-angle faults has not been appreciated, may need to be reassessed.

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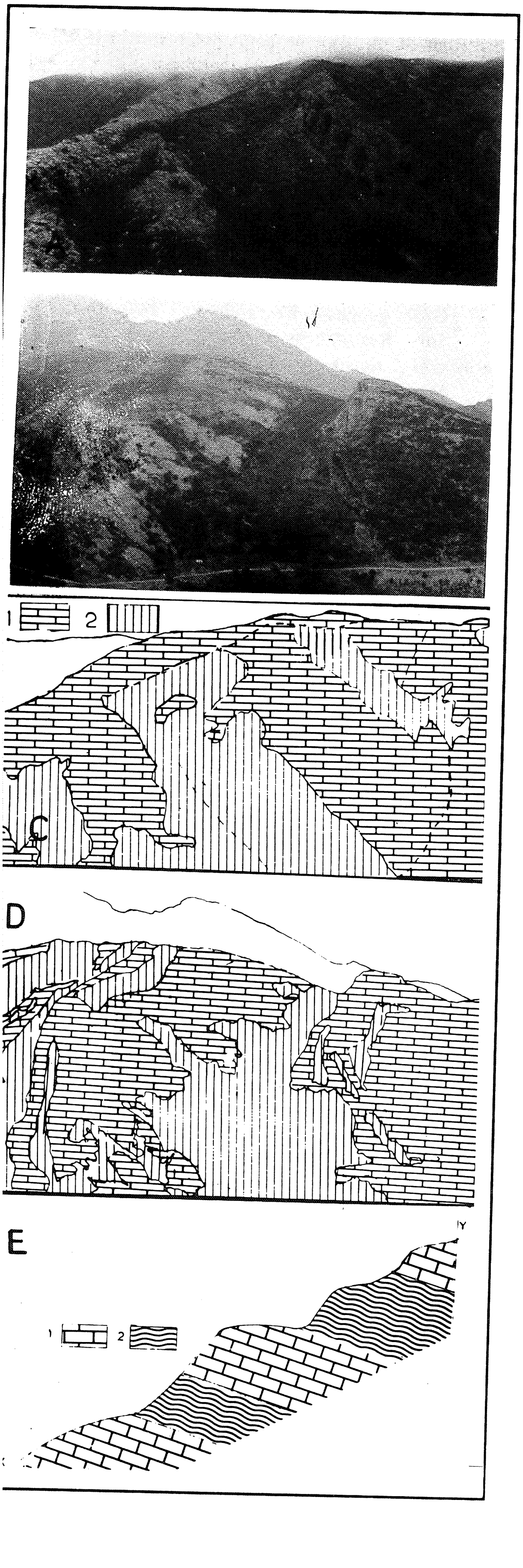

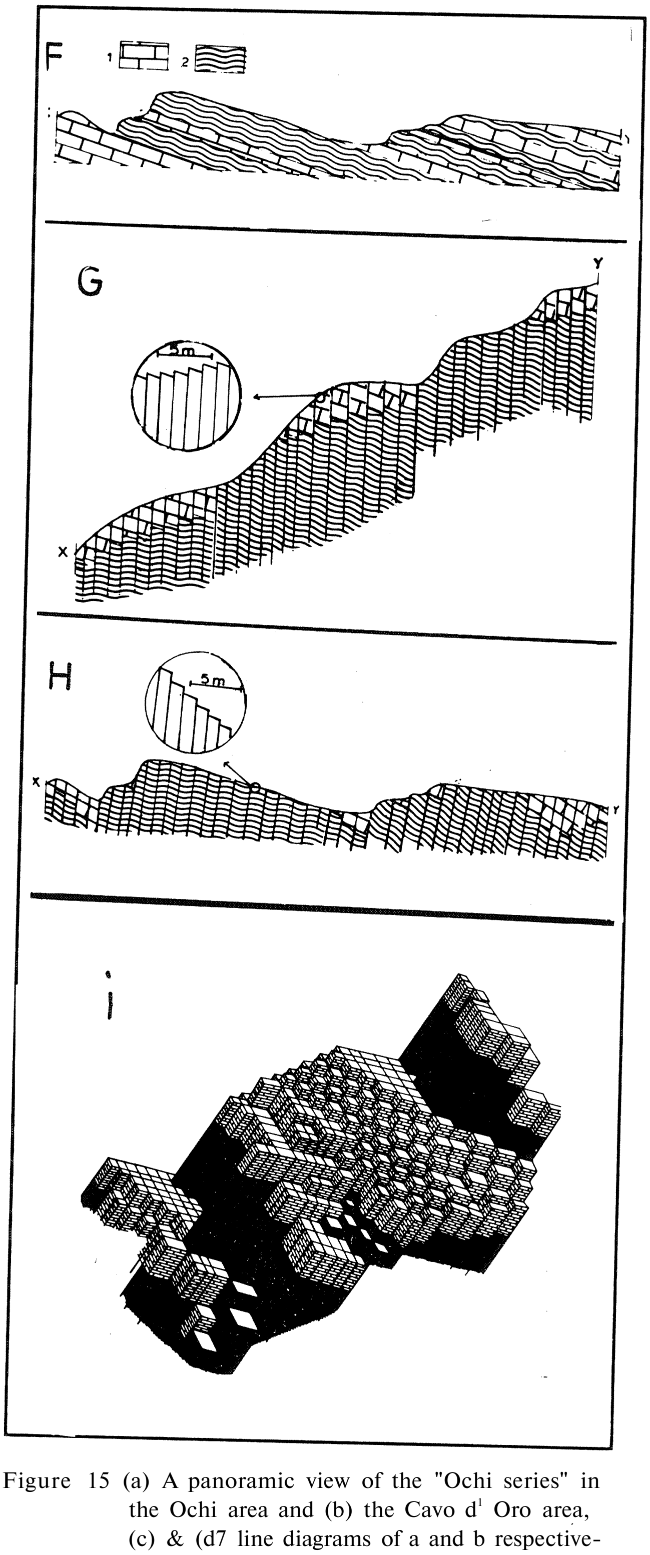

Figure 15 (a) A panoramic view of the "Ochi series" in the Ochi area and (b) the Cavo d' Oro area, (c) & (d7 line diagrams of a and b respectively, (key as in Fig. lc). (e7 & (f7 previous workers' interpertations of a & b, respectively. (g7 & (h), present author's interpretations of a & b respectively, (i) A model showing how movement on high angle faults can give rise to the repetition of marbles and schists in the Ochi and Cavo d' Oro areas, (Fig. la, key as in Fig. 3a).

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