



The late Messinian *Lago-Mare* molluscan assemblage from the Trave Horizon (Colombacci Fm) at Pietralacroce (Ancona, Central Italy)

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ABSTRACT - A molluscan assemblage from the biocalcarenitic Trave Horizon (Colombacci Formation) cropping out at Pietralacroce (Ancona, Marche, Central Italy) is described. The fossil assemblage consists of several taxa of bivalves of Paratethyan affinity and gastropods, belonging to *Lymnocardiinae*, *Dreissenidae*, *Hydrobiidae*, *Melanopsidae*, and *Thiaridae*, characterizing the latest Messinian "Lago-Mare" biofacies. Pulmonate freshwater and terrestrial gastropods (*Physidae* or *Lymnaeidae* and *Helicidae*) are also recorded. The autochthonous character of the assemblage is pointed out. The palaeoecological analysis reveals oligo-mesohaline shallow-water environment strongly influenced by freshwater input. The Messinian character of the molluscan assemblage from the Trave Horizon and the similarity with the ones from other upper Messinian deposits of the Colombacci Formation, cropping out in the Romagna-Marche sector (Apennine foredeep), allows to infer a latest Messinian age for the fossiliferous Trave Horizon.

RIASSUNTO - [L'associazione a molluschi della biofacies "Lago-Mare" tardo-messiniana dell'orizzonte del Trave (Formazione a Colombacci) a Pietralacroce (Ancona, Italia centrale)] - Il ritrovamento di un affioramento fossilifero, non ancora descritto, dell'unità litostratigrafica post-evaporitica detta "orizzonte del Trave" (Formazione a Colombacci), affiorante a Pietralacroce (Ancona, Marche, Italia centrale), ha fornito lo spunto per illustrare la caratteristica associazione fossile di "Lago-Mare" tardo-messiniana in esso contenuta e per discutere l'età di tale orizzonte biocalcarenitico, recentemente messa in discussione da alcuni autori. L'associazione fossile consiste di numerosi taxa di bivalvi oligo-mesolalini ad affinità paratetidea della sottofamiglia *Lymnocardiinae* e della famiglia *Dreissenidae*, e gasteropodi (*Hydrobiidae*, *Melanopsidae*, *Thiaridae*), caratterizzanti la biofacies "Lago-Mare" del Messiniano superiore nell'area mediterranea. Inoltre, elementi ipolalini, come *Physidae* o *Lymnaeidae*, ed elementi terrestri (*Helicidae*) indicano apporti di acqua dolce e ambiente emerso limitrofo, fornendo una connotazione paleoambientale di bacino ad acque poco profonde e bassa salinità. Lo stato di conservazione degli esemplari evidenzia il carattere autoctono dell'associazione a molluschi. Il carattere messiniano dell'associazione e la sua similarità con quelle di altri depositi della Formazione a Colombacci attribuiti al Messiniano superiore, nel settore Romagna-Marche dell'avanfossa appenninica, suggeriscono un'età tardo-messiniana per detto orizzonte.

INTRODUCTION

The "Trave" is a well-known upper Messinian post-evaporitic lithostratigraphical unit cropping out along the Adriatic coast, few kilometres South-East of Ancona. It was already recognized as fossiliferous deposit by Capellini (1879) and later by Carloni & Ceretti (1967), Gillet (1969), Moruzzi & Follador (1973), Crescenti et al. (1974). More recently, Roveri et al. (2005) considered the Trave Horizon "a peculiar expression of the Mio-Pliocene transgression" or, alternatively, the record of "a large part of the MPI1 and MPI2 biozones".

This unit, locally and also on the road maps known as "Scoglio del Trave", emerges from the sea and steeply rises along a cliff-like slope up to the Monte dei Corvi, 236 m a.s.l. Some authors consider it as a lenticular body passing laterally to the top of the upper Messinian Colombacci Formation (Capellini, 1879; Carloni & Ceretti, 1967; Gillet, 1969; Crescenti et al., 1974), but others (Moruzzi & Follador, 1973; Roveri et al., 2005) favour its attribution to the Early Pliocene. The Trave Horizon is actually encompassed between the post-evaporitic upper Messinian Colombacci Formation and Lower Pliocene clays.

The thickness of the Trave is about 15 m at the Trave reef. It is made of thin, dark-grey layers of calcareous

sandstone interbedded with yellowish marly limestone layers, which also contain a minor siliciclastic component. In its uppermost 5 m calcareous sandstone layers prevail (Crescenti et al., 1974; Coccioni & Moretti, 2001; Roveri et al., 2005).

A new outcrop of this horizon was discovered by the writers further North at Pietralacroce, in the outskirts of Ancona, suggesting that it could be a unit of larger extent rather than a reduced lenticular body.

THE SECTION OF PIETRALACROCE

Pietralacroce is a suburban district of the town of Ancona. Presently it is a residential area but it preserves some historical remains, among which the "Strada vecchia di Pietralacroce", a tortuous road, is running along a steep slope. Here, terrigenous rocks crop out for some tenth of metres at one side of the road (43° 36' 28" N, 13° 31' 54" E, altitude 163 m a.s.l.; Fig. 1). The visible thickness is about 9.30 m, but estimated up to 13 m taking into account the basal part covered by colluvium. Strata dipping SW for about 50° are composed of alternating thin calcarenitic layers, up to 10 cm thick, and bioturbated siltstones, up to 50 cm thick. The reddish colour and the lithological features of this outcrop correspond very well



Fig. 1 - Outcrop of the biocalcarenitic Trave Horizon at "Strada vecchia di Pietralacroce". A) the studied section. B) Alternating thin calcarenitic layers and bioturbated siltstones. C) Bioturbation structures; ochreous bands are visible. D) Lithological detail showing whitish, friable micritic limestone levels, few cm thick.

with the uppermost part of the Trave Horizon as described by Roveri et al. (2005) for the type locality, located at seaside about 4 km to SE. Whitish, friable limestone levels, few cm thick, are interbedded throughout the succession. The top and the base of the succession are not visible, but some metres above the outcrop true marine molluscs are spread on agricultural land, thus indicating the presence of marine Pliocene cover; downwards a small outcrop shows greyish siliciclastic strata compatible with the Colombacci Fm.

It is therefore reasonable to extend the presence of the Trave Horizon from its original exposure up to the outcrop of Pietralacroce.

The whitish friable micritic limestone levels are devoid of fossil remains similarly to the Colombacci limestone, the thin and hard calcarenitic levels do not show easily extractable fossils, whereas the bioturbated siltstones bear a significant molluscan assemblage that will be described below.

MOLLUSCS FROM THE TRAVE HORIZON AT PIETRALACROCE

Abundant molluscs occur in yellow-ochre calcareous mudstone of the measured section cropping out at "Strada vecchia di Pietralacroce". Several bivalves and gastropods with decalcified shells have been collected; many bivalves

show articulated valves. A typical oligo-mesohaline molluscan assemblage characterizing the "Lago-Mare" biofacies was recognized: several species of non-marine cardiid bivalves of the subfamily Lymnocardiinae, one species of Dreissenidae and few species of freshwater and terrestrial prosobranch and pulmonate gastropods have been recorded.

The molluscan assemblage is dominated by small-sized Lymnocardiinae, among which *Lymnocardium adriaticum* Gillet, *Euxinocardium subodessae* (Sinzov), *Pontalmyra anconaetana* (Capellini), *P. equilateralis* Gillet, *P. tenuicostata* Gillet, *Prosodacna* (*Prosodacna*) gr. *semisulcata* (Rousseau), *P. (?Prosodacna) elevata* Gillet, and *Plagiodacna sellii* Gillet are the best preserved. Moreover, sculptured shell fragments possibly belonging to *Pachydacna* (*Parapachydacna*) cf. *cobalcescui* (Fontannes) and very decalcified shells of different species of Lymnocardiinae are present in the sediment, but their poor preservation does not allow species-level identification. Dreissenidae are less abundant and represented by some small specimens of *Dreissena* ex gr. *D. rostriformis* (Deshayes).

Gastropods occur in very low percentage. Scattered specimens and shell fragments of oligohaline prosobranchs, such as *Melanopsis narzolina* D'Archiac, *Melanoides curvicosta* (Deshayes), and Hydrobiidae (?*Saccoia*) occur. Some freshwater and terrestrial pulmonates, such as one species of Physidae or

Lymnaeidae (?*Lymnaea* sp.) and one species of Helicidae (?*Klikia* sp., a little cup-shaped internal mould with depressed spire and four slightly convex whorls, the last one descending downward) are also present (Pl. 1).

The fossil material from Pietralacroce has been compared with Capellini's and Gillet's mollusc collections stored in the Geological and Palaeontological Museum "G. Capellini" in Bologna. Among bivalves it was possible to compare the following five species: *Lymnocardium adriaticum*, characterized by a strong carina, collected at Trave by G. Capellini, and mentioned as *Cardium carinatum* Deshayes by Capellini (1879, pl. 2, fig. 8); *Pontalmyra equilateralis*, recognizable for the numerous thin and flat ribs, the rounded anterior margin and the absence of a dorsal carina, reported from Monte dei Corvi and Trave by Gillet (1969) and synonymized by this author with *Cardium spratti* Fuchs described by Capellini (1879, pl. 2, fig. 13) from the same fossiliferous horizon; *Pontalmyra tenuicostata*, with very narrow and closely-spaced ribs and a slightly prominent small umbo, found at Monte dei Corvi by Gillet (1969); *Prosodacna elevata*, characterized by a prosogyre and prominent umbo and narrow ribs, found at Monte dei Corvi and Trave by Gillet (1969); *Plagiodacna sellii*, with a prosogyre umbo and about twenty flat ribs, recorded at Monte dei Corvi by Gillet (1969), and synonymized with *Cardium edentulum* Deshayes described in Capellini (1879, pl. 2, fig. 3). *Pontalmyra anconaetana* (Capellini, 1879, pl. 2, fig. 13) was not found in the mentioned collections.

These species seem to be endemic in the Adriatic margin, even if derived from Paratethyan elements: actually the genera *Lymnocardium*, *Pontalmyra*, and *Prosodacna* originated in the Paratethys realm where they are represented by several species (Müller et al., 1999; Magyar, 2004).

The other three bivalve species have a wider distribution and are immigrants from Paratethys: *Euxinocardium subodessae* is common in the Pontian and Dacian stages of Paratethyan basins (Papaianopol, 1989; Nevesskaja et al., 2001); *Prosodacna* (P.) gr. *semisulcata* belongs to a large group, with several subspecies (morphotypes?) described by Andreescu (1977), widespread in the Ponto-Caspian and Dacic basins during Bosphorian (upper Pontian) and Getian (Early Pliocene); *Pachydacna* (P.) *cobalcescui* is spread in upper Pontian and Getian (Early Pliocene) of the Dacic basin (Stefanescu, 1896; Papaianopol, 1989; Nevesskaja et al., 2001; and Papaianopol & Lubenescu, 1983, respectively). These three species have been also recorded from the Trave Horizon at Monte dei Corvi by Gillet (1969), but *Prosodacna* (P.) gr. *semisulcata* was identified there by Gillet as *Prosodacna* cf. *semisulcata minor* Eberzin.

Dreissena ex gr. *D. rostriformis*, a species of Paratethyan origin (Archambault-Guezou, 1976), has a wide Mediterranean distribution in the late Messinian, occurring in most of the "Lago-Mare" molluscan assemblages (Esu, 2007), thus testifying their oligohaline character.

As regards the recovered gastropods, *Melanopsis* specimens are very poorly preserved. The presence of carinae on the shell, however, allows us to identify them as *M. narzolina*, a common species in the upper Messinian "Lago-Mare" Mediterranean assemblages. The

state of preservation of the freshwater and terrestrial taxa (Physidae or Lymnaeidae and ?*Klikia* sp.) does not permit a complete identification.

The non-endemic bivalves and gastropods recovered at the Trave Horizon commonly occur in several latest Messinian "Lago-Mare" assemblages of Italy (Esu, 2007).

MOLLUSCS FROM THE TRAVE HORIZON AT MONTE DEI CORVI (CONERO RIVIERA)

Capellini (1879) studied the highly fossiliferous "Congeria beds" from "il Trave" cropping out at Monte dei Corvi (Conero Riviera) and described several species of Lymnocardiinae, Dreissenidae and gastropods of the family Melanopsidae.

Gillet (1963, 1969) carried out a revision of Capellini's material and also collected and described the rich molluscan fauna from the calcarenitic deposits of "il Trave" and "Monte dei Corvi". The recovered assemblages are dominated by abundant bivalves belonging to lymnocardiids and dreissenids, among which several species of *Lymnocardium*, *Paradacna*, *Euxinocardium*, *Pontalmyra*, *Plagiodacna*, ?*Tauricardium*, *Prosodacna*, and *Pachydacna* were identified by Gillet (1969): "*Limnocardium anconensis* Gillet; *L. adriaticum* Gillet, *L. cf. karreri* Fuchs, *L. laeviusculum* Capellini, *L. paolucci* Capellini, *Limnocardium* sp., *Paradacna* cf. *abichi* R. Hoernes, ?*Paradacna* sp., *Euxinocardium* gr. *subodessae* (Sinzov), *E. gr. subodessae ursina* Eberzin, *E. cf. nobile* Sabba, ?*E. pesarensis* Gillet, *Pontalmyra* sp. 1, *Pontalmyra* sp. 2, *Pontalmyra* sp. 3, *Pontalmyra* sp. 4, *P. equilateralis* Gillet, *P. tenuicostata* Gillet, *Plagiodacna sellii* Gillet, *P. corviensis* Gillet, *P. obliquata* Gillet, *Plagiodacna* sp. n., ?*Monodacna castellinensis* (Capellini), *M. fedrighinii* Capellini, *M. tenuicostata* Gillet, ?*Tauricardium* cf. *odessae* Barbot, *Prosodacna* aff. *littoralis* Eichwald, *P. aff. littoralis orientalis* Andrussov, *P. cf. barboti* Andrussov, *P. cf. eichwaldi* Andrussov, *P. cf. macrodon minor* Andrussov, *P. cf. semisulcata minor* Eberzin, *P. cf. scarabellii* Capellini, *P. elevata* Gillet, *P. (Pachydacna) acutensis* Gillet (sic!), *Pachydacna* aff. *sabbae* Eberzin". Gastropods are represented by very few species of Melanopsidae and Hydrobiidae. Some of the mentioned species collected by S. Gillet are stored in the Geological and Palaeontological Museum "G. Capellini" in Bologna.

A modern systematic revision of this material is needed, nevertheless it is possible to point out endemic and Paratethyan elements.

Further samplings on the Trave Horizon at Monte dei Corvi by D. Esu, O. Girotti, and R. De Mattia in the 1980's provided the following lymnocardiids: *Lymnocardium otiothorum* (Brusina), *Tauricardium* cf. *odessae*, *Phyllocardium complanatum* (Fuchs), *Pseudocatillus simplex* (Fuchs), *Prosodacnomys sturi sabbae* Andreescu, *Prosodacna elevata*, *Pachydacna* (*Parapachydacna*) *cobalcescui* (Fontannes). Some of these species have been also recorded from the Trave Horizon at "Strada vecchia di Pietralacroce" (see above).

Similar assemblages composed of small-sized lymnocardiids, dreissenids and gastropods, mostly

displaying common species to the Trave Horizon, occur at Capanne di Bronzo (Ca' Ciuccio section, Pesaro, Marche) and at Cella near Cesena (eastern Romagna) in deposits of the upper Messinian Colombacci Formation, just below the grey-blue marls of the Early Pliocene (Colalongo et al., 1976; Bellagamba, 1978).

PALAEOECOLOGICAL REMARKS

As known, from the second half of the Early Miocene up to the Pliocene, representatives of Lymnocypridae became common throughout the Paratethys in shallow water basins, with low salinities (5-18‰), displaying repeated events of adaptive radiation through time (Magyar et al., 1999; Nevesskaja et al., 2001; Magyar, 2004). According to Müller et al. (1999) the radiation of such cyprids and dreissenids within "lake Pannon" was exceptional during the early Tortonian, when a freshened phase took place giving rise to hundred of species which colonized the entire lake, from deep water to littoral brackish environment even to freshwater lagoons on the delta plains. According to Nevesskaja et al. (2001), Lymnocypridae occupied various ecological niches in the Paratethyan basins; some taxa, such as *Eupatoria*, *Prosodacna*, *Plagiodacna*, *Pachydacna*, could live in shallow water on shelly detritus and sandy-muddy sediment; others, such as *Lymnocardium*, *Pontalmyra*, *Pseudocatillus*, were shallow burrower infaunal suspension feeders, more or less close to the sediment surface. Similarly to the Trave Horizon, representatives of *Pontalmyra* are also found in sandy-coarse calcareous facies of early Pontian of the Dacic basin (Macalet, 2001).

The molluscan fossil assemblage recorded from the Trave is characterized by the most typical Mediterranean "Lago-Mare" taxa, such as Lymnocypridae, Dreissenidae and hypo-oligohaline prosobranch and pulmonate gastropods. Mediterranean Lymnocypridae could have environmental requests similar to those of the Paratethyan taxa, i.e. oligo-mesohaline shallow water; the gastropods, represented by species of *Melanopsis*, *Melanoides*, and Physidae (or Lymnaeidae), and bivalves Dreissenidae are

commonly linked to continental shallow freshwater systems, such as slow-running fluvial freshwater, or to slightly brackish waterbodies, such as estuarine environment (Archambault-Guezou, 1976; Esu, 2007 and references therein); the terrestrial taxa point to a near emerged environment. These evidences suggest that the recovered assemblages are most likely tied to a shallow water environment subject to continental freshwater influx (such as a deltaic system), with slight salinity variations from hypo- to mesohaline.

Similar palaeoenvironment is envisaged by Carnevale et al. (2006) for the latest Messinian fossiliferous deposits of the Ca' Ciuccio section, at Capanne di Bronzo, where, besides the "Lago-Mare" molluscan fauna described by Bellagamba (1978), euryhaline fishes have been recorded suggesting a deltaic depositional environment with variable salinity.

The dispersal of Paratethyan Lymnocypridae into the Mediterranean area during the latest Messinian was favoured by the spreading of such suitable habitats in depositional systems of marginal settings, characterized by increasing freshwater influx during the post-evaporitic phase.

Consequently, since the ecology of the latest Messinian "Lago-Mare" molluscan assemblages is mainly tied to continental/brackish environment, the abrupt disappearance of such communities at the Mio/Pliocene boundary is due to the sudden return to fully marine conditions at the beginning of Pliocene in the Mediterranean basin (Rio et al., 1991).

CONCLUSIVE REMARKS

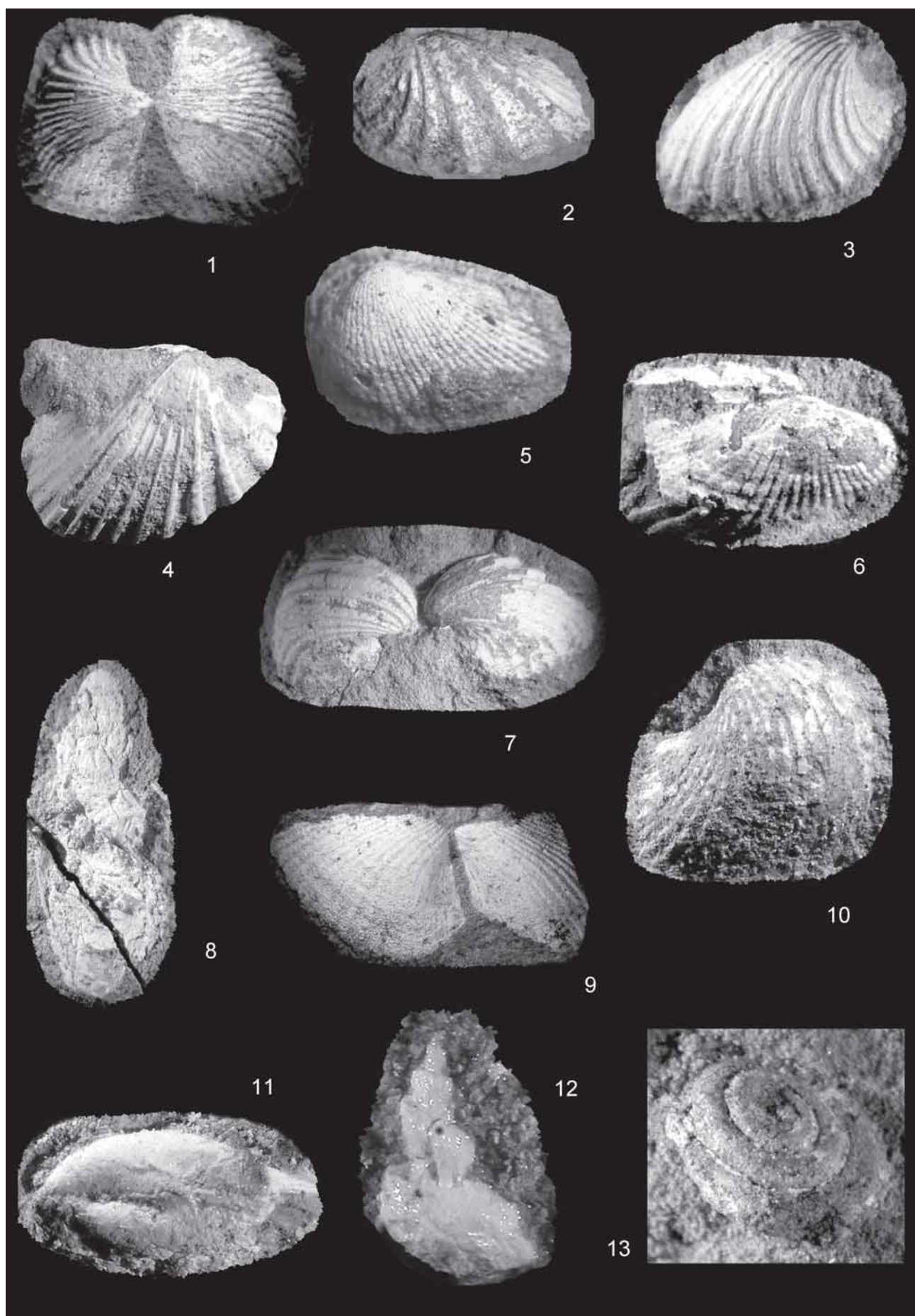
The molluscan fauna depicted from the Trave Horizon is typical of the latest Messinian "Lago-Mare" biofacies, which was widespread all over the margins (internal and external) of the Apennine Arc and in Sicily after the Mediterranean "salinity crisis" (Esu, 2007 and references therein).

Lithology and molluscan assemblage of the "Strada vecchia di Pietralacroce" section are correlatable with those of the Trave Horizon at Monte dei Corvi, even if

EXPLANATION OF PLATE 1

- fig. 1 - *Lymnocardium adriaticum* Gillet, 1969; specimen with articulated valves, x 3, MPUR-7-3483.
- fig. 2 - *Euxinocardium subodessae* (Sinzov, 1877); specimen with very decalcified shell; left valve, x 5, MPUR-7-3484.
- fig. 3 - *Prosodacna elevata* Gillet, 1969; right valve, x 5.5, MPUR-7-3485.
- fig. 4 - *Pontalmyra anconaetana* (Capellini, 1879); right valve, x 5, MPUR-7-3492.
- fig. 5 - *Pontalmyra tenuicostata* Gillet, 1969; left valve, x 6.5, MPUR-7-3486.
- fig. 6 - *Plagiodacna sellii* Gillet, 1969; specimen with articulated valves, x 5, MPUR-7-3487.
- fig. 7 - *Pachydacna* sp.; specimen with articulated valves, x 3, MPUR-7-3490.
- fig. 8 - *Melanopsis narzolina* D'Archiac, 1846; carinae are visible on the whorls, x 5, MPUR-7-3491.
- fig. 9 - *Pontalmyra equilateralis* Gillet, 1969; specimen with articulated valves, x 3, MPUR-7-3489.
- fig. 10 - *Prosodacna* (*Prosodacna*) gr. *semisulcata* (Rousseau, 1842); specimen with very decalcified shell; left valve, x 4, MPUR-7-3488.
- fig. 11 - *Dreissena* ex gr. *D. rostriformis* (Deshayes, 1838); specimen with articulated valves, x 5, MPUR-7-3493.
- fig. 12 - Physidae or Lymnaeidae; sinistral specimen, x 15, MPUR-7-3494.
- fig. 13 - Helicidae (? *Klikia* sp.); internal mould, x 8, MPUR-7-3495.

All the specimens are stored in the collection Esu & Girotti (MPUR-7, Museo di Paleontologia dell'Università di Roma "La Sapienza").



somewhat reduced in palaeontological content. The occurrence of true freshwater elements, such as Physidae or Lymnaeidae, shows the persistence of low salinity conditions.

There is no evidence of reworking of the recorded molluscan assemblage from the Trave Horizon at the Trave type locality as well as at Pietralacroce: the very thin and delicate shells of the sampled Lymnocyprinae could not tolerate the effects of sediment reworking without serious damage or destruction. Despite their evident fragility, it is not rare to collect bivalve specimens in a good state of preservation and not disarticulated. Moreover, complete small and thin gastropod shells, as freshwater Physidae or Lymnaeidae, confirm the absence of any transport of the fauna. Thus, as a whole the molluscan assemblage from the Trave Horizon and its preservation reflect a quite autochthonous palaeocommunity typical of the “Lago-Mare” biofacies.

As mentioned above, very similar “Lago-Mare” molluscan assemblages, composed of endemic and non-endemic small-sized lymnocyprids, dreissenids and gastropods, also occur in post-evaporitic upper Messinian successions (p-ev2 sensu Roveri et al., 1998) of other localities of the Romagna-Marche sector of the Apennine foredeep: at the Cella Section (Cesena; eastern Romagna) (Colalongo et al., 1976) and at Capanne di Bronzo (Montecalvo in Foglia syncline, Ca’ Ciuccio section, outer Marchean Basin; Bellagamba, 1978) from the upper part of the upper Messinian Colombacci Formation, just below the Mio/Pliocene boundary. The age of the fossiliferous horizon, containing also fish otoliths, described at Ca’ Ciuccio section, is estimated between 5.35 and 5.33 Ma by Carnevale et al. (2006). This age marks the return to fully marine conditions throughout the Apennine foredeep at the Miocene-Pliocene boundary (Roveri et al., 2005). Nevertheless, recently, Roveri & Manzi (2006) and Popescu et al. (2007) hypothesized that some “Lago-Mare” deposits in the Mediterranean basin could have an Early Pliocene age, on the basis of physical stratigraphy and biostratigraphical data. Further studies are needed to clarify the point at issue.

The molluscs of the Trave Horizon reveal a distinctive Messinian character, like the ones of the numerous upper Messinian assemblages spread all over the “Lago-Mare” biofacies of Italy (Esu, 2007). As regards the assumed possible Pliocene age of the Trave biocalcarene (Roveri et al., 2005), we observe that no Pliocene fossils *in situ* do occur in it, including foraminifers. About these Crescenti et al. (1974) already demonstrated the “infiltrated” character of *Globorotalia puncticulata* (Deshayes). Moreover, the “Lago-Mare” molluscs are incompatible in respect to those of the true marine Pliocene assemblages; not reworked or not infiltrated foraminifers, which are present in the Trave Horizon, belong to the so-called dwarf globigerinid assemblages peculiar of the Messinian post-evaporitic deposits, frequent in the “di tetto Formation” and less abundant in the Colombacci Formation, testifying a progressive continental influence (Crescenti, 1966; Girotti & Parotto, 1969; Crescenti et al., 1974; Colalongo et al., 1976).

On the basis of the malacofaunistic evidences it is possible to define the molluscan assemblage from the

Trave Horizon as a peculiar Lymnocyprinae faunal complex spread in the latest Messinian throughout the Romagna-Marche sector of the Apennine foredeep, which could be used as a correlation tool for the uppermost part of the Colombacci Formation.

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