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PLATTENKALK SERIES AND KASTANIA PHYLLITES OF THE TAYGETOS MTS.:NEW RESULTS ON STRUCTURE AND SUCCESSION

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ABSTRACT

Within the carbonates of the Plattenkalk Series of the Taygetos Mts. early Liassic ammonoids were found for the first time. The marls and clastics on top of the carbonate succession contain an ichnofauna as well as mass flow-sediments, both typical for a flysch depositional setting. The metamorphic clastic rocks underlying the Plattenkalk carbonates (Kastania Phyllites) yielded a paragenesis with carpholite, chlorite, pyrophyllite and quartz, which indicate a HP/LT metamorphism of 7 - 8.5 kbar at 310 - 360°C. The map scale structure of the western Taygetos Mts. is characterized by west facing, tight to isoclinal folds with detached backlimbs and eastward directed back thrusts. Metamorphic conditions and structure point to an allochthonous position of the Plattenkalk Series and the Kastania Phyllites.

INTRODUCTION

The external metamorphic belt of the Hellenides on the Peloponnesus is formed by different nappes or parts of nappes and considered parautochthonous units: the Tyros Beds, the Phyllite-Quartzite Series, the Plattenkalk Series and the Kastania Phyllites. Although the units of this metamorphic belt have recently been intensively investigated (THIÉBAULT 1982; THIÉBAULT & TRIBOULET 1984; THEYE & SEIDEL 1991; PSONIS 1981; BASSIAS & THIÉBAULT 1985; PAPANIKOLAOU & SKARPELIS 1987/88; MANUTSOGLU 1990; DITTMAR & KOWALCZYK 1991) questions remain unanswered. To answer some of these questions, investigations have been carried out in the western Taygetos Mts. to obtain further details for the lowermost units of this tectonically stacked succession, the Plattenkalk Series and their underlying metamorphic clastic rocks, the Kastania Phyllites. The aim of this study is to present new data on the biofacies of the sedimentary succession of the Plattenkalk Series and to discuss some aspects concerning the metamorphism of the Kastania Phyllites and the structural characteristics of the western Taygetos Mts. These data are based on results of field investigations, especially detailed mapping of Mavrovouna Mt. and areas near Saidona, Milea and Trachila (s. Fig. 1), which have been carried out in the years 1991/92 as a continuation of previous work.

In the following we use the term "Plattenkalk Series" for the carbonate succession of late Triassic to late Eocene age and its overlying clastics,

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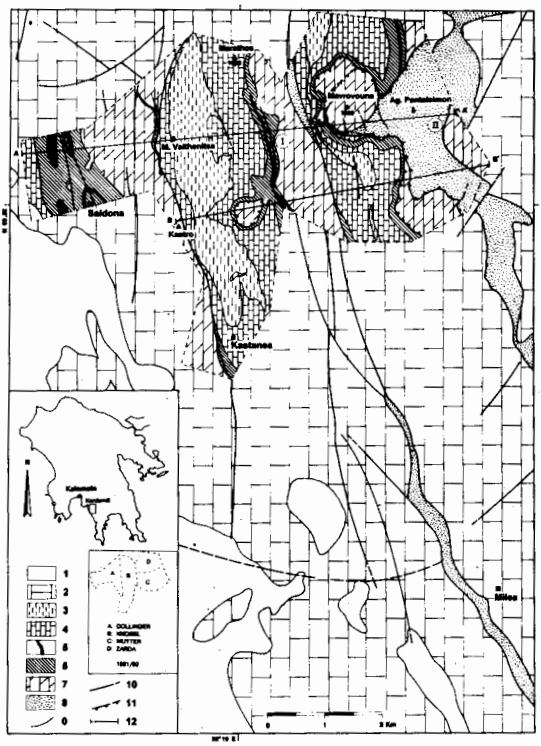

Fig. 1: Geological sketch map based on IGME (1983) and areas (A-D) mapped in detail.
1 - Neogene and Quaternary; 2 - Dolomitic and calcitic marbles, undivided; 3 - "Plattenkalk Flysch" (Vathia Beds); 4 - Multi-coloured- and blue-grey calcitic marbles; 5 - Bedded cherts; 6 - Chert bearing-calcitic marbles; 7 - massive dolomitic marbleswith chert nodules and stromatolites; 8 - Kastania Phyllites; 9 - Lithological boundary; 10 - Tectonic contact: dashed, assumed; 11 - Thrust: dashed, assumed; 12 - Geological section A and B; I - Ammonoid findings (s. Fig. 2); II - Occurrence of carpholite.

the so called "Plattenkalk Flysch". The Kastania Phyllites are the metamorphic clastic rocks underlying the Plattenkalk carbonates, after the classification of DITTMAR & KOWALCZYK (1991).

THE PLATTENKALK SERIES

The lithostratigraphical succession and biostratigraphical classification of the Plattenkalk Series in the Taygetos Mts. and the Parnon Mts. are known by the investigations of THIÉBAULT (1982), PSONIS (1981), BASSIAS & THIÉBAULT (1985), BASSIAS et al. (1987). While DITTMAR & KOWALCZYK (1991) have already reported aptychi at the base of the chert bearing calcitic marbles, now ammonoids could be detected in a section between Saidona and Mavrovouna Mt. (s. Fig. 1, 2).

The ammonoids occur in a sequence of dark, 10 to 15 m thick, chert-free marbles with thin pelitic intercalations. They overlie the basal dolomites of the Plattenkalk Series and represent the oldest pelagic environment in the stratigraphic column of the Plattenkalk Series (s. Fig. 4). Usually individual cephalopods are poorly preserved, often recognizable by spiral coils only. However, two evolute sculpturless ammonoids with straight ribs could be found. According to the examination by R. FISCHER, Hannover (pers. com.), they could be referred as *Megastomoceras megastoma* (WÄHNER) which would indicate an early Liassic (Hettangian) age (Plate 1, Fig. 1a, b). Because the underlying dolomitic marbles have been dated as late Triassic/early Jurassic this determination confirms previous biostratigraphic investigations (THIÉBAULT 1982). Hitherto, these ammonoids were unknown in this unit of the Peloponnesus and Crete, and even unknown in a similar position in the Ionian Series,

which may be correlated with the Plattenkalk Series.

The shales, marls and sandstones on top of the carbonate succession are time equivalent to the flysch of the Ionian and Tripolitza Series (West Hellenic Flysch, JACOBSHAGEN 1986). Therefore they were named "Plattenkalk Flysch" (PSONIS 1981). But in the Peloponnesus, clear paleoenviromental indications are rare within these often strongly deformed rocks. MANUTSOGLU (1990) suggested for this succession the term Vathia Beds. Only the occurrence of Globigerinids at some locations indicates pelagic conditions.

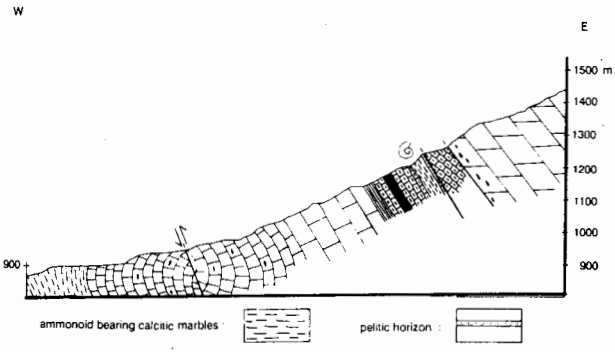

Fig. 2: Geological section along the road Saidona-Mavrovouna Mt., with the locality of ammonoid findings (s. Fig. 1).

Some new observations concerning the Mani Peninsula and the Taygetos Mts. provide additional data to describe the depositional environment of these beds. On the Peninsula north of Trachila village (Messinia) (s. Fig. 3) the Vathia Beds are well exposed over a distance of more than 800 m. They conformably overlie multicoloured marbles of early Tertiary age and show a (tectonic) thickness of at least 450 m. Above the contact with the underlying marbles, the succession consists of dark shales with numerous marl and limestone intercalations. Towards the top, the amount of sandstone increases. The Vathia Beds are overlain by light marbles, attributed to the Upper Cretaceous/Lower Tertiary

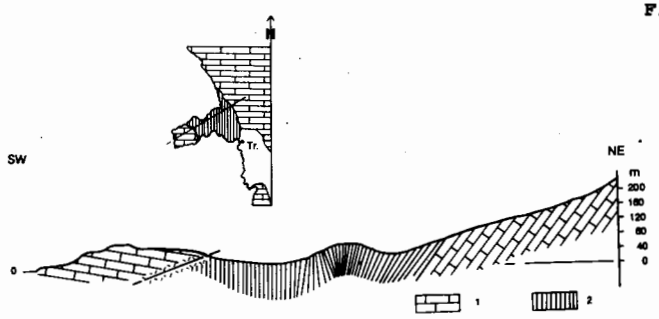

Fig. 3: Geological section of the Peninsula north of Trachila village (Tr.). 1 - Late Cretaceous/early Tertiary marbles of the Plattenkalk Series; 2 - "Plattenkalk Flysch" (Vathia Beds); * - occurrence of trace fossils. Map after IGME (1983).

(IGME 1983). The units are separated by a cataclastic thrust zone, which possibly forms one of the back thrusts that can be detected on the western flank of the Taygetos Mts. The beds are steeply dipping to the west and show only week mesoscopic deformation with one bedding-parallel schistosity.

The shales in the lower part of the succession yielded a small ichnofauna assemblage. Preliminary determinations of the fauna suggest that the following taxa are represented: *Helminthoida, Chondrites, Spirophycus-* and *Taenidium*-like forms (Plate 1, Fig. 5, 6). These traces occur in the *Nereites*

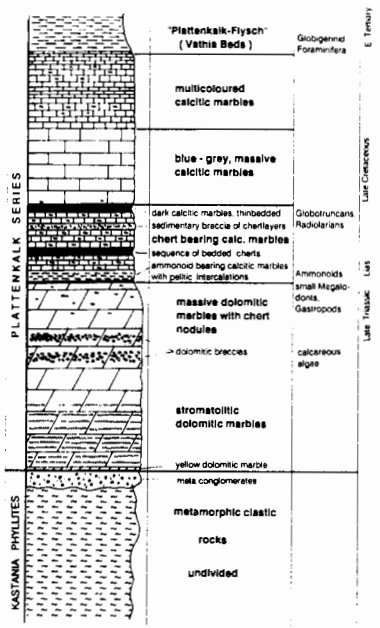

Fig. 4: Lithostratigraphic column of the Plattenkalk Series and the Kastania Phyllites of the area investigated. Not to scale.

ichnofacies, which is characteristic for a flysch also in terms of sedimentological criteria. Especially *Helminthoida* is restricted to this ichnofacies, while *Chondrites* and *Taenidium* occur in other facies as well. Sedimentological data support these interpretation. In the section mentioned above, dark carbonates with allodapic beds that contain extraclasts occur. Extraclasts consist of neritic limestones with numerous fragments of corals and echinoderms, and shale clasts with Globigerinids imbedded in a pelitic, Globigerinid bearing matrix (Plate 1, Fig. 4). The neritic carbonate clasts cannot be derived from the succession of the pelagic Plattenkalk carbonates.

Ichnofauna and sedimentological observations indicate that the final clastics of the Plattenkalk Series show, at least in some parts, characteri-stics of a flysch depositional setting.

METAMORPHISM OF THE KASTANIA PHYLLITES

The metamorphic conditions of the Kastania Phyllites are not known in detail. DITTMAR & KOWALCZYK (1991) deduced from mineral assemblages including quartz, phengite, chlorite, pyrophyllite and chloritoid P > 3.4 - 4 kbar and T < 400 - 450. Studies of the vitrinite reflectivity and the illite cristallinity by MANUTSOGLU (1990) indicate very low grade to lowermost low grade metamorphic conditions.

At the eastern slope of Mavrovouna Mt. ca. 1 km southeast of Ag. Panteleimon (s. Fig.1), as well as at the eastern mountain range of the Taygetos Mts., carpholite has been found as an additional phase (s. Plate 1, Fig. 2). It appears as a green coloured mineral (up to 10 cm long and 0.1 - 1.5 mm wide) forming mainly sheaves and fibrous clusters.

Carpholite grew simultaneously with quartz segregations, while the mineral assemblage consisting of carpholite, pyrophyllite, chlorite and quartz was formed in the host rock (s. Fig. 1, locality II; Plate 1, Fig. 7 a+b). Both have been isoclinally folded.

To unambiguously identify the minerals, RDX and microprobe analysis (CAMECA SX 50; 15 KV, 20 nA; Univ. Gießen) were used. The results of the latter analysis are listed in Fig. 5.

The carpholite was identified as a (Fe, Mg)-carpholite with Fe-Mg composition ranging from XMg = 0.48 to 0.51. Considering both, XMg and the mineral paragenesis (carpholite + chlorite + pyrophyllite + quartz) it is possible to calculate the P-T conditions of the metamorphism of the Kastania Phyllites. Based on the experimental and thermodynamical data from VIDAL et al. (1992), P of 7 - 8.5 kbar and T of 310 - 360°C have been determined (s. Fig. 6), reflecting HP - metamorphic conditions.

These data correspond well with the metamorphic conditions obtained

	cph1	cph2	cph3	cph4	pyr1	pyr2	chl1	chl2
wt%								
SiO_2	37.62	37.49	36.99	37.52	67.13	67.22	24.11	24.13
Al_2O_3	30.51	30.58	29.35	29.58	27.00	27.01	23.89	22.93
MgO	6.16	5.94	5.62	6.00	0.06	0.06	10.96	11.22
MnO	0.21	0.22	0.20	0.15	n.d.	n.d.	0.10	0.06
FeO	11.89	11.67	12.64	12.26	n.d.	n.d.	24.17	24.27
Fe_2O_3	n.d.	n.d.	n.d.	n.d.	0.59	0.43	n.d.	n.d.
total	86.38	85.89	84.80	85.91	94.78	94.72	83.22	82.61
O=	8.00	8.00	8.00	8.00	22.00	22.00	28.00	28.00
Si	2.03	2.03	2.04	2.04	8.08	8.09	5.31	5.37
$Al_{(tot)}$	1.94	1.95	1.91	1.92	3.83	3.83	6.20	6.01
$Al_{(Si)}$							2.69	2.63
Al							3.52	3.38
Mg	0.50	0.48	0.46	0.49	0.01	0.01	3.60	3.72
Mn	0.01	0.01	0.01	0.01			0.02	0.01
Fe^{2+}	0.47	0.48	0.49	0.48				
Fe^{3+}	0.06	0.05	0.09	0.08				
$Fe_{(tot)}$	0.54	0.53	0.58	0.56	0.05	0.04	4.45	4.52
total	5.00	5.00	5.00	5.00	11.98	11.97	19.59	19.63
X_{Mg}	0.51	0.50	0.48	0.50			0.31	0.32

Fig. 5: Microprobe analysis data of the sample Am 44.91, carpholithe (cph), pyrophyllite (pyr) and chlorite (chl).

from the carbonate succession of the Plattenkalk Series, the latter including Aegirinejadeite and phengite (DITTMAR & KOWALCZYK 1991). Thus, it is likely that Kastania Phyllites and Plattenkalk carbonates have suffered their tectometamorphic overprint within the same geodynamic setting.

From the similar type of HP-metamorphism of both the Kastania Phyllites and the second metaclastic unit, the Phyllite-Quartzite Series (PQS) the question arises how these units can be distinguished. Differences between these units could be found in lithological and structural features as well as in the mineral parageneses that reflect the metamorphic conditions.

Both the Kastania Phyllites and the PQS are formed essentially by metamorphic clastic rocks. In the Kastania Phyllites, the phyllites predominate and quartzites are subordinated. Typical are metaconglomerates with red quartz clasts at the top of the succession. In contrast, metaquartzites are more abundant in the PQS. Furthermore metavolcanics and carbonates occur which have not been detected in the Kastania Phyllites so far. All mineral assemblages found in the Kastania Phyllites are also described from the PQS (i.e. THEYE & SEIDEL 1991, IGME 1990). But the latter additionally contains in some places epidote, garnet, glaucophane and aegirinjadeite. These minerals have not been detected in the Kastania Phyllites. Further, albite is only rarely found in the Kastania Phyllites, but it is abundant in schists of the PQS.

The peak P-T conditions of the metamorphism of the PQS have been estimated at 17 ± 4 kbar and 450 ± 30°C for the Peloponnesus (THEYE & SEIDEL 1991) reflecting distinctly higher metamorphic conditions than those recently reported for the Kastania Phyllites. But there are also reports about lower P-T conditions for the PQS of the Peleponnesus (BALTATZIS & KATAGAS

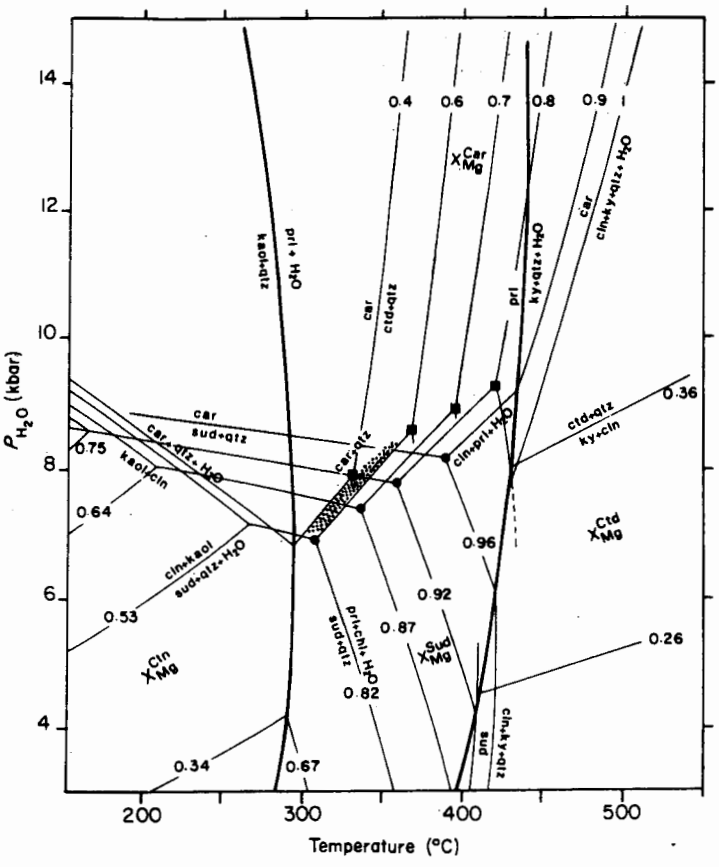

Fig. 6: Results of microprobe analysis plotted in the P-T grid of Vidal et al. (1992) (dotted area).

1984, BASSIAS & TRIBOULET 1985, DORNSIEPEN et al. 1986). Similarly, different lower P/T conditions, as mentioned above, have been reported recently for the Kastania Phyllites (e.g. DITTMAR & KOWALCZYK 1991, MANUTSOGLU 1990). These observations may imply that metamorphism in both units is inhomogeneous and both units are composed of successions different in metamorphism (cf. BLUMÖR & KOWALCZYK 1993).

The deformation structures of the Kastania Phyllites in the Taygetos Mts. include early recumbent isoclinal folds with NNE-SSW to NE-SW trending fold axes and west-facing, open to tight folds with NW-SE to N-S, subordinate to NNE-SSW trending fold axes. In the PQS of the southern Peloponessus the first folding is isoclinal with nearly E-W trending fold axes. Later folding is vergent with nearly NE-SW trending fold axes and (latest) with nearly NW-SE trending fold axes, forming an interference pattern. Especially in the Taygetos Mts. near the contact to the underlying Plattenkalk Series, the strike of fold axes in the PQS is often observed only in NW-SE to NNE-SSW direction. The PQS show intensive tectonic imbrications in most parts. In the Kastania Phyllites imbrications have only been found in contact to the overlying carbonates .

As stated above, the Kastania Phyllites and the PQS are not homogeneous considering their structure and metamorphism and parts of each unit can show many similarities. Especially in isolated outcrops, the distinguishing between the units can be difficult or impossible at present. In such cases the classification can mainly be obtained by detailed mapping.

GEOMETRIC AND STRUCTURAL ASPECTS

The map scale structure in the western Taygetos Mts. is marked by inclined to overturned, open to tight and isoclinal west-facing mega-folds. The back-limbs are detached which results in multiple thrusts within the succession of the Plattenkalk Series and the Kastania Phyllites. Similar to the direction of movements of the overlying units they are WSW-oriented. Already MANUTSOGLU (1990) reported such internal thrusts.

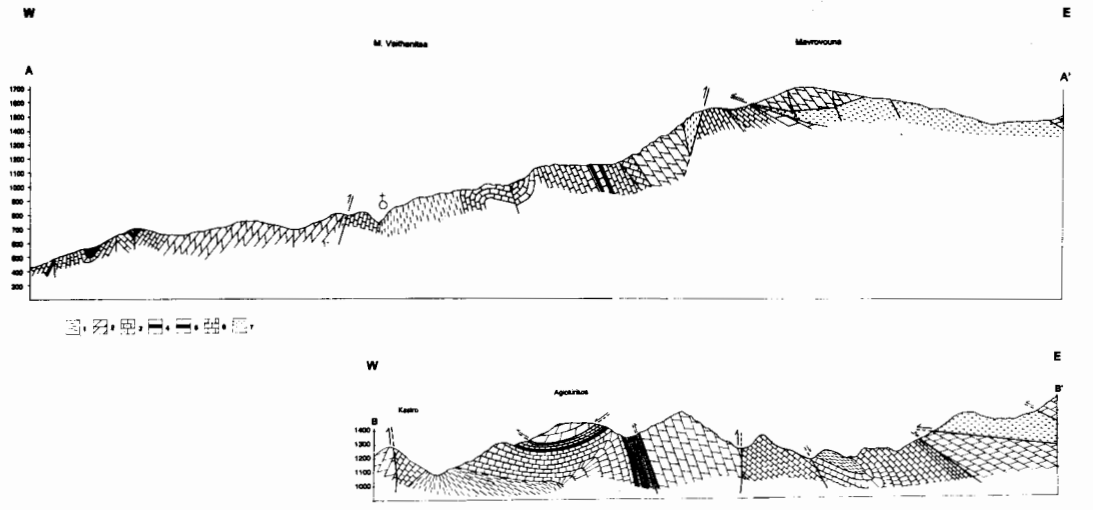

Fig. 7: Section A, Mavrovouna - M. Vaithenitsa; section B (locations s. Fig. 1). 1 - Kastania Phyllites; 2 - dolomitic marbles, undivided; 3 - chert bearing calcitic marbles; 4 - bedded cherts; 5 - thinbedded, dark calcitic marbles; 6 - multicoloured- and blue-grey marbles; 7 - "Plattenkalk Flysch" (Vathia Beds).

This type of structure becomes particular clear in the section from Saidona to the Mavrovouna Mt., where multiple tectonic stacks of the Plattenkalk Series and the Kastania Phyllites can be observed (Fig. 7). At the contact between the Plattenkalk Series and Kastania Phyllites, imbrications are developed.

Both the Plattenkalk Series and Kastania Phyllites have at least suffered the last act of folding together and they show a similar metamorphic overprint. This probably indicates that the Plattenkalk Series and the Kastania Phyllites have formed a previous stratigraphic succession, already assumed by PSONIS (1981) and DITTMAR & KOWALCZYK (1991). The tectonic contacts between both units, which mostly can be observed today, are due to differences in competence and, thus, in rheological behaviour. Characteristic features of the western Taygetos Mts. are parallel-running, NS-striking and west dipping back thrusts (s. Fig. 1, 7) (already noticed by THIÉBAULT 1982 in some places), indicating contra rotating east directed thrusts, which could be part of a triangle structure. Probably this back thrust zone marks the boundary of the area with intensive western transport of Plattenkalk Series and Kastania Phyllites. Except for the steeply dipping normal faults, these back thrusts represent the youngest movements related to the alpine deformation in the Taygetos Mts.

The data presented addresses the question of allochthony or parautochthony of these units. The low geothermal gradient, demonstrated by HP/LT-metamorphic conditions, is ascribed to subduction related burial to a depth in excess of 25 km. The lack of thermal equilibration indicates a rapid exhumation while the geothermal gradient was kept low by the still continuing subduction (cf. PLATT 1993). For the Plattenkalk Series including the underlying Kastania Phyllites, these geodynamic processes require a decoupling of their primary crustal basement. Moreover, the abundance of west-directed thrusts within the Plattenkalk-Series and the

Kastania Phyllites have to be considered. These thrusts are accompanied by further back thrusts, all of which may be parts of a triangle structure. Metamorphic conditions and structures of the Plattenkalk Series and the Kastania Phyllites suggest that both units are allochthonous, like the nappes forming the overlying units.

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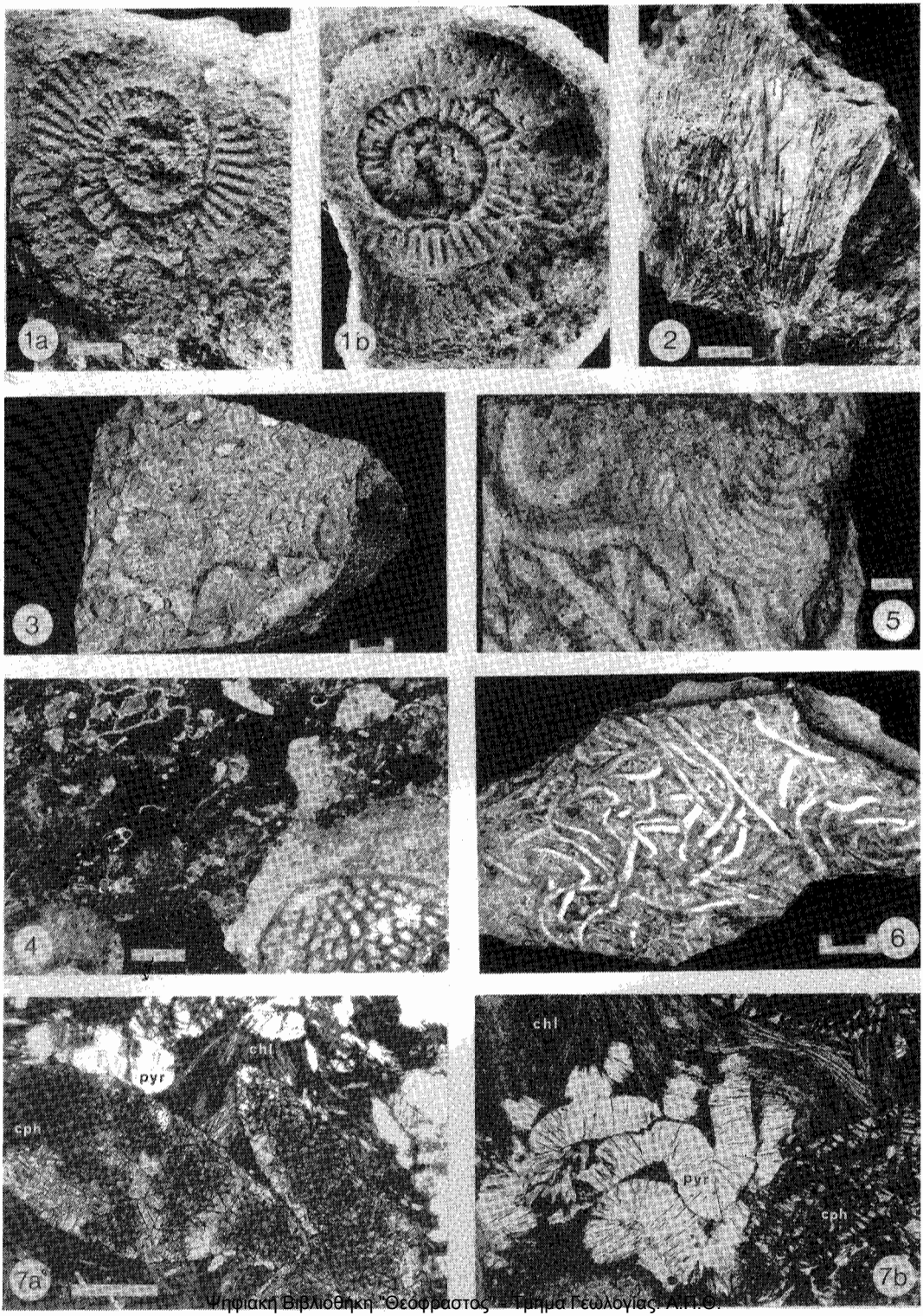
Plate 1: Fig. 1. a - Psiloceratid ammonoid (cf. *Megastomoceras*), Plattenkalk carbonates east of Saidona (location s. Fig. 1). Scale bar 1.5 cm. b - Silicone cast of specimen shown in Fig. 1. a.
Fig. 2. Carpholite in quartz veins, Kastania Phyllites southeast of Ag. Panteleimon (location s. Fig. 1). Scale bar 1 cm.
Fig. 3. Extraclast bearing-limestone within the "Plattenkalk Flysch" (Vathia Beds), north of Trachila village (location s. Fig. 4). Scale bar 1 cm.
Fig. 4. Thin section of extraclast bearing limestone, including neritic carbonates, and Globigerinids in the matrix, north of Trachila village (location s. Fig. 4). Scale bar 1 mm.
Fig. 5. *Helminthoida*, "Plattenkalk Flysch", north of Trachila village (location s. Fig 4). Scale bar 0.5 cm.
Fig. 6. *Taenidium*- and *Spirophycus*-like trace fossils, "Platten-kalk Flysch", north of Trachila village (location s. Fig. 4) Scale bar 1 cm.
Fig. 7 a, b. Paragenesis of carpholite (cph) - pyrophyllite (pyr) - chlorite (chl), Kastania Phyllites southeast of Ag. Panteleimon (location s. Fig. 1). Scale bar 0.2 mm.

PLATE 1



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