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STUDIES ON THE PERMIAN-JURASSIC CARBONATE SEQUENCES OF TALEA ORI, CRETE, GREECE

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ABSTRACT

The microfacies types, the diagenetic features and the porosity of the Permian-Jurassic carbonate sequence of Talea Ori, Crete in the area of Sisses-Aloides have been studied. This study verifies a sequence of diagenetic episodes with various evolution stages of the carbonatic platform.

We propose a depositional model of those sediments where the Stromatolitic dolomite formation is controlled by synsedimentary tectonics.

Tectonic episodes interrupt the development of stromatolite two times. In the first step, on top of the homocline ramp, ooids banks and belts formed under high energy intertidal conditions. In the second step, the stromatolite development was abruptly interrupted by debris flows originated by probable uplift of the surrounding intertidal areas. Once reinstalled the normal stable conditions, the growth begun again with shallow intertidal facies of stratified stromatolites in thick layers indicating continuous subsidence of the basin. The lower-seated Plattenkalk formation corresponds with a sedimentation at a subtidal platform with strong transgressive features.

ΣΥΝΟΨΗ

Στην παρούσα εργασία μελετώνται οι μικροφάσεις, τα διαγενετικά χαρακτηριστικά και το πορώδες ενός τμήματος της ανθρακικής ακολουθίας των Ταλαίων ορέων.

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Διαπιστώνεται μία ποικιλία περιβαλλόντων απόθεσης των ιζημάτων, ιδιαίτερα του "Στρωματολιθικού δολομίτη", από τα οποία προκύπτουν διαφορετικά στάδια εξέλιξης της ανθρακικής πλατφόρμας.

Προτείνεται ένα μοντέλο απόθεσης των ιζημάτων, σύμφωνα με το οποίο η δημιουργία του "Στρωματολιθικού δολομίτη" ελέγχεται από συνιζηματογενή ρηγματογόνο τεκτονισμό. Τεκτονικά αίτια διακόπτουν δύο φορές την ανάπτυξη των στρωματολίθων των οποίων ο σχηματισμός ελάμβανε χώρα, την με πρώτη φορά κάτω από υψηλής ενέργειας μεσοπαλιρροιακές συνθήκες, τη δε δεύτερη φορά κάτω από αβαθείς μεσοπαλιρροιακές συνθήκες με συνεχή καταβύθιση της λεκάνης. Ο σχηματισμός του κατωτέρου τμήματος των "πλακωδών ασβεστολίθων" έλαβε χώρα σε υποπαλιρροιακές συνθήκες με έντονους επικλυσιγενείς χαρακτήρες.

INTRODUCTION

The Permian-Jurassic siliciclastic-carbonate sequence of Talea Ori, Crete has been known since the early part of this century through the studies on several cross sections. Some of them was of general stratigraphy. Some local studies have been performed describing the paleontological content of the carbonate sequence. The recent bibliography, done in the last decades comprises those works of Epting et al. 1972; Hall and Audley-Charles, 1983, etc.

The studied sequence comprises, from bottom to top, the following formations: Fodele, Sisses, Stromatolite dolomite and Plattenkalk. One of the most complete studies is that of Epting et al. 1972, which describes the stratigraphic columns, sedimentary structures and the analyses of calcareous and stromatolite microfacies. According to these authors we can recognize a continuous stratigraphic sequence from early Permian to at least Jurassic age (Plattenkalk) with an angular unconformity at Late Triassic age.

This paper presents an updated synthesis of the known bibliography complemented with some new data collected by stratigraphic sections along road cuts between the towns of Sisses and Aloides in North Central Crete. The general location map and geological scheme is depicted in Plate 1, altogether with the detailed stratigraphic columns drawn later in the paper (Plate 2).

This microfacies analysis was performed based on randomly-taken samples which are representative of alternate cycles of deposition; and that represent to us, from the

PLATE 1

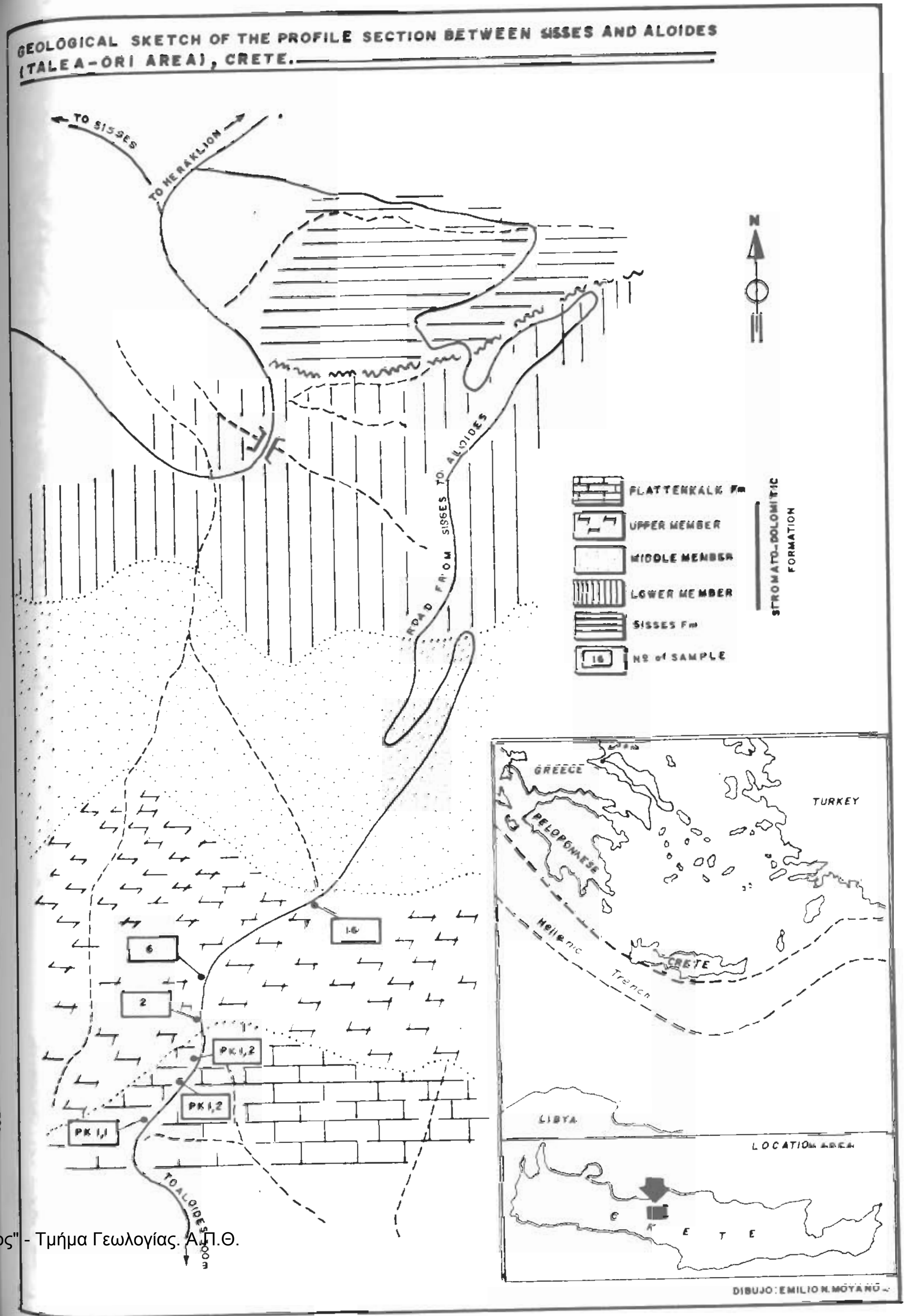
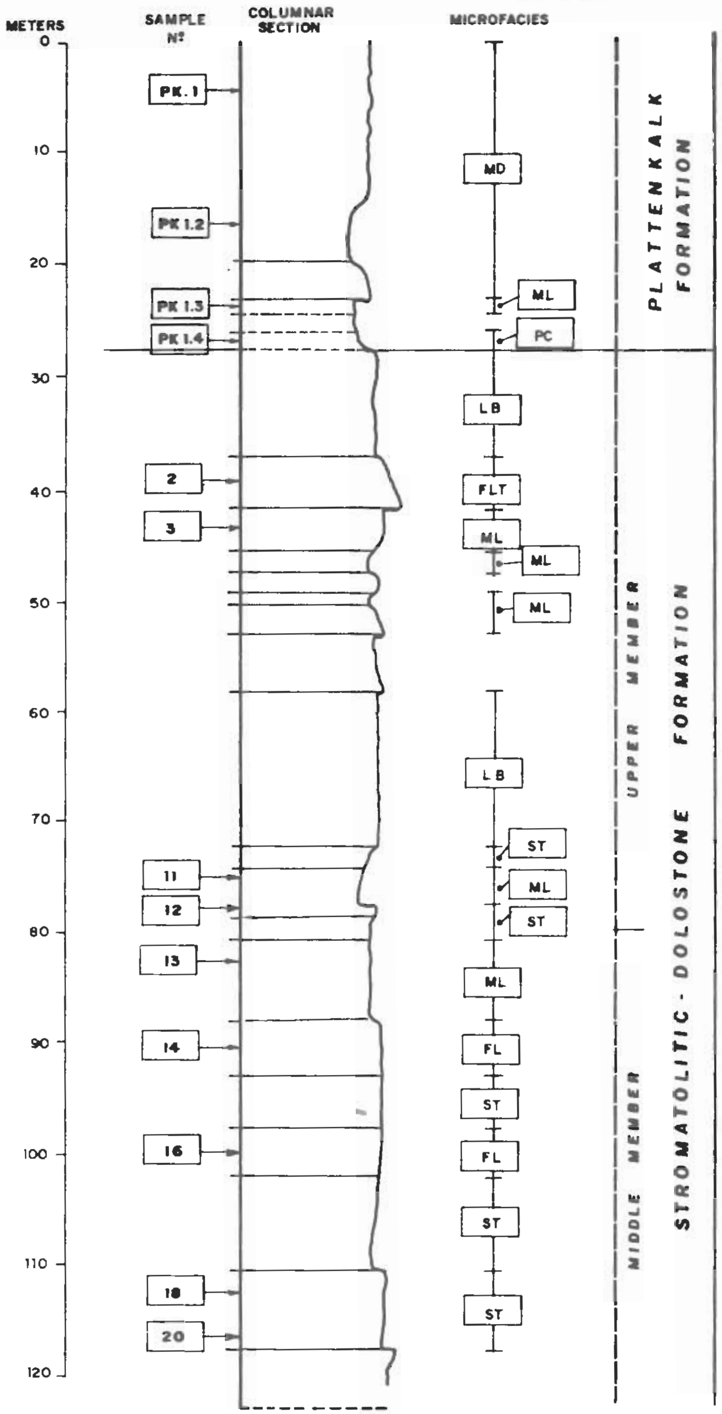


PLATE 2



FLT . FLAT-LAMINATED STROMATOLITES

ST PSEUDOCOLUMNAR-CUMULATE AND STROMATOLITES

LB FLOATSTONE

FL "ALGAL" FLOATSTONE

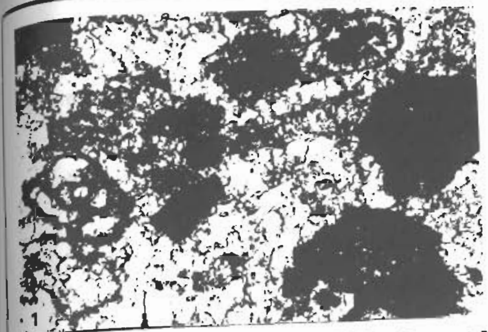
PC PACKSTONE

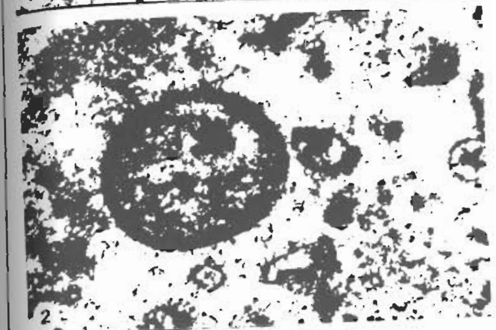
MD MUDSTONE WITH BIOCLASTS

ML LAMINATED MUDSTONE

COLUMNAR SECTION AND MICROFACIES TYPES

PLATE 3

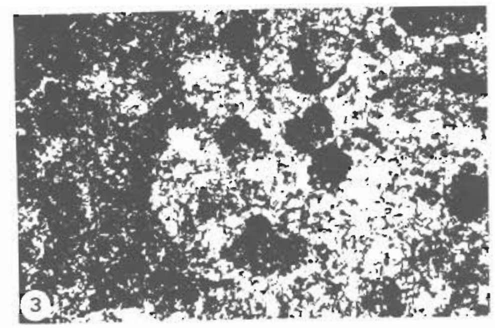


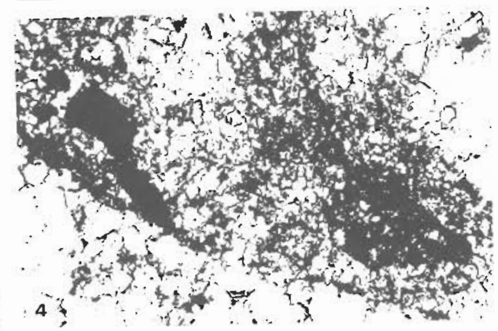


MICROFACIES : PELONCOBIOCLASTIC PACKSTONE

FIG. 1. INTRACLASTS, ALGAL PELOIDS AND FORAMS PLACED IN BLOCKY CEMENT

FIG. 2. OOID BOUNDED BY A THIN MICRITE FILM

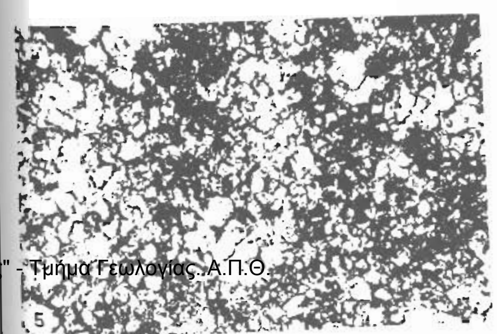




MICROFACIES : ALGAL FLOATSTONE

FIG. 3. SHARP CONTACT BETWEEN ALGAL INTRACLAST AND SPARITE CEMENT WITH "CLOUDS" OF MICRITE

FIG. 4. ALGAL PELOIDS, INTRACLASTS AND MICRITE "CLOUDS" IN THE SPARITE CEMENT



MICROFACIES : CUMULATE - LAMINATED AND NODULAR STROMATOLITES

FIG. 5. HIGHLY RECRYSTALIZED STROMATOID WITH BLOCKY CEMENT

stratigraphic point of view, the main characteristics of the "Stromatolitic dolomite" and the Plattenkalk formation. For description purposes, the "Stromatolitic dolomite" formation has been divided into three members: the lower member, of dominant dolomitic composition; the middle member, highly stromatolitic; and the upper member which is calcareous-dolomitic with frequent intraclastic breccias. Our observations refer mainly to this last mentioned section based on the implications that the flow elements give to the tectosedimentary evolution. A full interpretative study for the whole sequence is left for the near future.

Following the sketch of the stratigraphic column (Plate 2), the type-samples are described based on microfacial characteristics and some generalities about diagenesis, porosity and a postulated depositional model. The numbering of the samples represent typical rock compositions which are distinguishable in the entire sequence.

MICROFACIES TYPES:

This analysis does not follow a strict sequenciation but corresponds with a facial classification. Plate 2 displays the stratigraphic column and the position of the different microfacial types in accordance with the different strata. "M" identifies the type of microfacies.

SISSES FORMATION

Mudstones

M - 1 - fine granular micrite of algal origin, without calcite particles. Incipient, diffuse algal lamination with crenulated contacts. The matrix is formed by micrite "clouds" that obscure the fine crystals that form the cement.

Environment: Subtidal - lagoon

STROMATOLITIC DOLOMITE FORMATION (Middle and Upper Members)

M - 2 - stratified, with planar lamination. The top of the stromatolite is undulated, with a brownish red micrite film. The growth pattern displays alternate couples of pale brown micrite macrolaminae of coarse fabric with sparitic 0,5 - 2,5 cm thick, light grey strips.

Environment : Upper intertidal - peritidal

M - 3 - Non-columnar, and pseudocolumnar stromatolite, (Plate 3, Fig. 5), with low degree of inheritance, and nodular and cumulate stromatolites, close spacing, moderate synoptic relief which decrease upwards, the basal with of each stromatolite is approximately 5 cm. The laminae are generally planar, but also there are some undulated, in planar to slightly convex section, and parabolic in the cumulate stromatolites. The laminae is also

irregular, discontinuous with rough fabric changing to poloidal. The laminae or stromatoids show lobulated aspect, they are very porous, with fenestral fabric (birds-eye) and stromactatis filled by drusiform sparite. The stromatoids are linked by "bridges" or apophysis showing some parallelism. The accretion vector is vertical, with a coupling growth pattern given by 0,5 mm thick laminae with upward increasing micrite content forming sets. These stromatoids sets, approximate 2 cm thick, alternate with irregular sparite lamination. Microscopically the laminae are neosparite with rests of micrite (light) and micritic (dark), irregular contacts and bounded by dark micritic films.

Environment:Tidal pools

Grainstones

M - 4 - Ooidal, with forams and ostracods, bioclasts. Moderate sorting, the particles form a dense "package". Frequent tangential contacts. Bioclasts are rare and frequently eroded. Sparitic cement with fine, equigranular crystals. Porosity is obliterated by recrystallization.

Environment: High energy tidal bars.

Floatstone

M - 5 - Algal (Plate 3, Fig. 3-4), with more than 20% of prolate, big intraclasts of stromatolite fragments and algal mats (with fenestral fabric) and intra-particle porosity. Poor sorting, with sizes varying between 15x8 to 1x0,5 cm chaotically distributed in a wackstone with porous matrix and of possible microbialitic origin. The contact matrix-intraclast is definite. The matrix has fenestral fabric, with 1-3 mm diameter lobulated porous filled by a mosaic of coarse sparite.

Environment:Flow with peritidal supply (shoreline).

M - 6 - Intraclastic, composed of a 10% of micritic intraclasts and prolate, angular and poorly sorted possible plasticlasts with sizes changing from 30x7 to 10x0,3 cm. These particles show peloidal fabric, peripheral micritic film and are recrystallized to neosparite. Also, there are finely laminated intraclasts of algal aspect. Several disperse shell fragments were found. The matrix is a wackstone composed of minor intraclasts of fine sparite, with disseminated oxides and porous with drusiform sparite.

Environment: Flows from intertidal domains.

PLATTENKALK FORMATION

Mudstone

M - 7 - Laminated peloidal, characterized by micritic peloids of algal origin homogeneously set along thin laminated structures. There is no evidences of fossil rests. The cement is represented by fine, equigranular sparite forming a mosaic obscured by micrite "clouds".

Environment : Subtidal of shallow platform.

M - 8 - Bioclastic, with rests of cephalopods, forams and echinoderms spines. The cement is formed by a coarse, equigranular sparite mosaic, with superficial micrite and drusiform carbonatic crystal filling the porous spaces. It is important the presence of microstilolites.

Environment : Subtidal of shallow platform.

Packstone

M-9-Peloncobioclastic (plate 3, Fig. 3-4). The peloids appear as isolated individuals and as micritic aggregates with peloidal fabric of algal origin. The intraclasts are well-rounded, of micritic composition and show frequent high clay content. The ooids correspond to the types 1 and 2 of Strasser (1986). Bioclasts constitute 15% of the framework components and are represented according to abundance by: forams, Dasycladaceas algas, bivalve rests, gastropods, ostracods and echinoderms spines. Algal peloid equigranular saprite (blocky cement) which has reduced the intergranular porosity.

Environment: Protected subtidal

DIAGENETIC FEATURES:

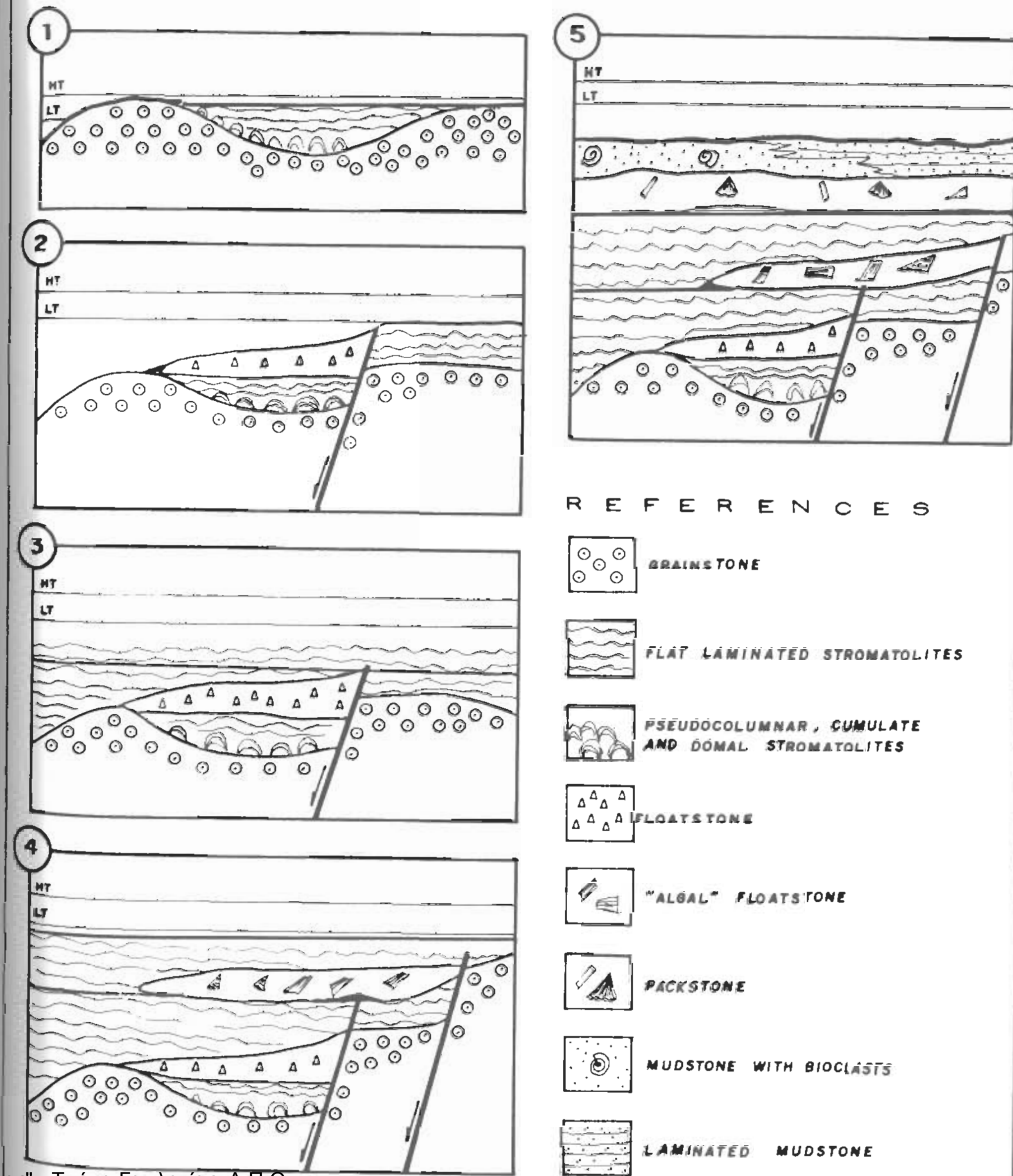
The sequence of diagenetic episodes determined for the different lithologist that form the described microfacies, results in different diagenetic environments. (See Plate 4).

Fresh water phreatic environment, produced by the incoming fresh water into the pore spaces and responsible for an intense chemical activity (James & Choquette, 1984). In this way, the cement is constituted by a prismatic calcite precipitate around the grains (bladed), with later growth of a crystalline mosaic (blocky). After these processes, followed a dissolution step with later recrystallization producing the growth of equigranular sparite in well-developed crystals with neomorphic calcite characteristics. The microbialitic microfacies were changed with the formation of a sparite mosaic with "ghosts" of the algal structures. The recrystallization of the matrix to subsparite and sparite has been determined in the mudstone facies.

Vadose environment: Recognized in the packstone microfacies. This environment is characterized by the presence of "silt vadose" with stalactite and meniscus structures (James & Choquette, op.cit.).

Burial environment: Determined on the mudstone of the Plattenkalk formation. The deep burial environment is indicated by the processes of physical and chemical compaction, the

A SKETCH ILLUSTRATING THE TECTONOSEDIMENTARY DEVELOPMENT OF THE STROMATOLITIC FM.- PLATTENKALK FM. BOUNDARY IN THE SISSES-ALOIDES SECTION



later evidenced by the development of microstalactites. The cements correspond to prismatic calcite crystals (bladed prismatic) and a mosaic of granular sparite (coarse mosaic calcspar).

POROSITY

The results of the diagenetic processes that affected these carbonates caused a marked reduction of the pore spaces. The only observed porosity, of scarce volume, is intracrystalline, developed within the totally recrystallized rocks.

DEPOSITIONAL MODEL

The depositional scheme of the Talea Ori calcareous sequence corresponds to an homocline platform with tectonic control, with tecto-sedimentary features similar to those of the model proposed by Bechstadt & Boni (1989) for the Sardinian Palaeozoic platform. These characteristics are mainly represented in the Stromatolitic Formation; the analyzed section of the Plattenkalk formation presents a simple structural history (Epting et al. 1972; and Hall & Audley-Charles, 1983) with higher tectonic stability and slow deepening of the basin.

The Stromatolitic-dolomite formation sequence shows different stages in the platform evolution through the time (Plate 4, Figs. 1 - 5). In a first step, on top of the homocline ramp, ooids banks and belts formed under high energy intertidal conditions. These belts presented tidal pools with growth of closely-spaced cumulate-laminated and nodular stromatolite that reached the low-tide level (Fig. 1) and emerged in peritidal facies of stratified and dolomitic stromatolite.

This stromatolite development was abruptly interrupted by debris flows (floatstone microfacies) originated by a probable uplift of the surrounding intertidal areas (Fig.2). Evidences of tensional tectonics (slumping, debris flows, internal breccias) are abundant.

Once reinstalled the normal stable conditions, the growth begun again with shallow intertidal facies of stratified stromatolites in thick layers indicating continuous subsidence of the basin (Fig.3).

This tectosedimentary pattern is repeated in the upper half of sequence, noting at the upper terms of the Stromatolitic formation a higher energy event due to the effects of strong storms.

The analyzed section of the Plattenkalk formation corresponds with a sedimentation at a subtidal platform with strong transgressive features (Fig.5).

The characteristics of the depositional environment, the low energy, quiet waters and absence of detritic supply favoured the development of thick algal mats. In the same way, is important that algal and microbacterial activity as indicated by particles with micritic cover

(cortoids) and algal peloids aggregates in protected facies below the level of wave action.

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