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THE METAMORPHICS UNDERLYING THE PLATTENKALK CARBONATES IN THE TAYGETOS MTS. (SOUTHERN PELOPONNESE)

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ABSTRACT

Metamorphic clastic rocks underlying the carbonates of the Plattenkalk series occur widespread in the central and southern Taygetos Mts. They consist of phyllites, quartz phyllites, metaquartzites, and conglomerates of at least 500-600 m thickness, and locally show an undisrupted succession into the overlying Upper Triassic dolomites of the Plattenkalk series. The metaclastics are overprinted by a lower greenschist facies metamorphism. The Plattenkalk carbonates and the underlying metaclastics show the same structural and metamorphic features. Therefore a uniform deformation and metamorphic history is considered.

INTRODUCTION

The Plattenkalk series, consisting of a Mesozoic - Early Tertiary carbonate sequence and Oligocene marls ("flysch"), is hitherto considered the lowermost tectonic unit on the Peloponnese (cf. AUBOUIN et al. 1976, JACOBSHAGEN 1986), its tectonic position being autochthonous resp. parautochthonous.

Contrary to the setting on Crete, the footwall of the Plattenkalk carbonates was unknown in detail on the Peloponnese. PHILIPPSON (1892) has reported only thin phyllites underlying the Plattenkalk carbonates and THIEBAULT (1982) also mentioned few clastics in this position. However, PSONIS (1981) first described a thicker succession of phyllites, metaquartzites, and conglomerates from the footwall of the Plattenkalk carbonates and mapped these metamorphics extensively on Xirokambion sheet (IGME 1983).

His observations, however, were subsequently not generally accepted. THIEBAULT & TRIBOULET (1984) interpreted the metaclastics described by PSONIS (1981) as parts of the Phyllite-Quartzite series (resp. the "formation de Lakkomata"), considering that these units form nappes overlying the Plattenkalk series. Also PAPANIKOLAOU & SKARPELIS (1987/88) did not mention metamorphic

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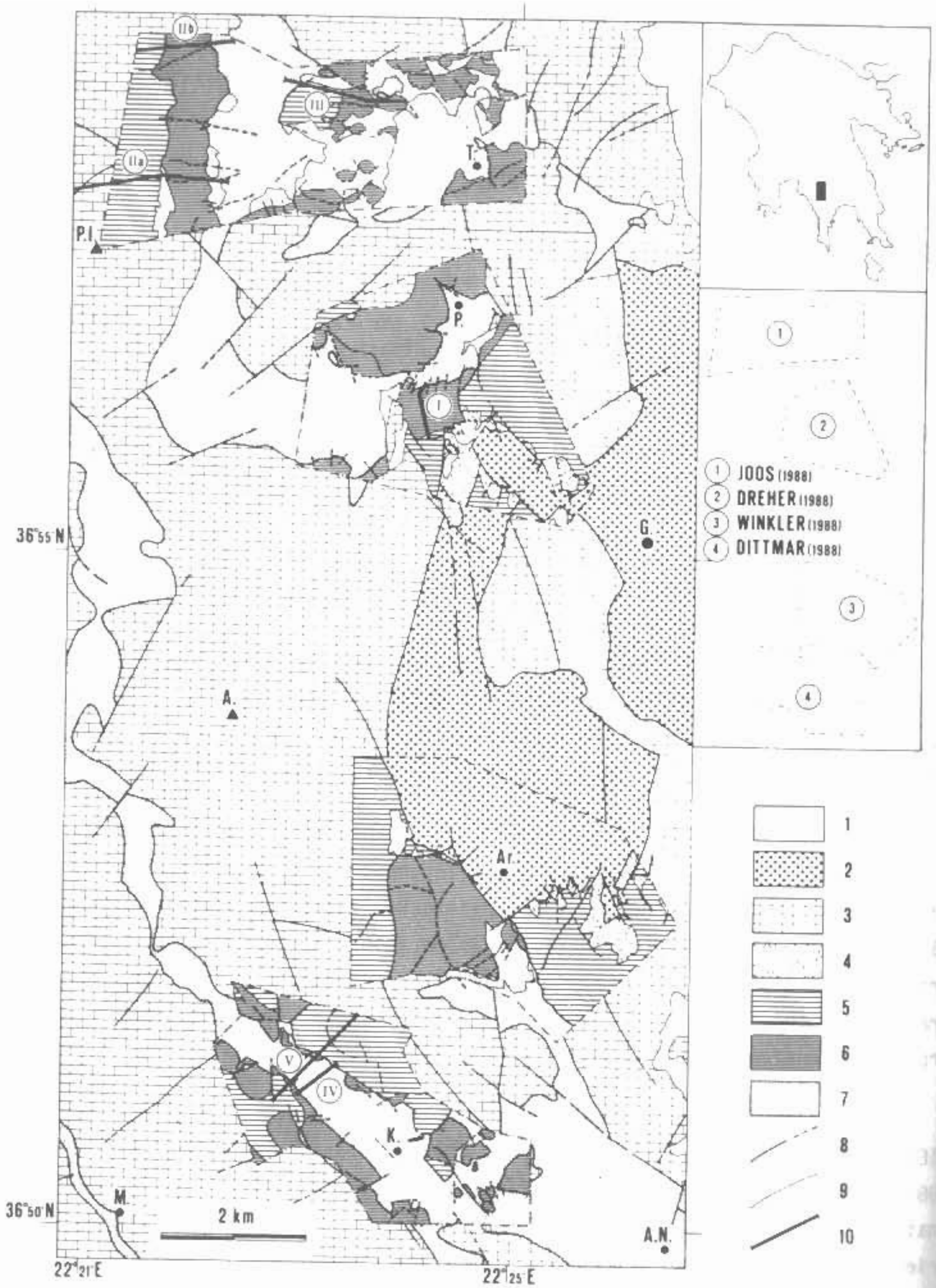


Fig. 1: Geological sketch map based on IGME (1983) and areas mapped in detail.

clastic rocks underlying the Plattenkalk carbonates as reported by PSONIS (1981).

To solve the contradictory interpretations, detailed mapping (scale 1: 10000) was undertaken in selected areas of the central and southern Taygetos Mts. (Fig. 1). These investigations confirm and extend the statements of PSONIS: at the tectonic footwall of the Plattenkalk carbonates a complex of 500 - 600 m thickness can be detected. In the following we will use the informal term "Kastania-Phyllites" for this complex (coined after the village Kastania, in which surroundings most of the characteristics of this complex can be observed).

FIELD OBSERVATIONS AND SUCCESSION

Metamorphic clastic rocks of the central and southern Taygetos Mts. have been known for a long time, but their relation to the different tectonic units is still discussed controversially. Most investigators, except PSONIS, attributed them to the tectonic hanging wall of the Plattenkalk series, e.g. the Phyllite-Quartzite series or parts of the Tyros Beds ("formation de Lakkomata", THIEBAULT 1982). The contrasting interpretations are based on the fact, that the carbonates overlying the metaclastics have been considered to represent parts of the Tripolitza series and do not belong to the Plattenkalk series. The reason for this is the similarity of the Upper Triassic - Lower Jurassic part in each sequence. Only successions younger than Lower Jurassic can be clearly differentiated lithologically in isolated outcrops.

Therefore it was generally necessary to prove that the carbonates directly overlying the metamorphic clastics are part of the Plattenkalk series. This can be successfully demonstrated in sections on the eastern side of the Taygetos Mts. (Fig. 2, 3).

Legend to Fig. 1: 1 - Neogene and Quaternary; 2 - Phyllite-Quartzite series; 3 - 6 - Plattenkalk series: 3 - carbonates, undivided; 4 - "flysch"; 5 - thinbedded marbles (mostly Cretaceous); 6 - massive carbonates (U. Triassic - Jurassic); 7 - Kastania-Phyllites; 8 - tectonic contact, dashed: assumed; 9 - geological boundary; 10 - locations of section I - V. A.N. - Agios Nikolaous; Ar. - Arna; G. - Gorani; K. - Kastania; M. - Milea; P. - Pentavlos; T. - Torisa; A. - Annina; P.I. - Profitis Ilias.

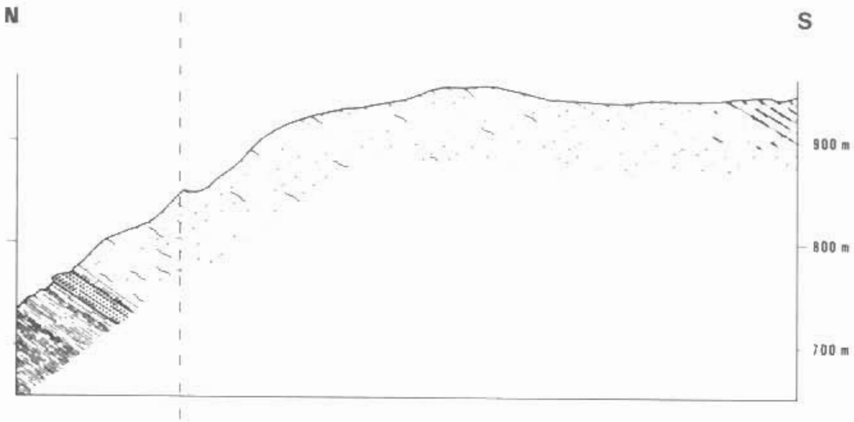
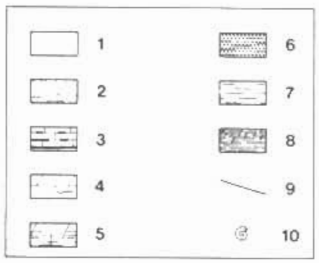


Fig. 2: Section I, southwest of Pentavlos; location s. Fig. 1.



Legend to Fig. 2 - 7

1 - debris; 2 - cataclastic rocks; 3 - thinbedded marbles and chert/carbonate alternation; 4 - massive marbles; 5 - brown dolomites with phyllitic intercalations; 6 - metaconglomerates; 7 - metaquartzites; 8 - phyllites; 9 - faults; 10 - fossil findings.

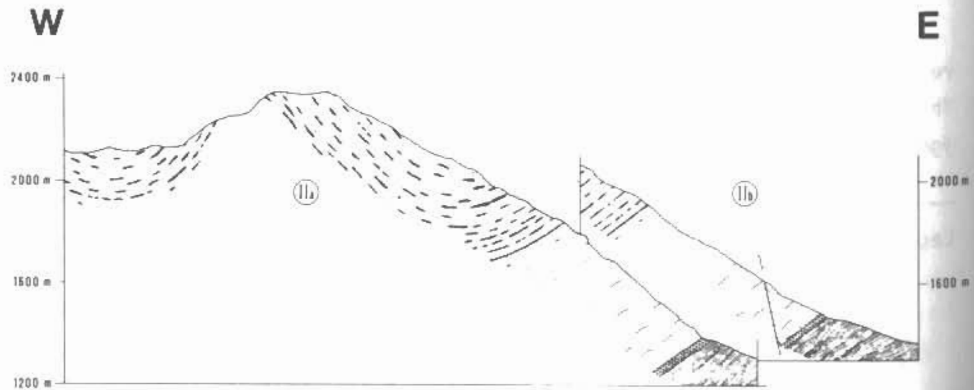


Fig. 3: Section IIa and IIb at the eastern slope of Profitis Ilias; location s. Fig. 1.

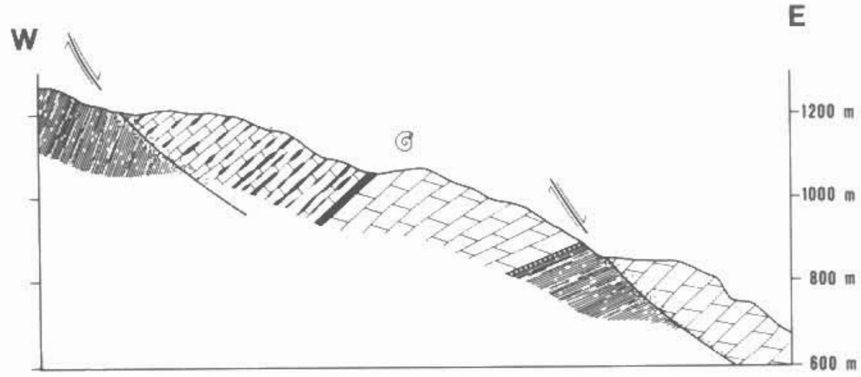


Fig. 4: Section III, northwest of Torisa; location s. Fig. 1.

Relatively simple structured sections occur in the neighbourhood of the village Pentavlos (s. Fig. 1). In the first example (Fig. 2) metaclastics are conformably overlain by thickbedded or massive, light coloured, stromatolithic and dolomitic marbles with some pelitic intercalations. Towards the top marbles follow with silified layers and lenses and chert nodules in their uppermost part. Without detectable faults or change in attitude the sequence is overlain by a chert/marble alternation. Such rocks are well known from the Plattenkalk carbonate sequence of this region, but do not occur in the sequence of the Tripolitza series. In the close surroundings of this section the uppermost part of the Plattenkalk series is exposed (multicoloured marbles and marls with Oligocene Globigerines, s. Fig. 1). Furthermore, high-pressure metaclastics and glaukophane bearing volcanics are placed upon these carbonates, separated by a flat, cataclastic thrust plane. These metamorphic rocks are part of the Phyllite-Quartzite series, resp. the Arna Unit (PAPANIKOLAOU & SKARPELIS 1987/88), which overlie the Plattenkalk series tectonically.
There is no reason to interpret the field observations in an other way than by the superposition of these metaclastics by carbonates, which belong to the Plattenkalk series - either tectonically or in the primary succession.

Sections, structured in the same way as demonstrated in Fig. 2, can be observed at the eastern slope of the Profitis Ilias (Fig. 3, 4; location s. Fig. 1). Here too thickbedded, light, dolomitic and stromatolithic carbonates overlie uniformly composed metaclastics, detectable over some km. These carbonates are

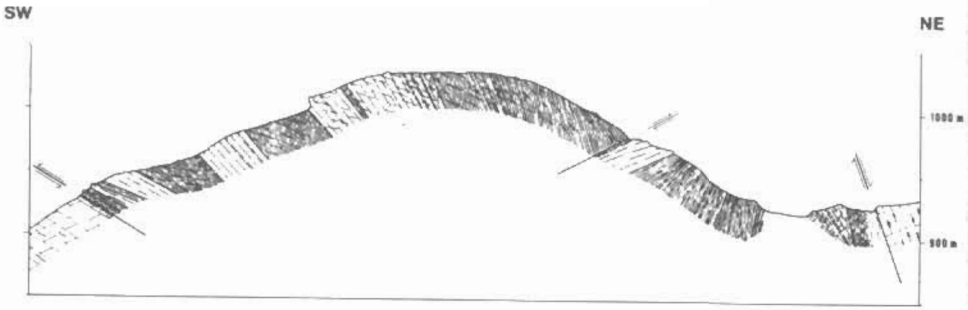


Fig. 5: Section IV near Moni Panagia Iatrissa; location s. Fig. 1.

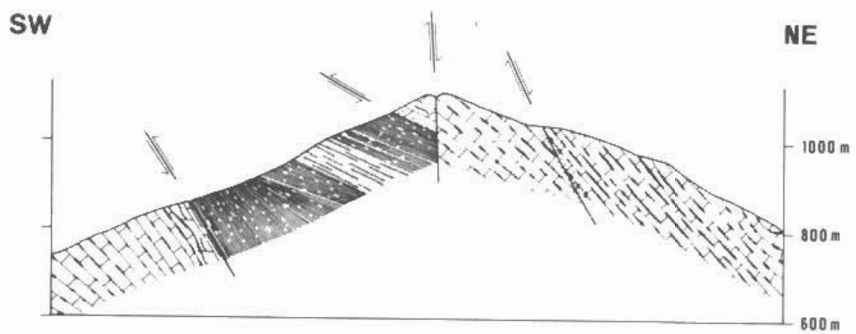


Fig. 6: Section V, northwest of Moni Panagia Iatrissa; location s. Fig. 1.

followed by dark, chert bearing marbles, which all investigators have attributed to the Plattenkalk carbonates.

Neither direct field observation nor geological mapping gave any indication, that the carbonate sequence of these sections is dissected by strike parallel normal faults with vertical displacements exceeding the thickness of the affected beds. Consequently, the light dolomites are part of the Plattenkalk sequence and do not form a separate unit.

Composition and sequence of rocks in the presented examples (Fig. 2, 3, 4) are quite similar to sections published by THIEBAULT (1977, 1982). However, there is one essential difference: in his sections the light, dolomitic marbles and the underlying metaclastics are separated from the chert bearing Plattenkalk

carbonates by steep dipping normal faults with vertical displacements exceeding the thickness of the Plattenkalk carbonates of this area. Consequently, THIEBAULT (1982) placed this unit into the tectonic hanging wall of the Plattenkalk series (as part of the "formation de Lakkomata").

However, in the area mapped there was no evidence for faults in that position with such a huge throw. As a consequence, the light, dolomitic marbles have to be attributed to the Plattenkalk carbonates, which overlie the complex of metaclastics. This confirms the observations of PSONIS (1981, IGME 1983) in general, but not in detail.

More complicated are the spatial relationships between the metaclastics and the Plattenkalk carbonates in the southern Taygetos Mts., e.g. in the surroundings of Moni Panagia Iatrissa west of Kastania village. In this region the metaclastics form an overturned large scale fold, covered by Plattenkalk carbonates, but dissected by thrust planes, back thrusts and normal faults (Fig. 5, 6).

LITHOLOGY AND DEFORMATION

The complex of the Kastania-Phyllites consists of a succession of phyllites and quartz phyllites alternating with quartzites as well as metaconglomerates (Fig. 7). Metavolcanics are unknown, as are evaporites and carbonates, except of few very thin dolomitic layers.

The phyllitic successions show a widespread alternation of characteristically thinbedded (mm - cm) silt-rich and phyllitic layers. These textures are partly of sedimentary origin (Pl. 1, Fig. a), but are locally also developed as differentiated layering. The long lateral extend of these banded successions indicates that they are affected only by weak shear deformation.

In the pelitic parts of the Kastania-Phyllites up to three, mostly homoaxial fold and cleavage generations can be detected (Pl. 1, Fig. b), striking NNW - SSE to NW - SE. A SW facing, gently inclined or recumbent isoclinal fold generation is often only recognizable as relics and corresponds to a widespread bedding-parallel slaty cleavage. These structures are commonly overprinted by SW facing, tight B_2-folds, which developed together with an also penetrative axial planar second cleavage. Contrary to that, upright to SW facing, moderately inclined, gentle to open B_3-folds with an incipient third cleavage can only

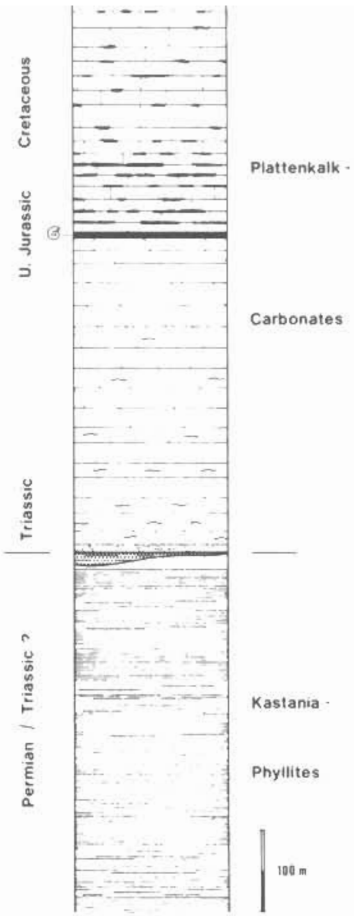


Fig. 7: Stratigraphic column, legend s. Fig. 2.

be observed locally.

The type of metamorphism, the complex has suffered is indicated by chloritoid, which occurs abundantly in the Kastania-Phyllites (Pl. 1, Fig. c). It grew synkinematically to the first and second cleavage, locally in association with pyrophyllite. We therefore assume a lower greenschist facies metamorphism for the Kastania-Phyllites (cf. FREY 1987). Because pyrophyllite has been detected only by X-ray diffraction analysis and the geochemistry of chloritoid has not yet been investigated, it is not possible to specify the exact P-T-range of the metaclastics. Using the calculations of SPEAR & CHENEY (1989) it may be above 4 kb and below 375°C.

The transition from the metaclastics to the overlying carbonates of the Plattenkalk series is not formed uniformely. At the eastern slope of the central Taygetos Mts. a conformable succession is developed. On the top of the metaclastics metaconglomerates of up to 20 m thickness occur. Their pebble association consists of quartz, quartzite and few schist components already foliated (Pl. 1, Fig. d).

Especially in the southeastern Taygetos Mts., e.g. in the neigbourhood of Moni Panagia Iatrissa, the boundary between the metaclastics and carbonates is formed by a thrust plane (s. Fig. 5, 6). The conglomerates and the adjacent phyllite and quartzite successions then show a mylonitic overprint with the development of asymmetric porphyroclast-, S-C- and shear-band-textures and are locally affected by a younger cataclastic deformation.

The metaconglomerates persist over some km on the eastern slope of the Taygetos Mts. and are overlain by conspicuous yellow-brown dolomites, which are often phyllosilicate-rich and show widespread cataclastic deformation. In general, the character of the transition between Kastania-Phyllites and Plattenkalk carbonates can be explained most reasonable in terms of a - former - sedimentary sequence.

However, on the western side of the Taygetos Mts. (e.g. in the area between Milea and Neochori) after hitherto existing field observations this boundary seems to be marked by an imbrication. This imbrication is probably generated by a NE dipping detachment, cutting the former continuous sequence at different levels. Therefore the autochthony of the Plattenkalk series may be in question.

The sequence of the Plattenkalk carbonates is largely identical with the successions already described by THIEBAULT (1977, 1982) or BASSIAS & THIEBAULT (1985). The sequence starts with massive dolomitic marbles of several 100 m thickness, showing stromatolithic structures at its base (s. Fig. 7). The whole succession is similar in facies to the Ionian Pantokrator Limestone and overlying beds. They are superimposed by well bedded, chert bearing marbles and a characteristic chert/carbonate alternation, 10 - 20 m in thickness.

Macrofossils with *Lamellaptychus* sp. were observed for the first time at the base of the chert/carbonate alternating sequence west of Xirokambion (Pl. 1, Fig. e; location s. Fig. 4). They indicate probably an Upper Jurassic age. These fossil findings may be additional evidence, that the Plattenkalk sequence in the

Taygetos Mts. show more affinities to the Ionian series than to the Preapulian series, as already demonstrated by the French school of investigators (in contrast to the former German opinion, cf. JACOBSHAGEN et al. 1976, but see also BASSIAS et al. 1987).

The succession of the Plattenkalk carbonates, however, suffered a metamorphism, as indicated by the recrystallization of quartz and the occurrence of chloritoid in thin, phyllitic intercalations (Pl. 1, Fig. f). Chloritoid is found not only in the basal dolomitic carbonates, but also in the chert bearing marbles, belonging doubtless to the Plattenkalk series. The occurrence of chloritoid in the Plattenkalk carbonate sequence matches very well with the results from Crete presented by THEYE (1988).

Also in the Plattenkalk carbonates up to three, mostly homoaxial fold generations are developed. Additionally, three corresponding cleavages can be identified within the phyllosilicate rich intercalations (Pl. 1, Fig. g, h). The first fold generation consists of inclined, SW facing or recumbent, tight to isoclinal B_1- folds in dimensions of cm to m, formed with a widespread recognizable first cleavage. Subsequently, SW facing, gentle to open B_2-folds occur on m-scale, accompanied by a spaced s_2- cleavage and locally followed by a weak third cleavage. The most prominent structure, however, is a NNW - SSE to NW - SE striking, overall large-scale folding, probably generated with the B_2-folds. These mega-folds with fold wavelengths partly over 1 km include the Plattenkalk carbonates as well as the Kastania-Phyllites (s. Fig. 6). Locally, as e.g. near Moni Panagia Iatrissa, these mostly W facing, open or close, inclined to overturned mega-folds are dissected by E dipping thrust faults with a marked tectonic thinning of the fold limbs (Fig. 6).

The similarity of the structural development and metamorphic overprint as well as the formation of large-scale fold structures leads to the assumption, that the Kastania-Phyllites and the Plattenkalk carbonates underwent a uniform metamorphic and tectonic history.

CONCLUSION

In the central and southern Taygetos Mts. the Plattenkalk carbonates are underlain by a thick succession of metamorphic clastic rocks, which are affected by a greenschist metamorphism, multiple folding and cleavage formation.

The metaclastics underlying the Plattenkalk carbonates can - by present knowledge - be differentiated from the metamorphics of the Phyllite-Quartzite series by the lack of volcanics and carbonates. Evaporites also have not been observed. Furthermore the internal deformation type of the clastics underlying the Plattenkalk carbonates is characterized by homoaxial fold generations and large-scale folding. In contrast, the metamorphics of the Phyllite-Quartzite series are marked by strong shear deformation with only local homoaxial structures.

The Plattenkalk carbonates, however, show the same type of deformation as the underlying metaclastics and the same content of metamorphic minerals. Although the boundary between these two units is either conformable or formed by a thrust plane, we suggest, according to present knowledge, that a - former - sedimentary sequence has existed, which suffered a uniform tectonic and metamorphic history. However, until this suggestion has been verified, the metaclastics should not be attributed to the Plattenkalk series, but classified as a separate unit. For this we propose the informal term "Kastania-Phyllites".

So far biostratigraphical determinations of the Kastania-Phyllites do not exist. Assuming a conformable succession, the only age constraint is given by the Upper Triassic age of the basal part of the Plattenkalk carbonates (THIEBAULT 1982). Accordingly, one can suggest an approximately similar stratigraphic extent for the Kastania-Phyllites (Permian - Upper Triassic) as for the Phyllite-Quartzite series (DOERT et al. 1985) or the Tyros Beds of the Peloponnese (THIEBAULT 1982).

There is little lithological similarity between the underlying sequences of the Plattenkalk carbonates on Peloponnese and on Crete, though they are considered to occupy the same stratigraphic position. Whereas on Crete the Upper Triassic Stromatolithic Dolomite is underlain by sequences containing thick carbonates, on Peloponnese just clastics occur (cf. new classification of the succession on Crete by KRAHL et al. 1988).

Because of the type of deformation and metamorphism the autochthonuous character of the Plattenkalk series is uncertain.

Plate 1

Fig. a - d: Kastania-Phyllites

a - banded phyllites; b - microtextures in phyllites; c - chloritoid in phyllites; d - metaconglomerates.

Fig. e - h: Plattenkalk carbonates

e - *Lamellaptychus* sp. from the chert/carbonate alternation; f - chloritoid from phyllosilicate rich layers in the chert bearing marbles; g - macrotextures in thinbedded marbles; h - microtextures in a phyllitic layer.

REFERENCES

AUBOUIN, J.; BONNEAU, M.; DAVIDSON, J.; LEBOULENGER, P.; MATESCO, S. & ZAMBETAKIS, A. (1976): Esquisse structurale de l'Arc égéen externe: des Dinarides aux Taurides.- Bull. Soc. géol. France, (7) **18**: 327-336.

BASSIAS, J. & THIEBAULT, F. (1985): Les "plattenkalk" du Parnon (Péloponnèse oriental, Grèce): confirmation de leur rattachement à la zone ionienne; données préliminaires sur leurs charactéristiques structurales et métamorphiques.- Bull. Soc. géol. France, (8) **1**: 495-501.

-- ; SALOMON, D. & JACOBSHAGEN, V. (1987): Upper Cretaceous fossils from the Plattenkalk series of the Parnon (Peloponnesus, Greece).- N. Jb. Geol. Paläont. Mh., **1987** (8): 449-466.

DOERT, U.; KOWALCZYK, G.; KAUFFMANN, G. & KRAHL, J. (1985): Zur stratigraphischen Einstufung der "Phyllit-Serie" von Krokee und der Halbinsel Xyli (Lakonien, Peloponnes).- Erlanger geol. Abh., **112**: 1-10.

FREY, M. (ed.) (1987): Low temperature metamorphism.- 351 pp.;(Blackie) Glasgow, London.

IGME (1983): Geological map of Greece, 1 : 50000, Xirokambion sheet.

JACOBSHAGEN, V. (1986): Geologie von Griechenland.- 363 pp.; (Borntraeger) Stuttgart.

-- ; MAKRIS, J.; RICHTER, D.; BACHMANN, G.H.; DOERT, U.; GIESE, P. & RISCH, H. (1976): Alpidischer Gebirgsbau und Krustenstruktur des Peloponnes.- Z. dt. geol. Ges., **127**: 337-363.

KRAHL, J.; RICHTER, D.; FÖRSTER, O.; KOZUR, H. & HALL, R. (1988): Zur Stellung der Talea Ori im Bau des kretischen Deckenstapels.- Z. dt. geol. Ges., **139**: 191-227.

PAPANIKOLAOU, D. & SKARPELIS, N. (1987/88): The blueschists in the external metamorphic belt of the Hellenides: composition, structure and geotectonic significance of the Arna unit.- Ann. géol. Pays hellén., **33**: 47-68.

PHILIPPSON, A. (1892): Der Peloponnes - Versuch einer Landeskunde auf geologischer Grundlage.- 642 pp.; (Friedländer und Sohn) Berlin.

PSONIS, K. T. (1981): Presence of Permo (?) Lower triassic beds at the base of the Plattenkalk series in Taygetos. Description of a continuous section.- Ann. géol. Pays hellén., **30**: 578-587.

SPEAR, F. S. & CHENEY, J. T. (1989): A petrogenetic grid for pelitic schists in the system SiO_2 - Al_2O_3 - FeO - MgO - K_2O - H_2O.- Contrib. Mineral. Petrol., **101**: 149-164.

THEYE, T. (1988): Aufsteigende Hochdruckmetamorphose in Sedimenten der Phyllit-Quarzit-Einheit Kretas und des Peloponnes.- Thesis, 224 pp.; Braunschweig.

THIEBAULT, F. (1977). Établissement du caractère ionien de la série des calcschistes et marbres ("Plattenkalk") en fenêtre dans le massif du Taygète (Péloponnèse - Grèce).- C. R. somm. Soc. géol. Fr., **3**: 159-161.

-- (1982): Evolution geodynamique des Héllénides externes en Péloponnèse méridional (Grèce).- Soc. géol. Nord, Publ. **6**: 1-574.

-- & TRIBOULET, C. (1984): Alpine metamorphism and deformation in Phyllites nappes (external Hellenides, southern Peloponnesus, Greece): geodynamic implications.- J. Geol., **92**: 185-199.

DITTMAR, U.; DREHER, T.; JOOS, C.; WINKLER, B. (1988): Unpubl. Diploma-Thesis; Frankfurt am Main.

Plate 1