BIOSTRATIGRAPHIC OBSERVATIONS ON THE UPPER MIOCENE DEPOSITS IN ARMYRI PANAYIA SECTION (HERAKLION PROVINCE, CENTRAL CRETE) *

by

MICHAEL D. DERMITZAKIS **

Introduction

The area of Armyri is situated nearby the Panayia Monastery, next to the road from Heraklion to Agioi Deka, after the village Ano Moulia (Kainourgiou district) and in front of the nearby entrance of a gorge (Fig. 1). The sediments of Armyri Panayia section approximate 50 meters of thickness. The majority of the rock types is conglomerates, sands, silts, clays and intercalations of lignites and fresh-water limestones.

The fossil exposure of this area has been referred by PSARIANOS and VETOULIS (1958) as also by PAPAPETROU-ZAMANI (1966) and the Ostracods by SISSINGH (1972).

The purpose of this paper, is to present a detailed lithostratigraphic description of the section Armyri Panayia. An attempt will be made on Biostratigraphy and Chronostratigraphy based on macrofaunistic data and the correlation of them with the microfaunal assemblages, in order to conclude their position relative to the succession of Mediterranean Neogene stages.

The author wishes to thank Dr. A. JONKERS for his information about the lithostratigraphy of the area. Also many thanks are due to Prof. Dr. H. BÖGER and Dr. R. WILLMAN for their pleasant cooperation in solving problems concerning the fresh - water Molluscs.

Lithostratigraphy

In the section Armyri Panayia is exposed the local base of the Ambelouzos Formation (JONKERS, in prep.). The lower part of this formation is characterized by

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* Βιοστρωματογραφικαὶ παρατηρήσεις ἐπὶ τῶν ἄνω-μειοκαινικῶν στρωμάτων τῆς τομῆς Ἀρμυρῆς Παναγίας (Νομὸς Ἡρακλείου, Κεντρικὴ Κρήτη).

** Department of Geology and Paleontology of Athens University, Akadimias 46, Athens (143).

Κατετέθη τὴν 12 - 5 - 79 καὶ ἀνεκοινώθη κατὰ τὴν συνεδρίαν τῆς 22 - 6 - 79.

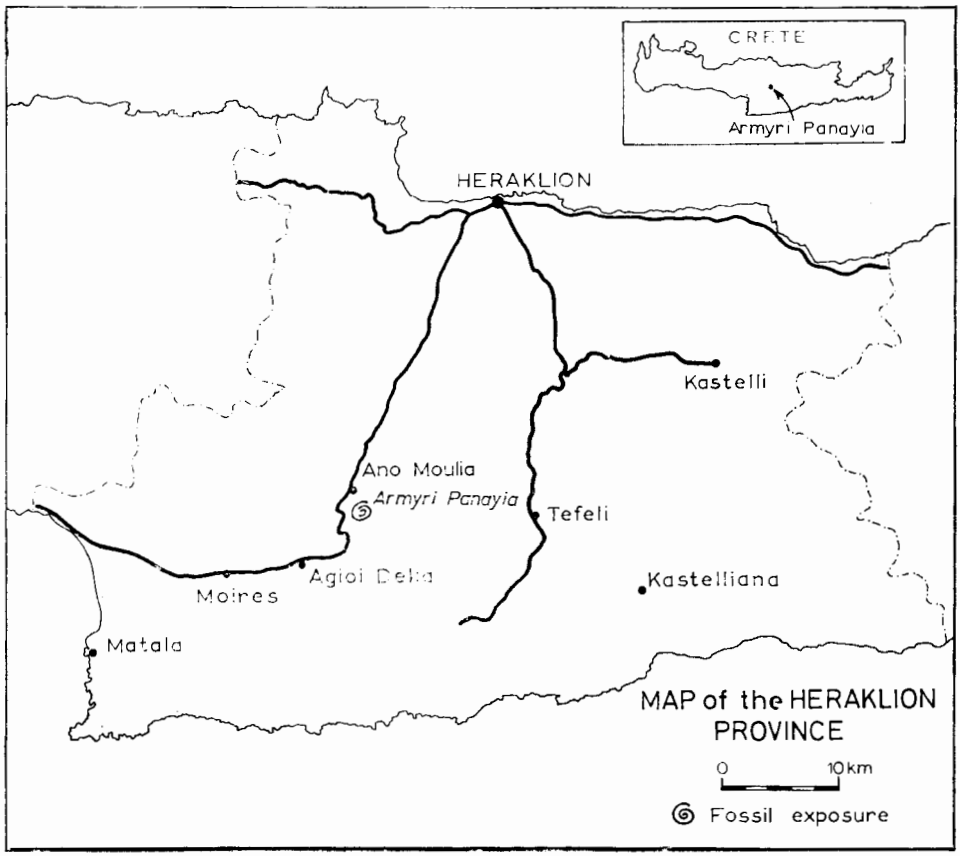

Fig. 1. Location of the Armyri Panayia section.

a rapid change in lithology, in vertical as well as in horizontal sense. The major rock types are conglomerates, sands, silts and clays; some of them are extremely rich in Molluscs. Lignites and freshwater limestones form a minor constituent. The depositional environment varies from fluvio-lacustrine and brackish to shallow marine. In the upper part of this highly variable succesion reefal limestones intercalate, the reefs having been built up by Corals and Hydrozoans. The reefs are accompanied by *Crassostrea* - clays and conglomerates. The top of the Ambelouzos Formation consists of blue - coloured silty clays, laid down in an open marine environment. These clays contain abundant Molluscs: *Ancilla* (*Baryspira*) *glandiformis* (LK.), *Clavatula* (*Clavatula*) *saubrigiana* (GRAT.), *Conus* (*Conospirus*) *dujardini* DESH., *Euthria* (*Euthria*) *cornea* (L.), *Natica* (*Nacca*) *millepunctata* (LK.), *Terebra* (*Terebra*) *acuminata acuminata* BORS., *Dentalium* (*Entalis*) *badensis* PARTCH etc., which are exposed at Ano Moulia. The Ambelouzos Formation is here in Ano Moulia, conformably overlain by calcareous sediments-homogeneous and laminated marls,

Fig. 2. A view of Armyri Panayia area with Ambelouzos Formation deposits. With arrow is shown the brook along western bank of which is exposed the studied section.

limestones-belonging to the Varvara Formation. The thickness of the Ambelouzos Formation in this area is some 200 meters.

Description of the section

The basal part of the section —some 15 meters of sediment— are exposed in the western bank of the brook, the contact with folded preneogene rocks not being exposed.

1) 4,00 m. gray-brown finegrained sand
2) 0,45 m. rather finegrained green-coloured sand, with some benthic Foraminifera and debris of *Cardium* etc.
3) 0,20 m. lag-deposit, containing angular "ophiolite"-pebbles, Oysters, *Cardium*, *Cerithium*, *Terebralia* and *Turritella*.
4) 0,20 m. sandy clay, multicoloured, but brown in the major part.
5) 0,15 m. black marly limestone with casts of Gastropods and red-stalks.
6) 0,95 m. silty clay, finely layered with individual layers up to 5 cm, the colour shows all shades of brown, the upper part is black.
7) 0,30 m. lignite with *Quercus* spores.
8) 0,20 m. pebble-bed with badly rounded "flysch"-components up to 3 cm in diameter; remains of Gastropods, *Terebralia*, *Melanopsis* etc.

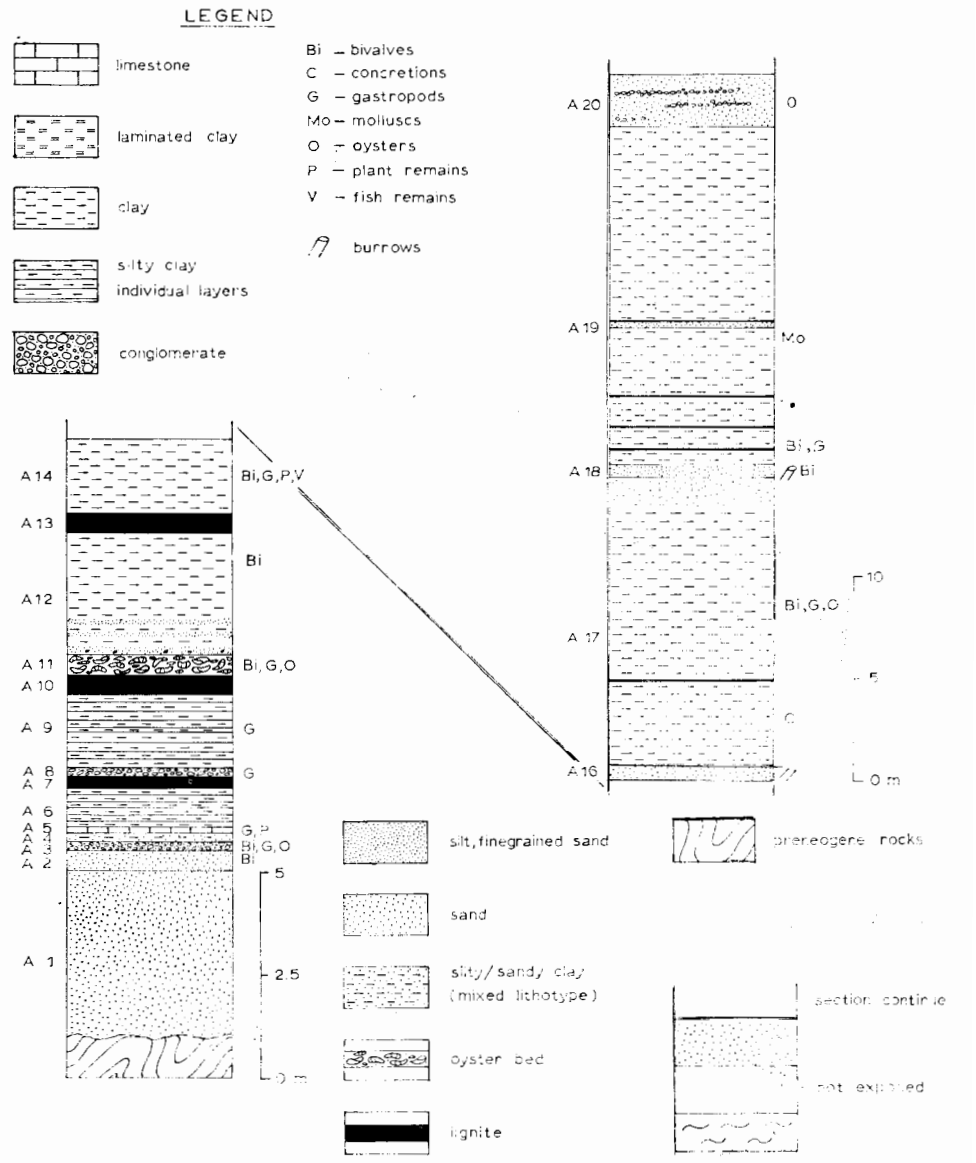

Fig. 3. Lithostratigraphic columns of Armyri Panayia section (after Jonkers).

9) 1,80 m. silty clay, grey-black and brown coloured, individual layers up to 20 cm. In the lower part of this unit abundant *Hydrobia*, *Cardium*, in the upper part *Melanopsis* and *Theodoxus*.

10) 0,45 m. lignite.

11) 0,50 m. coarse-grained bed with *Crassostrea*, *Cardium* and *Terebralia*.

12) 3,00 m. silty clay, black to darkbrown. In the lower part coarse sandy intercalations up to 20 cm, containing pieces of lignite. In the upper part *Cardium* and abundant smooth Ostracods.
13) 0,50 m. lignite.
14) 1,80 m. darkbrown silty clay with abundant *Hydrobia*, *Melanopsis*, *Theodoxus*, *Unio*, fish-teeth, plant remains, etc.
15) 2,00 m. not exposed. The section now continues in northern direction beginning with a sand-layer, which is cut by the brook, right column. (note different scale).
16) 0,80 m. finegrained sand, cemented calcareous material. Bioturbation and parallel lamination.
17) 14 m. dark-blue silty clay. In the lower part ironoxide-concretions; 4 m above the base a thin lignitic horizon occurs. The clay contains abundant Molluscs, among which *Terebralia*, *Cerithium*, *Turritella*, *Theodoxus*, *Melanopsis* giant *Pyrula* small Oysters, *Arca* and *Dentalium*. The upper 1.5 m is sandy, laminations occur; the mollusc-content is less than below.
18) 0,60 m. sand, fine to coarse-grained with burrows and casts of Molluscs. At this level the parth, running from the chapel to the north-east, crosses the section.
19) 16 m. blue-gray silty clay with thin lignitic horizons. The lower part is rich in *Terebralia*, *Turritella* and *Arca*
20) 2,5 m. finegrained sand, mottled, with some oysters and pebble-horizons. This is the end of the measured section (top of the small hill northwards off the path).

Biostratigraphy and Chronostratigraphy

A distribution chart of the Molluscs associations in the section Armyri Panayia is given in Fig.4. Here we should mention that the given data is of relative value and is indicated as: frequent (●), common, (O), rare (o).

Three environments are reflected from the Mollusc assembalges, a fresh water, a brackish water and a shallow marine environment. The subdivision however is not decisive.

The Molluscs associations present in the two lowermost samples (A2, A3) of the Armyri Panayia section can be assigned to Tortonian age, indicated by the co-occurrence of *Terebralia bidentata bidentata*, *Terebralia lignitarum lignitarum*, *Turritella* (*Archimediella*) *archimedis dertonatior*, *Turritella* (*Archimediella*) *pythagoraica pythagoraica*, *Cerithium* (*Thericium*) *italicum dertonensis*, and the giant oysters of *Gryphaea* (*Crassostrea*) *gryphoides crassissima*. The faunal composition of these samples represents a fairly shallow marine environment which in the next sample (A6) turns

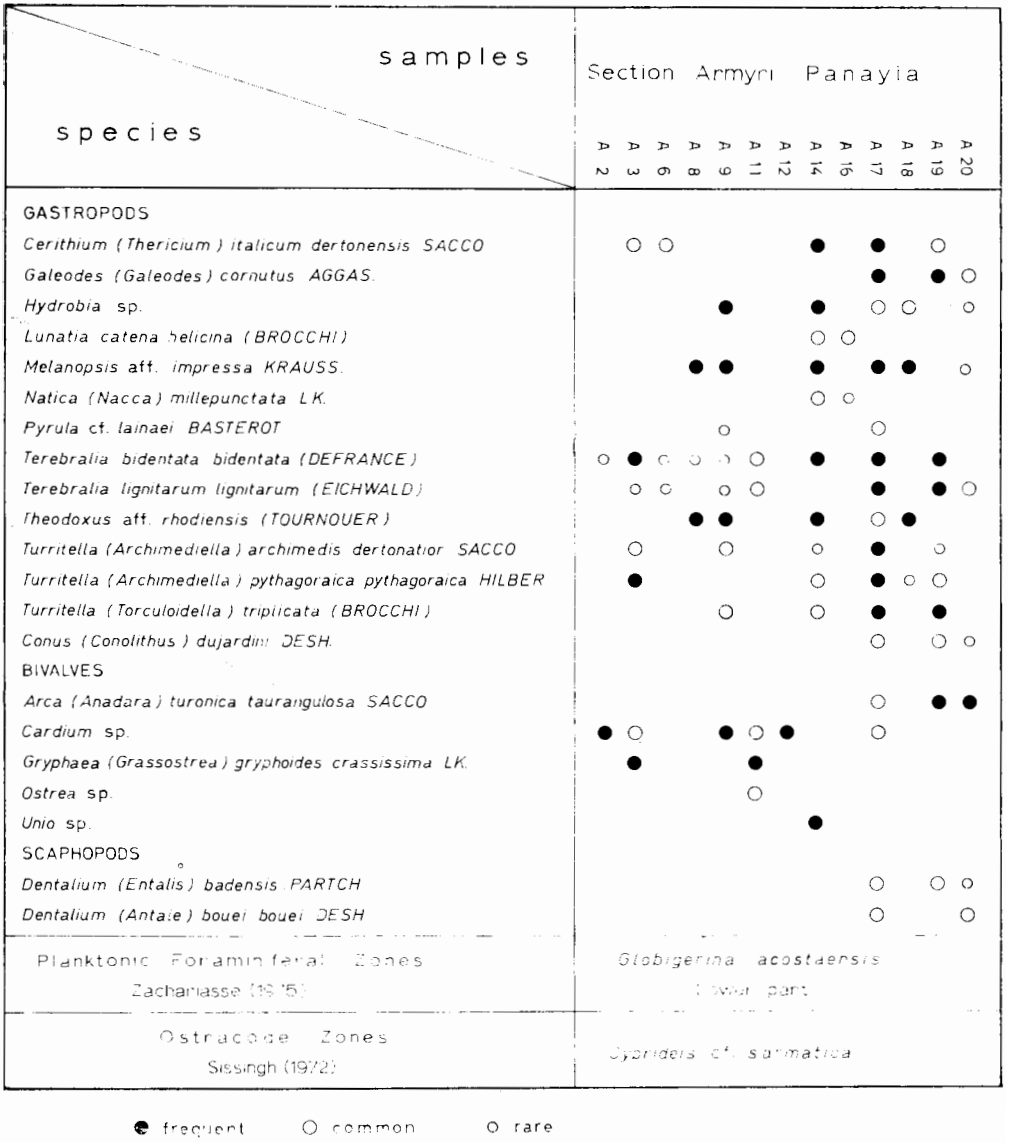

Fig. 4. Distribution and frequency of larger invertebrates in section Armyri Panayia in relation with planktonic foraminifera and ostracode Biozones.

into a shallow brackish one. The associations of this interval represented by the sample A6, contain common *Cerithium* (*Thericium*) *italicum dertonensis* and rare *Terebralia bidentata bidentata, Terebralia lignitarum lignitarum* and *Cardium* sp.

The Ostracod assemblages of the same interval (SISSINGH, 1972, sample 6 - 11)

contain: *Cyprideis mehesi* (very frequent), and *Cyprideis* cf. *sarmatica* (very rare). According to the same author the sediments of this interval were laid down in a brackish water environment. The macrofauna and microfauna composition corresponds with the Middle Tortonian chronostratigraphic interval.

The next-higher sample A7 is lignite with spores of *Quercus* group and can be assigned to fresh-water environment.

The associations derived from the next-higher samples A8, A9, indicate more brackish water environment with frequent *Melanopsis* aff. *impressa*, *Theodoxus* aff. *rhodiensis*, *Hydrobia* sp., *Cardium* sp. and common *Turritella* (*Archimediella*) *archimedis dertonatior*, *Turitella* (*Archimediella*) *triplicata* and rare *Terebralia bidentata bidentata*, *Terebralia lignitarum lignitarum*. Also the brackish water environment can be assigned by the presence of frequent *Cyprideis mehesi* and common *Cyprideis* cf. *sarmatica* (SISSINGH, 1972, sample 6-12).

The sample A10 with lignite indicate fresh-water environment. In the next-higher sample A11 the associations derived indicate fully marine shallow-water environment with benches of *Gryphaea* (*Crassostrea*) *gryphoides crassissima* and common *Ostrea* sp., *Terebralia bidentata bidentata*, *Terebralia lignitarum lignitarum*.

The sample A12 contains specimens of *Cardium sp.* and abundant smooth Ostracoda. The composed fauna indicates brackish water environment. This environment became gradually a fresh-water one with deposition of lignite (A13).

The sample A14 contains fish-teeth, plant remains and frequent *Cerithium* (*Thericium*) *italicum dertonensis*, *Hydrobia* sp., *Melanopsis* aff. *impressa*, *Terebralia bidentata bidentata*, *Theodoxus* aff. *rhodiensis*, *Unio* sp. and common *Lunatia catena helicina*, *Natica* (*Nacca*) *millepunctata*, *Turritella* (*Archimediella*) *archimedis dertonatior*, *Turritella* (*Archimediella*) *pythagoraica pythagoraica*, *Turritella* (*Torculoidella*) *triplicata*. The composed fauna and the plant remains indicate a brackish water to marine environment. The macrofaunistic species, which are present in this lithostratigraphic interval, are a mixture of brackish and marine types. Also, from the Foraminifera only *Ammonia becarii* and some Miliolids were found. All this evidence leads us to conclude a brackish to fairly marine water environment.

For the next higher sample A16 we can say, that it is of marine environment with the common presence of Molluscs as *Lunatia catena helicina*, *Natica millepunctata*.

The associations derived from the interval of the sample A17 indicate a marine to fairly brackish water environment with lignitic intercalation. The upper part of the section with the samples A19, A20, contain numerous marine Molluscs associations and Foraminifera indicating a marine environment. From the Molluscs assemblages the most common ones are those of *Terebralia bidentata bidentata*, *Terebralia lignitarum lignitarum*, *Turritella triplicata*, *Conus* (*Conolithus*) *dujardini*, *Galeodes* (*Galeodes*) *cornutus* etc.

From the planktonic Foraminifera are common *Neogloboquadrina acostaensis*, *Globigerina nepenthes*, *Globorotalia gigantea*, *Globigerinella siphonifera*, *Globorotalia*

suterae etc., which allows us to recognize the lower part of *Globigerina acostaensis* biozone, according to ZACHARIASSE (1975).

The above mentioned biostratigraphic data is in good agreement with the results of ZACHARIASSE (1975),who studied the planktonic associations from several sections of Heraklion province. Based on these results, we can say that section Armyri Panayia covers the biostratigraphic interval of the lower part of *G. acostaensis* biozone.

Also, according to the Ostracode study of SISSINGH (1962), the section Armyri Panayia covers the Ostracode biozone of *Cyprideis* cf. *sarmatica.*

Summarizing the biostratigraphic evidence, we may conclude, that the sediments of the section Armyri Panayia were deposited in the middle Tortonian time-span.

ΠΕΡΙΛΗΨΙΣ

Εἰς τὴν παροῦσαν μελέτην ἐξετάζονται τὰ Ἄνω Μειοκαινικὰ στρώματα τῆς τομῆς Ἁρμυρῆς Παναγίας πλησίον τοῦ χωρίου Ἄνω Μούλια εἰς τὴν Μεσσαρᾶν Ἡρακλείου. Τὰ ἰζήματα τῆς τομῆς παρουσιάζουν πάχος 50 μέτρων περίπου καὶ ἀνήκουν εἰς τὸν Σχηματισμὸν Ἀμπελούζου (συμφώνως πρὸς τὸν A. Jonkers). Τὰ ἰζήματα τοῦ σχηματισμοῦ αὐτοῦ παρουσιάζουν ἀποτόμους ἀλλαγὰς τῆς λιθολογίας καὶ εἰς κατακόρυφον καὶ εἰς ὁριζοντίαν διεύθυνσιν. Ἐπικρατοῦντες λιθολογικοὶ τύποι τοῦ σχηματισμοῦ Ἀμπελοῦζος εἶναι τὰ κροκαλοπαγῆ, οἱ ἄμμοι, αἱ ἄργιλοι καὶ αἱ ἰλεῖς. Ὡρισμένοι ὁρίζοντες εἶναι πλουσιώτατοι εἰς περικλειόμενα Μαλάκια, ἐνῶ παρατηροῦνται καὶ ἐνδιαστρώσεις λιγνιτικαὶ καθὼς καὶ λιμναῖοι ὁρίζοντες. Τὸ περιβάλλον ἀποθέσεως κυμαίνεται ἀπὸ ποταμο-χειμάρριον πρὸς ὑφάλμυρον ἕως καὶ ἀβαθὲς θαλάσσιον.

Ἐκτὸς τῆς λεπτομεροῦς λιθοστρωματογραφικῆς περιγραφῆς τῆς τομῆς Ἁρμυρῆς Παναγίας εἰς τὴν παροῦσαν ἔρευναν μελετᾶται ἡ Βιοστρωματογραφία καὶ ἡ Χρονοστρωματογραφία τῆς τομῆς. Οὕτω ἐμελετήθησαν αἱ περικλειόμεναι συγκεντρώσεις τῶν διαφόρων εἰδῶν Γαστεροπόδων, Ἐλασματοβραγχίων, Θυσανοπόδων, προσδιωρίσθη δὲ καὶ ἡ σχετικὴ συχνότης των.

Ἐκ τῶν βιοστρωματογραφικῶν δεδομένων τῶν μακροαπολιθωμάτων συμπεραίνεται ὅτι ἡ ἡλικία τῆς τομῆς Ἁρμυρῆς Παναγίας εἶναι ἡ τοῦ Μέσου Τορτονίου. Ἐπὶ τῇ βάσει τῶν περικλειομένων πλαγκτονικῶν Τρηματοφόρων εἰς τὸ ἀνώτερον τμῆμα τῆς τομῆς ἀνεγνωρίσαμεν τὴν βιοζώνην τῆς *Globigerina acostasenas* ὡς τὴν εἶχε προσδιωρίσει διὰ τὴν Κρήτην ὁ Zachariasse (1975). Ἐπίσης τὰ ἰδικά μας στρωματογραφικὰ στοιχεῖα εὑρίσκονται εἰς συμφωνίαν μὲ τὴν βιοζώνην τῶν ὀστρακωδῶν *Cyprideis* cf. *sarmatica* ὡς τὴν εἶχεν προσδιορίσει εἰς τὴν τομὴν αὐτὴν ὁ Sissingh (1972).

Ἐξ ὅλων τῶν ἀνωτέρω κατελήξαμεν εἰς τὸ συμπέρασμα ὅτι τὰ ἰζήματα τῆς τομῆς Ἁρμυρῆς Παναγίας ἀπετέθησαν κατὰ τὴν διάρκειαν τοῦ Μέσου-Τορτονίου.

Τὴν ἡλικίαν τοῦ Τορτονίου, εἶχον προσδιορίσει οἱ ΨΑΡΙΑΝΟΣ καὶ ΒΕΤΟΥ-

ΛΗΣ (1958) οἱ ὁποῖοι ἐμελέτησαν μόνον τὰ ἀπολιθώματα τοῦ ἀνωτέρου τμήματος τῆς τομῆς Ἁρμυρῆς Παναγίας.

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