PALEOENVIRONMENTAL OBSERVATIONS BASED ON THE FAUNA ASSEMBLAGES FROM THE MIOCENE DEPOSITS OF PSATHI SECTION (STALOS, KYDONIAS, W. CRETE) *

by

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Introduction

The section Psathi is exposed on the road from Chania to Kastelli near the village Kato Stalos, Kydonias (Fig. 1). The sediments of Psathi section are approximately 15 meters thick and they are abundant in macrofossils. The major rock type is blue or purple, generally, amorphous clays with intercalations of non-graded cla-

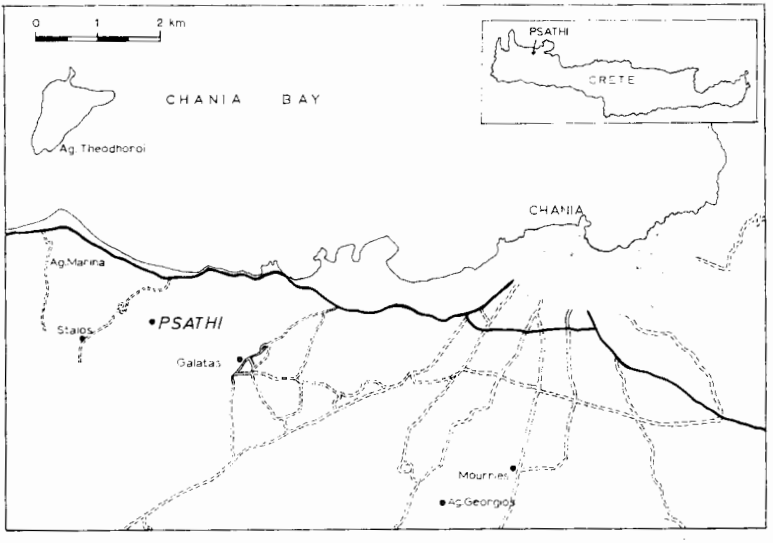

Fig. 1. Location of the Psathi section.

* Παρατηρήσεις ἐπὶ τοῦ παλαιοπεριβάλλοντος βασισμέναι ἐπὶ τῶν συγκεντρώσεων τῶν πανίδων εἰς τὰς μειοκαινικὰς ἀποθέσεις τῆς τομῆς Ψαθὶ (Σταλὸς Κυδωνίας, Δ. Κρήτη).

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Κατετέθη τὴν 7 - 6 - 79 καὶ ἀνεκοινώθη κατὰ τὴν συνεδρίαν τῆς 22 - 6 - 79.

stics. KOLIOPOULOS (1952), CHRISTODOULOU (1963) and FREUDENTHAL (1969) referred to this locality previously. The first author accepts the presence of Vindobonian and lower Pliocene deposits. According to the third one these deposits belong to the Kissamou formation.

The purpose of this paper is to clarify the correct chronostratigraphic age and to present detailed lithostratigraphic and biostratigraphic information, based on close sampling from the section Psathi. An attempt will be made to correlate biostratigraphically the macrofauna and planktonic foraminiferal assemblages.

Lithostratigraphy

In the section Psathi, sediments of the Kissamou formation are exposed (FREUDENTHAL, 1969). The main body of this formation consists of blue or purple amor-

Fig. 2. A view of Psathi section.

phous clays. Within these clays intercalations of strongly indurated and ungraded or graded sandstones, calcarenites and organic limestones occur. The Kissamou formation deposits are overlying the Roka formation and are partly lateral, equivalent with Koukounaras formation.

In the blue or purple amorphous clays macrofossils are present. Among them numerous Molluscs have been collected such as *Amussium*, *Flabellipecten*, *Chlamys*, *Arca*, *Cardium*, *Turritella* etc. In the sand or gravel intercalations no clear graded

bedding occurs. They have often been indurated by calcareous matter and they consist of an irregular mixture of sand and medium-sized calcareous (mainly algal) components. They contain also Bryozoan, Coral debris and *Heterostegina.*

Description of the section

The section Psathi —some 15 meters of sediments— is exposed along the side of the hill of the same name (Fig. 3), the basal part of the section not being exposed.

Ψ1) 4,20 m. Blue clays, generally amorphous. Macrofossils are present among them *Amussium cristatum badense, Chlamys latissima, Pycnodonta cochlear navicularis, Glycymeris* sp., *Chlamys varia* etc.

Ψ2) 0,40 m. Sandy material indurated by calcareous matter, without any clear graded bedding. They contain abundant Algae, *Lithothamnium*, Bryozoan, Coral debris etc.

Ψ3) 4,00 m. Blue amorphous clays with numerous macrofossils as *Chlamys haueri,*
Ψ4) *Amussium cristatum badense, Pycnodonta cochlear navicularis etc.*

Ψ5) 0,30 m. Sandy material indurated by calcareous matter, without any clear graded bedding. They contain abundant Algae, *Lithothamnium*, Bryozoan, Coral debris, *Dentalium* etc.

Ψ6) 2,10 m. Purple amorphous clays with macrofossils as *Chlamys haueri, Amussium cristatum, Flabellipecten ugolinii, Cardium* (*Cerastoderma*) *edule, Terebratula sinuosa, Turritella* (*Archimediella*) *archimedis dertonatior* etc.

Ψ7) 0,42 m. Calcareous sandy material with clear graded bedding. They contain Bryozoan, Scaphopods, Echinoids of species *Clypeaster altus* and *Heterostegina.*

Ψ8) 1,23 m. Purple or yellowish clays with *Amussium cristatum, Chlamys varia, Cardium tuberculatum, Arca* (*Pectinarca*) *pectinata, Chlamys scabrella, Pycnodonta cochlear navicularis.*

Ψ9) 0,36 m. Calcareous sandy material with small gravels, coral debris, medium-sized calcareous algal components and *Dentalium* (*Antale*) *fossile* etc.

Ψ10) 0,84 m. Calcareous sandstones which are composed of an irregular mixture of sand gravel and clay balls. They contain *Glycymeris* sp., *Dentalium fossile, Amussium cristatum, Chlamys multistriata* etc.

Bio-chrono-stratigraphy and paleoecological observations

Close sampling along the section Psathi gave a very rich macro-and microfauna. The studied fauna of planktonic Foraminifera and the macrofossils are given in the distribution chart of Fig. 4 and 5, where the frequency of distribution is also given. Here it should be mentioned that the given data is indicated as : frequent—more

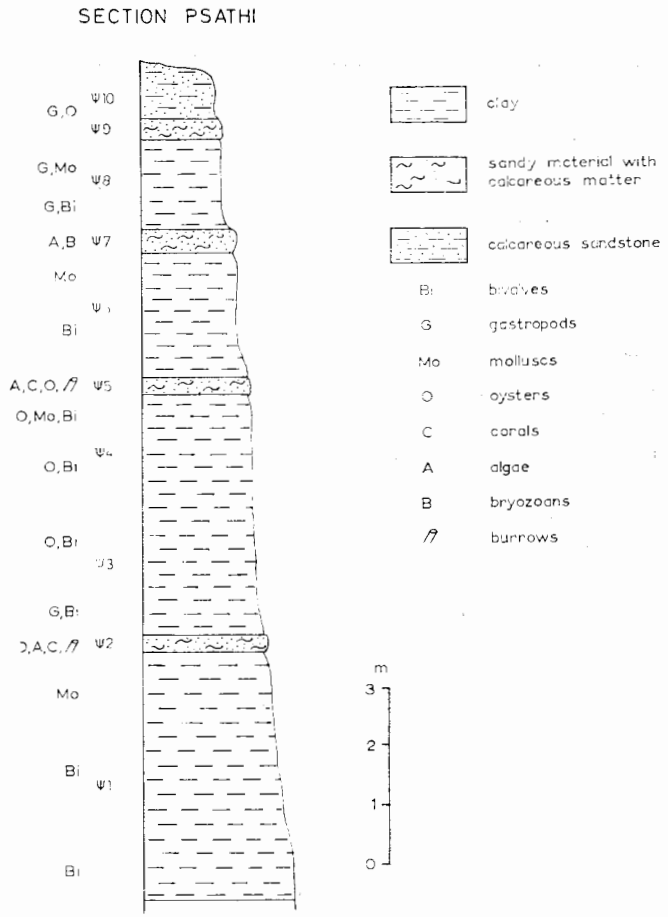

Fig. 3. Lithostratigraphic column of Psathi section.

than 50 %, common—less than 50 % and rare—less or equal to 10 %. The abundant benthonic Foraminifera species have also been collected and are the subject of another paper.

Two types of macrofauna are reflected in the Mollusc assemblages. The first one is that contained in the amorphous clays and points to a fairly quiet environment certainly not very shallow. The second type of macrofauna included in the intercalated coarse to fine-grained graded beds has to be regarded as displaced fauna, originating from a near-shore, shallow environment.

The macrofauna assemblages consist of Bivalves, Gastropods, Scaphopods, Echinoids, Brachiopods, Corals and Bryozoans. Among this fauna the Pectinids dominate. The determined species *Amussium cristatum badense*, *Chlamys haueri*, *Flabellipecten ugolinii*, *Glycymeris pilosa deshayesi*, *Turritella* (*Archimediella*) *archi-*

medis dertonatior, *Dentalium fossile*, *Clypeaster altus*, *Terebratula sinuosa*, give an upper Miocene (Tortonian) age to the sediments of the Psathi section. The frequency of *Pycnodonta cochlear navicularis* among the mentioned fauna should be noticed. The above mentioned characteristic species, collected from the blue amorphous clays horizons, consist of entire valves or fragments without any indication of transportation. They are all representatives of marine waters. The abundance of small sized Pectinids, which live in deeper sea waters and the absence of giant sized *Chlamys* indicate a deposition to a fairly quiet environment, certainly off-shore to a deeper sea environment.

The species *Chlamys haueri* is very frequent in all the amorphous clays layers along the section and is represented by a great number of young and adult individuals. It exists in association with *Pycnodonta cochlear navicularis* whose biotope is a sea depth of about 50-100 meters. The representatives of the genera *Terebratula*, *Arca*, *Glycymeris*, *Turritella* etc. confirm also the above mentioned depth of the sea environment. From the associations derived from the blue amorphous clays horizons and the above mentioned data it can be concluded that these sediments were deposited in a quiet deeper sea environment at a depth of about 50-100 meters.

The intercalated coarse to fine-grained graded beds contain *Heterostegina*, *Lithothamnium*, *Glypeaster*, Bryozoans and Coral debris. All of them live in a shallow-water, near-shore environment. Based on lithostratigraphic data and the contained fossils it can be concluded that they have been trasported by turbidity currents into deeper, off-shore environment.

The associations of the planktonic Foraminifera are generally abundant in all samples. The fauna recovered from the blue amorphous clays are fairly well preserved, but those from the coarse to fine-grained graded beds are a little distorted.

The distribution of planktonic foraminiferal taxa in section Psathi is represented in the chart Fig. 4, in relation with the Mollusc frequency distribution in Fig. 5.

Neogloboquadrina acostaensis occurs regularly distributed throughout the succession of clays and graded calcarenites. The association found in the sample Ψ1 contain types with transitional characters between the species *Neogloboquadrina continuosa* and *Neogloboquadrina acostaensis*. In the succeeding assemblages only species of *Neogloboquadrina acostaensis* have been recognized. From the co-occurrence of the associations of *Globorotalia menardii* form 4 and of *Globorotalia menardii* ex. interc. form 4-5, it may be concluded that the faunal associations from Psathi section cover the biostratigraphic interval of the *Neogloboquadrina acostaensis* Zone (N16). Apart from these Globorotaliids the co-existence of *Globorotalia ventriosa*, *Globorotalia suterae*, *Globigerina apertura*, *Globigerina bulloides*, *Globigerina nepenthes*, *Globigerina decoraperta*, *Globorotaloides falconarae*, *Globigerina falconensis*, *Globigerinoides bulloideus*, *Globigerinoides obliquus* etc. allow the conclusion that Psathi sediments belong to the lower and middle (?) part of *Neogloboquadrina acostaensis* Zone.

This conclusion is in line with the frequent presence of individuals of the ben-

species of planktonic foraminifera \ samples	SECTION PSATHI									
	∈ 1 F	∈ 2 F	∈ 3 F	∈ 4 F	∈ 5 F	∈ 6 F	∈ 7 F	∈ 8 F	∈ 9 F	∈ 10 F
Globigerina apertura CUSHMAN	□	□	□	□		□		□		□
Globigerina bulloides D'ORBIGNY		□	□	□						□
Globigerina decoraperta TAKAYANAGI & SAITO	□	□				□		□		□
Globigerina druryi AKERS	■	□	□							
Globigerina falconensis BLOW		□						□		□
Globigerina nepenthes TODD	□	□	■			□				□
Globigerina obesa BOLLI	□							□		□
Globigerina obesa-pseudobesa type			□			□				□
Globigerina praebulloides BLOW	□	□								□
Globigerina pseudobesa (SALVATORINI)	□	□	□	□		□		□		
Globigerina quinqueloba NATLAND			□	□						□
Globigerina sp.	□	□	□	□		□		□		□
Globigerina woodi JENKINS	□	□	□		□					□
Globigerinella siphonifera (D'ORBIGNY)	□	□				■		■		
Globigerinita glutinata (EGGER)		□	□					□		□
Globigerinoides bulloideus (CRESCENTI)	□		□	□		□		□		□
Globigerinoides obliquus BOLLI	■	□	□	▩		□		■		□
Globigerinoides sacculiferus (BRADY)	□							□		
Globigerinoides spp.			□	□		□		□		□
Globigerinoides subsacculiferus CITA, PREMOLI, SILVA, ROSSI.	□	□	□	■		□		□		□
Globigerinoides trilobus immaturus LE ROY	■	□	▩	■		□		□		□
Globigerinoides trilobus trilobus (REUSS)		□								
Globoquadrina altispira CUSHMAN & JARVIS						□				□
Globoquadrina dehiscens CHAPMAN PARR & COLLINS		□								
Globoquadrina venezuelana HEDBERG								□		□
Globorotalia menardii form 4 TJALSMA	□	□	□	□						□
Globorotalia ex. interc. menardii form 4-5 TJALSMA	□	□								
Globorotalia pseudomiocenica BOLLI & BERMUDEZ							□		□	□
Globorotalia scitula (BRADY)	□	□								□
Globorotalia ventriosa OGNIBEN				■						
Globorotalia suterae CATALANO & SPROVIERI	□			□				□		
Globorotaloides falconarae GIAN. & SALV.	□	□	□	□		□		□		□
Neogloboquadrina acostaensis (BLOW)	□	□	□	□				□		□
Orbulina bilobata (D'ORBIGNY)	□			□		■		□		□
Orbulina universa D'ORBIGNY	□	□	□	□		□		□		□

Fig. 4.

Distribution and frequency of planktonic Foraminifera in Psathi section.

species of macrofauna \ samples	SECTION PSATHI									
	ε 1 M	ε 2 M	ε 3 M	ε 4 M	ε 5 M	ε 6 M	ε 7 M	ε 8 M	ε 9 M	ε 10 M
BIVALVES										
Amussium cristatum (BRONN.)	○		○	○		○			○	
Amussium cristatum badense FONT.	●		◕	○		o				
Arca (Pectinarca) pectinata BROCC	o					o			○	o
Cardium (Cerastoderma) edule LINNE				o		o			○	
Cardium tuberculatum LINNE						o			○	
Chlamys haueri MICHELOT.	●		●	●		o				
Chlamys multistriata POLI	o		o	o					○	o
Chlamys scabrella LAMARCK	o					o			o	
Chlamys latissima (BROCC.)	o		o	o						
Chlamys varia (LINNE)	o		o	o		o			o	
Flabellipecten ugolinii DEP. & ROM.	o		○	○		○				
Glycimeris (Glycimeris) pilosa deshayesi (MAY)	o		o	o						
Ostrea (Ostrea) lamellosa BROCC.	o	○	o	o	○		◕		●	o
Pecten (Flabellipecten) besseri (ANDREJ.)						o			o	o
Pecten revolutus MICHT.	o					o			o	
Pycnodonta cochlear navicularis (BROCC.)	◕		●	○		o		◕	o	o
GASTROPODS										
Dolium sp.						o			o	
Turritella (Archimediella) archimedis dertonatior SACCO						○		o		o
SCAPHOPODS										
Dentalium (Antale) fossile LINNE		◕	o	o	●	o	○			o
ECHINOIDS										
Clypeaster altus KLEIN		○			○	o	o			
BRACHIOPODS										
Terebratula sinuosa BR.					●	○	o			
ALGAE										
Lithothamnium sp.		◕			◕	o	o		○	o
BRYOZOANS										
Membranipora lana REUSS		●		o	○		◕		○	○
CORALS (indet.)		○			○		○		○	o

LEGEND

F Foraminifera — ☐ Common — ■ Frequent — □ Rare

M Macrofauna — ○ Common — ● Frequent — o Rare

Fig. 5.

Distribution and frequency of larger Invertebrates in Psathi section.

thonic Foraminifera *Bolivina miocenica* (GIANNOTI) which is characteristic taxon for the Tortonian age in the Mediterranean area.

The biostratigraphic data from the macrofossil associations and from the planktonic Foraminifera assemblages demonstrate that the blue amorphous clays and the coarse to fine-grained graded beds of Psathi section are of T o r t o n i a n age.

SUMMARY

The section Psathi contains abundant micro-and macrofossil associations. The major rock-type is blue or purple amorphous clays with coarse to fine-grained intercalations. The amorphous clays with the contained fauna reflect deposition in a fairly quiet, deeper sea water environment at a depth of 50-100 meters.The coarse graded intercalations with algal balls, Heterosteginids and Coral debris were redeposited from a near-shore shallow water environment to a deeper off-shore environment.

The *Neogloboquadrina acostaensis* Zone, from the biostratigraphic data, can be recognized and it can be concluded that the Psathi succession is of Tortonian age. The chronostratigraphic conclusion drawn from the planktonic foraminiferal associations and the data derived from the macrofossil assemblages are in complete agreement.

ΠΕΡΙΛΗΨΙΣ

Τὰ ἰζήματα τῆς τομῆς Ψαθὶ εἰς τὴν Δυτ. Κρήτην περικλείουν ἀφθονίαν μακροαπολιθωμάτων καὶ μικροαπολιθωμάτων. Οἱ κυριώτεροι λιθολογικοὶ τύποι τῶν ἰζημάτων τῆς τομῆς εἶναι αἱ ἄμορφοι κυανοῦ χρώματος ἄργιλοι μὲ ἐνδιαστρώσεις χονδροκόκκων ἕως λεπτοκόκκων ἰζημάτων.

Αἱ κυαναὶ ἄμορφοι ἄργιλοι μὲ τὴν ἐγκλειομένην πανίδα ὑποδηλοῦν ἔν σχεδὸν ἥσυχον περιβάλλον ἀποθέσεως μακρὰν τῆς ἀκτῆς εἰς βάθος περίπου 50-100 μέτρα. Αἱ ἀδρομερεῖς κοκκώδεις ἐνδιαστρώσεις μὲ Φύκη, Κοράλλια, *Heterostegina* κ.λ.π. ὑποδηλοῦν μίαν ἐπανεπεξεργασίαν τοῦ ὑλικοῦ καὶ μεταφοράν του ἀπὸ ρεύματα θολότητος εἰς ἐν βαθύτερον θαλάσσιον περιβάλλον.

Τὰ βιοστρωματογραφικὰ δεδομένα ἐκ τῆς μελέτης τῶν πλαγκτονικῶν Τρηματοφόρων μᾶς ἐπέτρεψαν νὰ ἀναγνωρίσωμεν τὴν βιοζώνην τῆς *Neogloboquadrina acostaensis*.

Ἐκ τούτου δυνάμεθα νὰ συμπεράνωμεν ὅτι ἡ χρονοστρωματογραφικὴ ἡλικία τῶν ἰζημάτων τῆς τομῆς Ψαθὶ εἶναι ἡ τοῦ Τορτονίου. Ἡ χρονοστρωματογραφικὴ ἡλικία τοῦ Τορτονίου ἐπὶ τῇ βάσει τῶν πλαγκτονικῶν Τρηματοφόρων συμφωνεῖ ἀπολύτως πρὸς τὴν ἡλικίαν ἡ ὁποία ἐξάγεται ἐκ τῆς μελέτης τῶν συγκεντρώσεων τῶν μακροαπολιθωμάτων.

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