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A LITHOSTRATIGRAPHIC CORRELATION OF THE PLATTENKALK OCCURRENCES OF CRETE (GREECE)

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ABSTRACT

Lithological investigations of the Plattenkalk occurrences of western, central and eastern Crete lead to a lithostratigraphic subdivision of the Cretan Plattenkalk group and to a revision of its stratigraphic nomenclature. Our investigations revealed considerable changes in the sedimentary facies. Terrigenous influences can be traced throughout the group. Siliciclastic input is widespread, but there is a decrease from west to east. Sedimentological rhythmicity is common in large parts of the Plattenkalk group, but turbidites are absent. Our results point clearly to differences in the depositional history of the Plattenkalk group and the sedimentary sequences of the Ionian zone. We support the model that the Plattenkalk group represents the stable, but structured shelf of the Adria microplate.

KEY WORDS: Crete, Plattenkalk group, nomenclature, lithostratigraphic correlation, palaeogeography

1. INTRODUCTION

In the external Hellenides a belt of HP/LT metamorphic rocks is exposed, which mainly consists of metasedimentary and / or metavolcanic sequences of Palaeozoic to Tertiary age. They belong to different lithostratigraphic groups, which are believed to represent different isopic zones, now being arranged in a pile of tectonic nappes (e.g. AUBOUIN et al. 1963, JACOBSHAGEN et al. 1978, JACOBSHAGEN 1986). From bottom to top these are the Plattenkalk group, believed to be autochthonous or parautochthonous by many authors (e.g. EPTING et al. 1972, BONNEAU 1973, KÖNIG & KUSS 1980, WACHENDORF et al. 1974), and the overlying nappes of the Trypali Unit (e.g. Omalos nappe, restricted to Crete), the Phyllite-Quartzite group and the Tyros group, the latter being the original basement of the non- to very low grade metamorphic Tripolitza limestone of the Tripolitza group (e.g. MANUTSOGLU et al. 1993).

In this paper, we shall try to draw out a lithological correlation between the occurrences of the Plattenkalk group of the Talea and the Ida Ori (central Crete) with those of the Lefka Ori (western Crete) and of the Mirabello peninsula (eastern Crete), based on field observations during 1992 and 1997. To our knowledge, no such attempt has been made so far to this extent, although some publications point to that direction (comp. HALL & AUDLEY-CHARLES 1983, KRAHL et al. 1988). Correlations with the Plattenkalk group of the Peloponnesus are possible as well and will be presented in future publications. Each chapter will be introduced by the state of research, followed by our observations.

We also present a recommendation for a lithologic subdivision of the Plattenkalk group, maintaining the term "Plattenkalk" because of historic reasons. Previous workers often subdivided and termed the group mixing lithostratigraphic, chronostratigraphic or neutral criteria, resulting in a variety of terms for its members (comp. MANUTSOGLU et al. 1995a for a compilation). A chronostratigraphic division of the Plattenkalk group would be desirable, but since the biostratigraphic data are still very incomplete, this paper is confined to a lithostratigraphic subdivision. The stratigraphic terms are revised according to the

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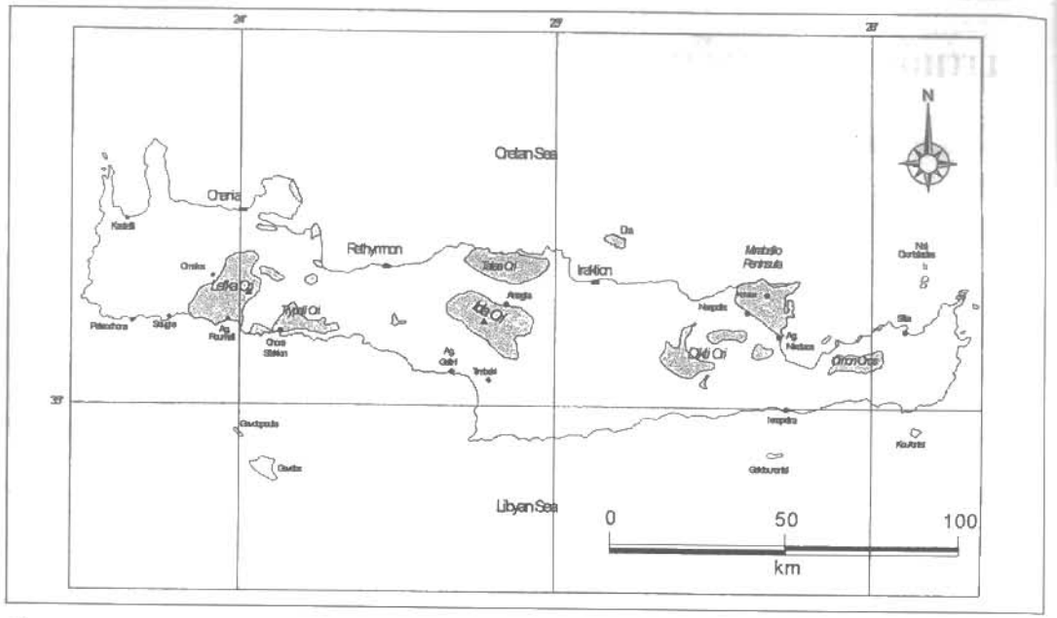

Fig. 1: Distribution of the Plattenkalk group on Crete

2. SUBDIVISION AND NOMENCLATURE OF THE PLATTENKALK GROUP OF CRETE

Recently, MANUTSOGLU et al. (1995a) had already proposed a unification of the subdivision and the nomenclature of the metamorphic rocks of Crete. Within the Plattenkalk group we find, however, lithological terms like "Stromatolithic Dolomite" or "Plattenkalk" mixed up with names of locations (e.g. "Kalavros", "Fodele" or "Sisses"). Therefore we hereby propose a new terminology, which is in harmony with the rules of stratigraphy (Tab.1). With our terminology we do not change any lithostratigraphic boundaries, but follow the traditional subdivisions.

We also avoid to transfer the stratigraphic termini of the Ionian series to the Plattenkalk group ("Pantokrator limestone", "Viglaes beds", "Upper Posidonia schist" etc.) because we don't agree with the hypothesis that the Plattenkalk group is a metamorphic part of the Ionian series (see "conclusions and discussion").

This work			MANUTSOGLU et al. (1995a)	
Plattenkalk group	Kalavros formation		Plattenkalk group	Kalavros formation
	Aloides formation			Plattenkalk formation
	Mavri formation			Stromatolithic Dolomite formation
	Sisses formation	Talea Ori Subgroup		Sisses formation
	Fodele formation (incl. Galinos member)			Fodele formation (incl. Galinos member)

Tab. 1: Proposed unified subdivision and nomenclature of the Plattenkalk group of Crete, compared with Manutsoglu et al. (1995a)

early Mesozoic age, are only exposed in the Talea Ori, whereas members of the Plattenkalk group as well be localised in other areas of the island. We therefore suggest a grouping of the Fodele- and Sisses formations into a Talea Ori subgroup.

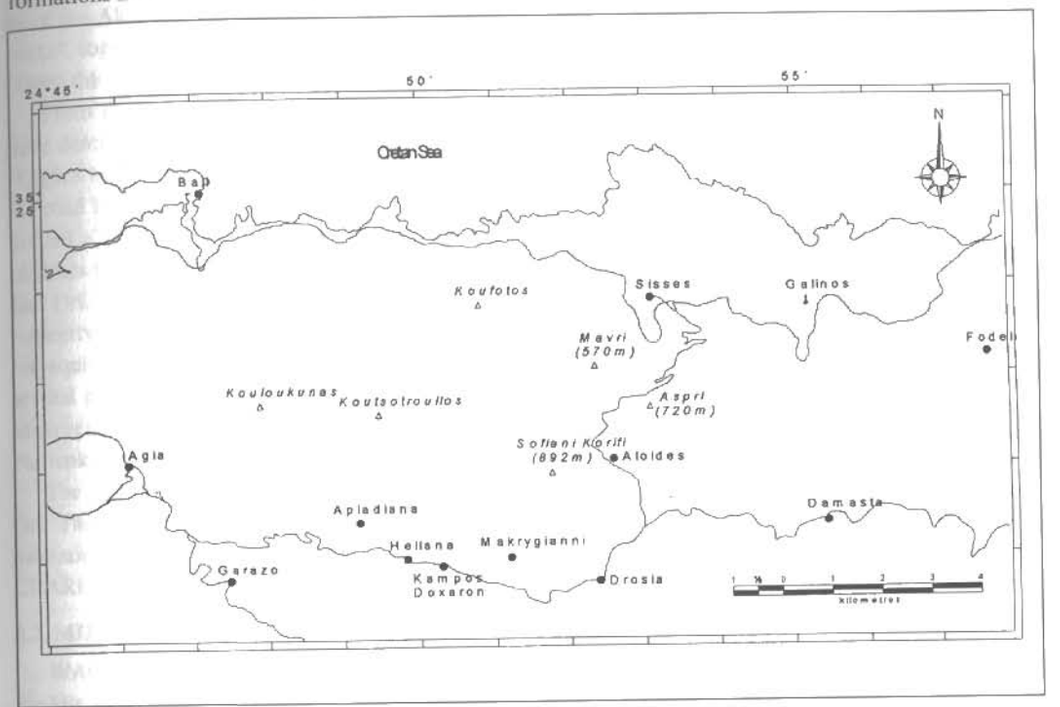

Fig. 2: Type localities of the Cretan Plattenkalk group in the Talea Ori, Crete

The members of the Mavri formation have been described by many authors (e.g. EPTING et al. 1972, HALL & AUDLEY-CHARLES 1983). They are well exposed at the northern part of the road from Sisses to Aloides (fig.2) in the Talea Ori. A similar profile is exposed at the eastern slope of the adjacent Mt. Mavri (fig.2), which was named by the local people after its dark appearance caused by the stromatolithic layers (mavros = gr. black). Therefore, we suggest Mt. Mavri as the type locality of the formation and rename the former Stromatolithic Dolomite formation into Mavri formation.

All the members of the Aloides formation are exposed in the area from the pass Stavros between Mt. Mavri and Mt. Aspri, following the road from Sisses to Aloides, and at Mt. Sofiani Korifi, west of Aloides, from its beginning in the north to the foothills at the old road from Heraklion to Rethymnon. Because Aloides is centring these localities, we have named the formation after that village (fig.2).

3. REGIONAL STRATIGRAPHY

3.1. TALEA AND IDA ORI

Detailed stratigraphic investigations of the Plattenkalk group of Crete island had previously concentrated mainly on the Talea and Ida Ori of central Crete (BONNEAU 1973, EPTING et al. 1972, HALL & AUDLEY-CHARLES 1983, KÖNIG & KUSS 1980, KRAHL et al. 1988, KUSS & THORBECKE 1974). These areas contain the complete stratigraphic range of the Plattenkalk group from the Carboniferous/Permian border (Galinos member of the Fodele formation, KÖNIG & KUSS 1980) to the early Oligocene (Kalavros formation, BONNEAU 1973, FYTROLAKIS 1972). The sequences of the Talea Ori are overturned, whereas those in the Ida Ori are in a normal position.

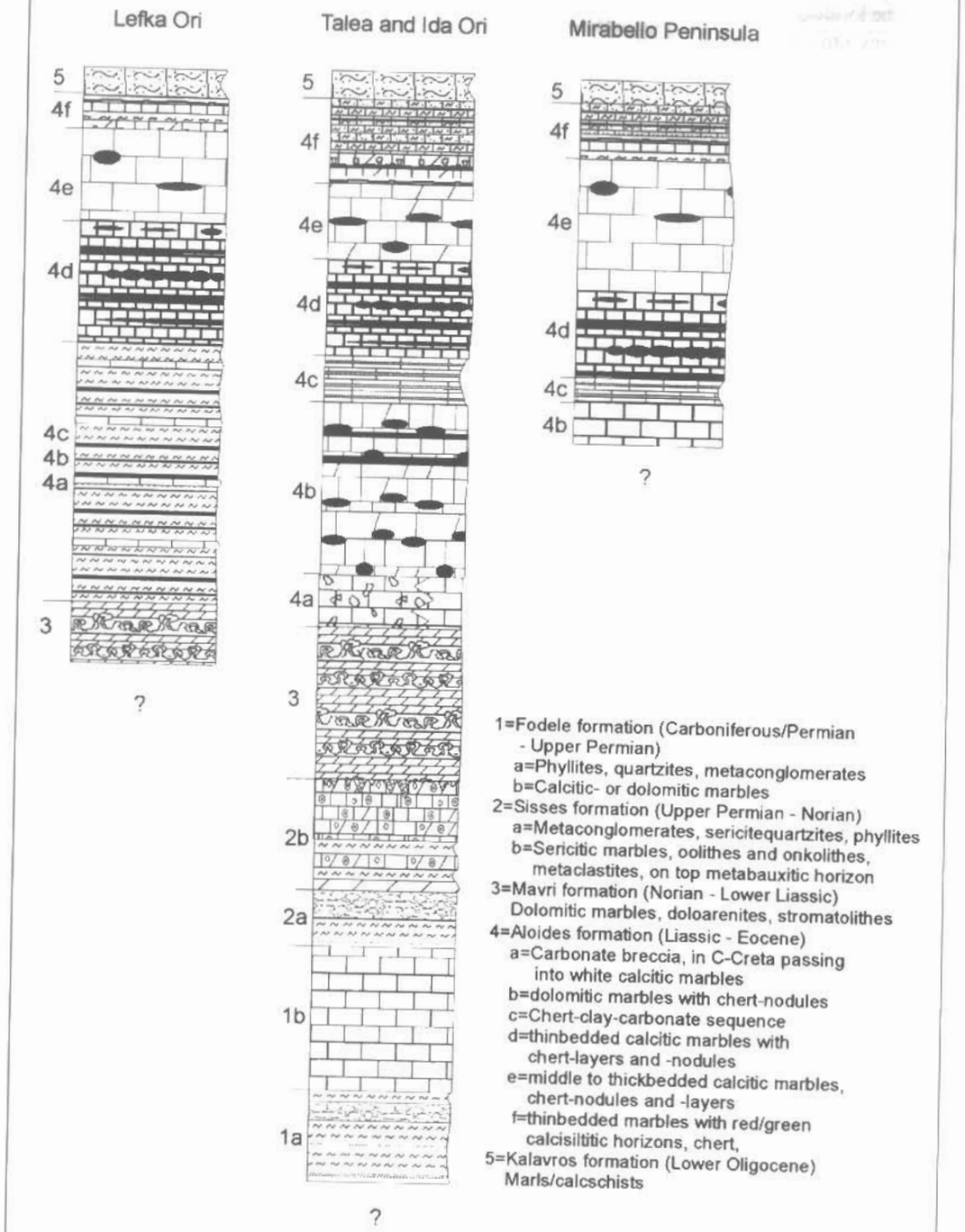

Fig. 3: Simplified stratigraphical columns of the Plattenkalk group of Crete

we shall concentrate our explanations on the overlying Mesozoic to Tertiary members of the group. A compilation of the sedimentological features of these members was given by HALL & AUDLEY-CHARLES (1983). These authors, however, put erroneously the quartzitic schists near Aloides (member 4c of the Aloides formation, formerly described by EPTING et al. 1972) into a system of "metamorphic rocks", together with the Fodele and Sisses formations and the Phyllite-Quartzite group. In KRAHL et al. (1988) this concept had already been revised.

From the tectonically deepest exposed parts of the cherty limestone sequence KRAHL et al. (1988) have described locally green phyllites intercalated by marble beds. They correlated these rocks with the "Gigilos beds" of the Lefka Ori (FYTROLAKIS 1980, compare also chapter "Lefka Ori"). Following the old road Heraklion - Rethymnon from Drosia to Kampos Doxaron for about 2 km, at the foothills of Mt. Sofiani Korifi, one encounters a sequence of calcite marbles, cherty layers and intercalations of green phyllites to calcschists. Also embedded are very characteristic green calcisiltitic horizons, known from the Ida Ori. They represent the very top of the formation (the tectonically deepest exposed parts, respectively), elsewhere underlying the Kalavros formation (member 4f of the Aloides formation), and are not equivalents of the "Gigilos beds". Equivalents of the "Gigilos beds" (member 4c) are also exposed in several places of the Talea Ori, but farther to the north (e.g. west of Aloides at Mt. Sofiani Korifi, at Makrygianni, at Agia). Thus, we have evidence for the first time, that in the Talea Ori all members of the Plattenkalk group are exposed, with the only exception of the Kalavros formation (fig.3).

The calcschists of the Kalavros formation are exposed farther to the south near Garaso and in the Ida Ori. The term "Plattenkalk flysch" repeatedly referred to by several authors for the members of this formation is misleading, since they do not consist of typical flysch sediments (HALL & AUDLEY-CHARLES 1983 and own observations).

3.2. MIRABELLO PENINSULA (EASTERN CRETE)

WACHENDORF et al. (1980) had already published stratigraphic data from the Plattenkalk group of the Mirabello peninsula (Eastern Crete). They described only cherty limestone sequences ("Plattenkalke"), suggesting that the underlying units are not exposed there and the overlying Kalavros formation was tectonically suppressed. These authors subdivided the rocks lithostratigraphically into three units, according to the amount of cherty layers or horizons of chert nodules embedded, supposing that the sequence was not overturned: The base containing more than three layers of chert per meter (about 200 m thick), a transitional zone with 1–3 chert-layers per meter (about 80 m thick) and an upper unit with less than one chert layer per meter (about 1300 m thick).

This sequence corresponds with the members 4d and 4e of the Aloides formation (fig.3). It is a typical feature of these members of the group and not restricted to eastern Crete that the chert layers diminish towards the upper parts of the sequence, although we cannot agree with the numerical method of WACHENDORF et al. (1980). These authors also mentioned thick limestone layers with numerous chert nodules of irregular shape and differing size repeatedly intercalated in the basal unit. According to our observations, it is characteristic for member 4d of the Aloides formation throughout Crete that the "chert nodules" are solitary lithistide sponges, which may be of round or irregular shape.

In the areas of Neapolis and Agios Nikolaos member 4d is underlain by a silica-rich bed with a high content of clay minerals and carbonates. It's thickness varies from a few decimetres up to 3 m. Near Neapolis these rocks are again underlain by grey, coarse-grained, thick-bedded to massive calcite marbles with only very few chert nodules. Only a few metres of them are exposed, the entire thickness is unknown. These two rock-types are correlated with the members 4c and 4b of the Aloides formation (fig.3), the member 4b representing the so far deepest known part of the Plattenkalk group in eastern Crete.

Following the road from Neapolis to Nofalias (fig.1) and leaving Kouroumes towards the northern coast, thin bedded limestones with some red or green calcisiltitic horizons and chert-layers are observed at several localities, normally overlying member 4e. These very characteristic rocks correspond with

reddish or greenish calcschists of the Kalavros formation, which are often mylonitised and tectonically overlain by brecciated limestones of the Tripolitza group. The thickness of these members of the Plattenkalk group can not be estimated exactly, as the outcrops are bad. We suggest only a few metres for each type of rock.

3.3. LEFKA ORI (WESTERN CRETE)

In the Lefka Ori of western Crete, especially the area of the Samaria National Park has been investigated geologically in former times. TATARIS & CHRISTODOULOU (1965, 1969) have been the first to describe a "system underlying the platy crystalline limestones" which consists of phyllites and limestones / dolomites, for which they suggested a Carboniferous age. According to CREUTZBURG & SEIDEL (1975) a correlation with the sequences underlying the "Plattenkalk" in the Talea Ori (EPTING et al. 1972) is not possible. FYTROLAKIS (1978) mentioned flysch-like sediments beneath the platy limestones which he thought to be equivalents of the Fodele, Sisses and Mavri formations of the Talea Ori. Later he named them "Gigilos beds" after Mt. Gigilos at the entrance of the Samaria gorge, which is the type locality of these strata (FYTROLAKIS 1980).

Profiling in the Samaria Gorge and in the area north of Poria (a mountain rescue service station), supported by investigations near Chora Sfakion and the Klados gorge led to the following results (fig.3):

The stratigraphic spectrum of the Plattenkalk group of the Lefka Ori reaches from the Kalavros formation far into the Mavri formation, but not beyond it. The sequence is not overturned. Mt. Gigilos consists mainly of whitish to grey dolomites, partly stromatolithic. Like in the Talea Ori (EPTING et al. 1972, HALL & AUDLEY-CHARLES 1983 and own observations), we observe tempestites and intercalations of thin, reddish phyllites as well as intraformational breccia.

The "Gigilos beds" overly the dolomites normally, with well exposed contacts at Mt. Gigilos itself and about 1,5 km north of Samaria village. At the base and in the upper parts they consist mainly of multicoloured phyllites or calcschists, the latter looking similar to those of the Kalavros formation. With the onset of this clastic sedimentation we recognise also the appearance of lithistide sponges. The middle part of the "Gigilos beds" consists of rhythmic sequences of pelites, chert (dense colonies of silicosponges), and carbonates, the latter being mostly concentrated on intercalated beds of about 1,5 m thickness, containing numerous individuals of silicosponges everywhere (see "Mirabello peninsula"). The thickness of the "Gigilos beds" is about 500 m. Between the Mavri formation and the typical chert-bearing platy limestones, horizons of siliciclastic material are intercalated throughout Crete (Trypali Ori, Talea Ori, Mirabello peninsula; 4c in fig.3). Those are equivalents of the "Gigilos beds" of the Lefka Ori, although generally of a much lesser thickness. The members 4a and 4b, overlying the Mavri formation elsewhere on Crete, are completely substituted by the facies of the "Gigilos beds".

The transition from the "Gigilos beds" (4c) to member 4d of the Aloides formation is – as elsewhere on Crete - abrupt, and characterised by the ending of the siliciclastic input. It is well exposed e.g. north of Poria at the western slopes of Mt. Axes. There follows a pile of about 900 m, which is dominated by a rhythmic change of platy to thin-bedded carbonates with intercalated layers or nodules of chert, known as the typical "Plattenkalk". Most of the silica phase originated in lithistide silicosponges, to be recognised not only by the shape of the individual sponges, but also by spongocoels often filled with calcite/dolomite. It is noteworthy that the dense facies of the sponges of member 4c is trespassing the border to member 4d, but being replaced by more loose occurrences towards the upper parts of the sequence. At irregular intervals, thick carbonate layers with numerous individuals of round or irregularly shaped lithistides are intercalated, which points to cyclic sedimentary events. The carbonate sedimentation was interrupted several times by the input of fine-grained siliciclastic material, forming separate horizons.

The transition to member 4e of the formation is fluently and marked by a decrease of chert (sponge) layers until nearly total absence and an increase of the thickness of the calcitic,

passes into about 250 m of thin-bedded to platy calcitic marbles without chert.

The following sequence is characterised by an increase in chert (sponges) and thin clayey or marly intercalation as well as by the appearance of the characteristic green calcisiltites, representing member 4f. It starts with intercalations of only a few millimetres thickness and ends up into a horizon of about 2 m. The exposed thickness of member 4f is about 80 m at Poria. The sequence is tectonically overlain by dark cellular dolomites of the Omalos nappe (Trypali Unit).

The Kalavros formation is not exposed in the profiles of Samaria and Poria, but in the adjacent Klados gorge and at Chora Sfakion. Here, the calcschists contain more carbonatic material than in the other parts of Crete.

4. CONCLUSIONS AND DISCUSSION

Our lithostratigraphic correlation showed that it is possible to identify the different members of the Aloides formation and the Kalavros formation in all areas investigated. It also revealed considerable changes in the sedimentary facies. Siliciclastic input in the lower parts of the Aloides formation is common, but there is a decrease from west to east from about 500 m in the Lefka Ori to only a few metres on the Mirabello peninsula. In the Lefka Ori the members 4a and 4b of the Aloides formation are substituted by the facies of the "Gigilos beds" (member 4c).

These observations confirm the statement of EPTING et al. (1972) that the Plattenkalk group shows lateral facies changes. Later on this was denied by several authors (e.g. KUSS & THORBECKE 1974). Our results show that parallelizations of Plattenkalk from different occurrences, especially the lower members of the Aloides formation, have to be carried out very carefully.

The Plattenkalk group was repeatedly influenced by the input of continental material throughout its sedimentological history, which implies that the depositional environment was adjacent to a landmass. The widespread occurrences of lithistide silicosponges both laterally and vertically throughout the Mesozoic to Tertiary members of the Plattenkalk group indicate shallow to intermediate water depths as well as continental influences (comp. MANUTSOGLU et al. 1995b, SOUJON et al. 1995). In common there is a rhythmicity in the sedimentary sequences especially in the Aloides formation. These are not turbiditic sequences, as was implied by the attribute "flysch-like" for the "Gigilos beds" (FYTROLAKIS 1978). Further investigations on that subject could reveal the nature of these rhythmites. We interpret them to have been a result of sea-level changes. In general, the depositional area of the Plattenkalk group seems to have been structured and slowly subsiding.

These observations show that the sedimentological history of the Plattenkalk group differs to a certain degree from that of the Ionian series. We therefore do not support the hypothesis that the Plattenkalk group is the metamorphic equivalent of the Ionian sequence. We rather prefer the idea that the Plattenkalk group was deposited on the stable, but structured shelf of the Adria microplate, being the distal continuation of the Preapulian sequence.

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