

AN OVERVIEW ON THE MESSINIAN 'LAGO-MARE' PALEONTOLOGICAL RECORD

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Fig. 1 - Location of study areas
1: Romagna basin;
2: Crotone basin.

INTRODUCTION

In this work we will focus on the foraminifer and ostracod content of several stratigraphic sections from the northern Apennine foredeep (SCAB Well and Buttafuoco section) and Calabria (Crotone basin) (fig. 1, 2 e 7). In the northeastern Apennines basin a stratigraphic framework was reconstructed (fig. 2; Roveri et al., 1998), at the present the knowledges on the Crotone basin are still in progress (Dominici et al., this session) in order to recognise unifying stratigraphic features; however for these stratigraphic sections data from literature are known (Roda, 1964).

Recent micropaleontological studies on the "Lago-Mare" facies have proposed that they record evidences of marine influences, proving the connection between brackish environment and marine one.

Here, we summarise the state of the art on the "Lago-Mare" event and on the hypothesis of marine influences within it. Besides, we show some photographs about the faunal assemblage of three sections from the northeastern Apennines and Calabria (Crotone basin) together with a preliminary quantitative study

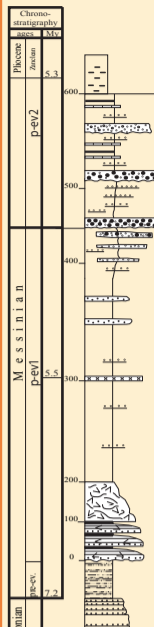


Fig. 2 - Stratigraphy of the south-eastern sector.

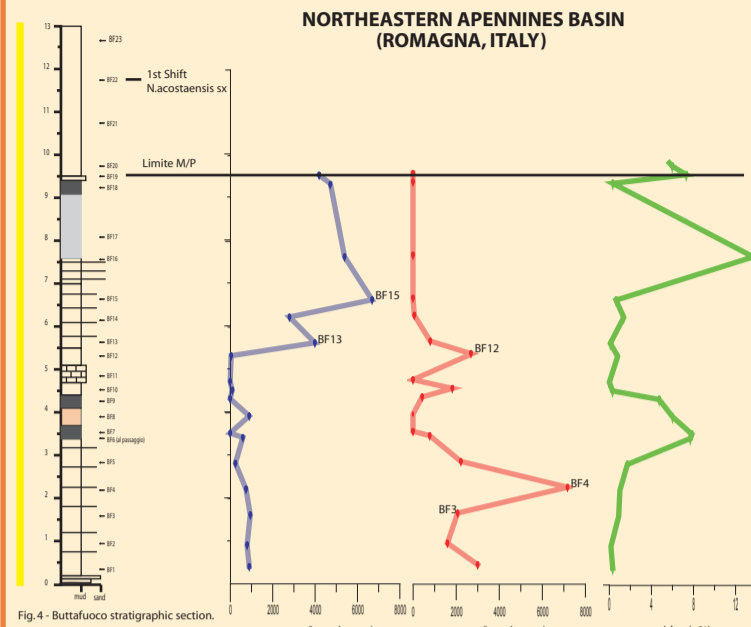


Fig. 4 - Buttafuoco stratigraphic section.



Sample BF3, 1.6m. X 25.
Description: Abundant detritic component; common recrystallized ostracods (*Cyprioides*), rare and small sized planktic foraminifers.

Sample BF4, 2.2m. X 25.
Description: Abundant detritic component; common ostracods (*Cyprioides*), and very rare small planktic foraminifers.

Sample BF5, 5.3m.
Description: Ostracods are common and foraminifers are absent. The detritic component is relatively abundant, but the residue is very low.



Sample BF13, 5.7m.
Description: Ostracods are rare, while planktic foraminifers are common, small, but well preserved. The residue is very low.

Sample BF15, 6.6m.
Description: Ostracods are absent, planktic foraminifers are common and, together with benthic of different dimensions. The residue is still very low.

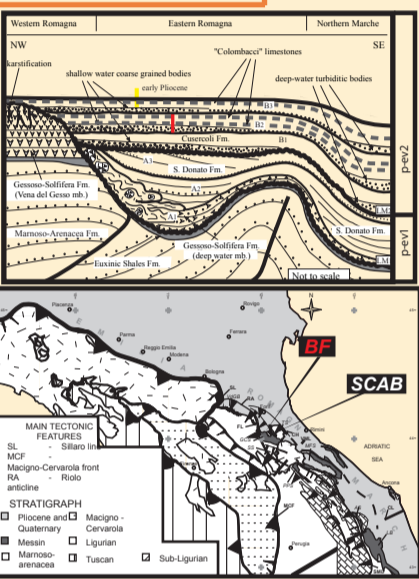


Fig. 3 - The geologic-stratigraphic model for the Messinian deposits of the Apennine foredeep (Roveri et al., 1998).

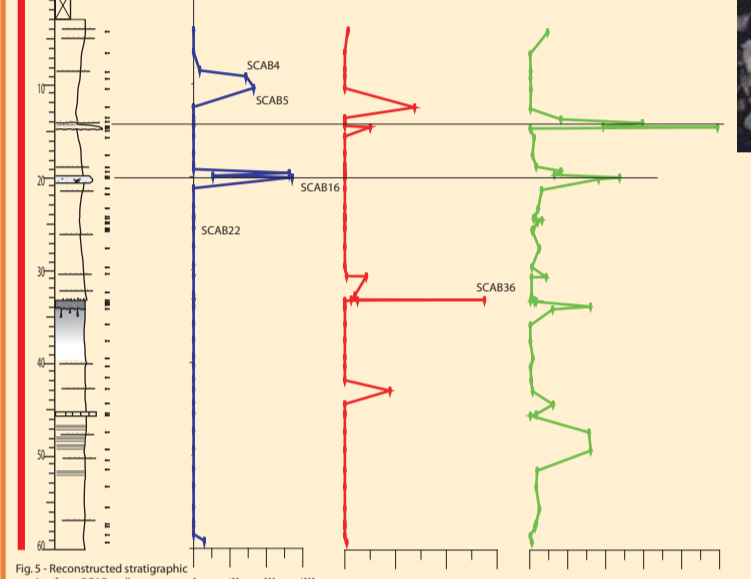
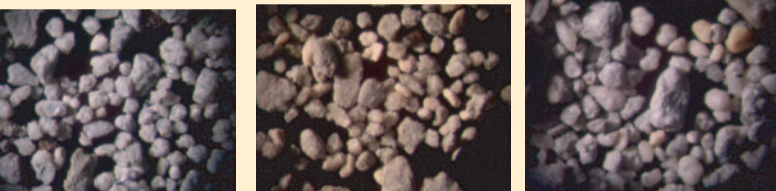


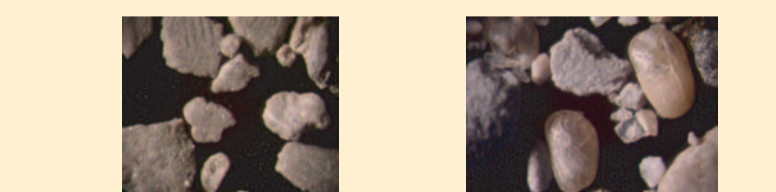
Fig. 5 - Reconstructed stratigraphic section from SCAB well



Sample SCAB4, 9.20 - 9.21 m.
Description: The residue is low, very rare and equidimensional planktic foraminifers are present.

Sample SCAB5, 10.44 - 10.46m.
Description: Similar to SCAB4, but planktic foraminifers are more frequent and commonly pyritized.

Sample SCAB16, 19.60-19.61m.
Description: Higher residue; foraminifers are common and different in size. Ostracods are rare.



Sample SCAB22, 24.29 - 24.30 m.
Description: Barren.

Sample SCAB36, 33.16 - 33.17m.
Description: Residue is low. Abundant ostracods and fragmented macrofossil.

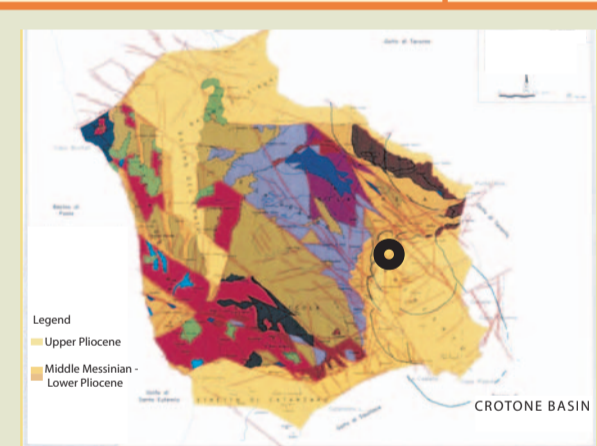


Fig. 7 - Schematic geological map of Calabria are the circled indicates the location of Ogliastro section. Unit lower than Miocene are not reported in the legend, (modified after VanDijk et al., 2000).

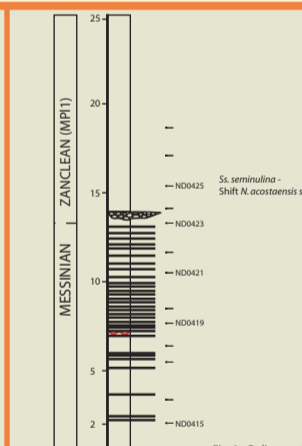
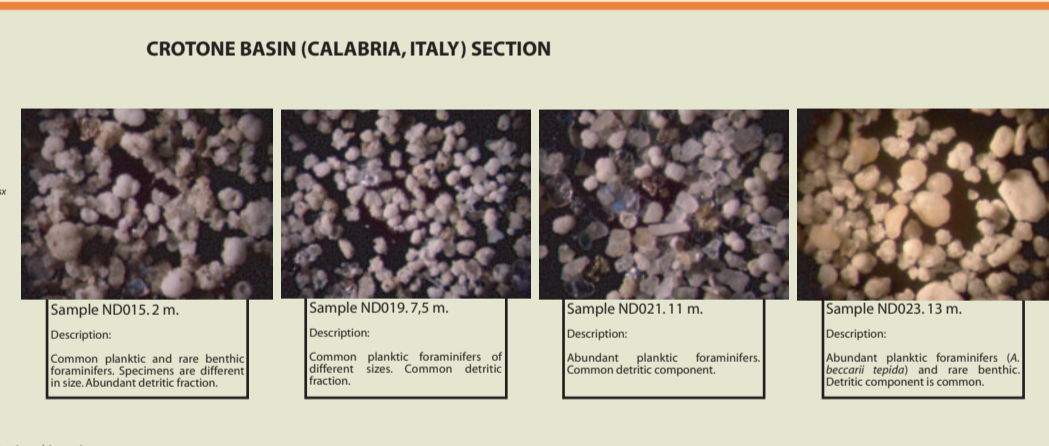


Fig. 6 - Ogliastro stratigraphic section.



Sample ND015, 2.2 m.
Description: Common planktic and rare benthic foraminifers. Specimens are different in size. Abundant detritic fraction.

Sample ND019, 7.5 m.
Description: Common planktic foraminifers of different sizes. Common detritic fraction.

Sample ND021, 11 m.
Description: Abundant planktic foraminifers. Common detritic component.

Sample ND023, 13 m.
Description: Abundant planktic foraminifers (*A. beccarii tepida*) and rare benthic. Detritic component is common.

OVERVIEW ON THE "LAGO-MARE"

The term "Lac Mer" was first used by Gignoux (1950) to indicate the ancient eastern Mediterranean (Tortonian to Messinian) paleoenvironment. This setting was created since the Tortonian by the disconnection and consequently isolation of Paratethyan basin with respect to the open sea. Thus, the fluvial input gradually transformed the marine water in brackish one, while faunal assemblage changed from marine to internal marine and finally to desalinized lagoon one (Lac-mer) and was represented first by *Cerithes* and, then, by *Congeria*. From this type of fauna derived the present day Caspian fauna.

This setting was recalled by Ruggeri (1967) to describe the paleoenvironment of the Messinian western Mediterranean basins, that after the closure of the Atlantic connection were "transformed into a series of lagoons, which either dried up, or became gradually desalinized". In fact an oligohaline gastropod fauna (*Melampus*) was recovered within the correlative deposits of many western Mediterranean sites. During the '70 the Deep Sea Drilling Project provided a new set of data, and the theory of the Salinity Crisis of the Mediterranean was hypothesized (Hsu et al., 1973). After that, they proposed to use the term "Lago-Mare" (the Italian translation for Lac-Mer) to indicate "the latest Messinian oligohaline paleoenvironment". The authors collocated this event approximately after the evaporite deposition and before the Pliocene marine sedimentation.

According to the desiccation model (Hsu, Ryan & Cita, 1973) the Mediterranean was dried up after the deposition of evaporite; recently this event was dated by Kringsman et al. (1999) at 5.61 Ma. On the unconformity generated by the desiccation deposited the Upper Evaporite Unit and, then, the Arenazzolo Formation. Bonaduce & Sgarella (1999) distinguished in the "Lago-Mare" deposits two different biofacies, distinctly represented in southern Sicilian successions. The first is characterised by ostracode monospecific population of *Cyprioides* and/or by monospecific population of *Ammonia beccarii tepida*. Hypohaline mollusks can occur in some layers. This biofacies was interpreted as representative of an hyperhaline environment with brackish or fresh water influx and was found within the Upper Evaporite Unit between the sixth and the seventh gypsum beds.

The second, upper biofacies is characterised by the *Laxoconcha diaffarovi* biozone (Carbonnel, 1978) that should correspond to the caspi-brackish fauna. In Sicily biofacies 2 is representative of the Arenazzolo Formation. The second biofacies assemblage is thought to be of Paratethyan origin (Bonaduce & Sgarella, 1999; Giolzi, 1999). The appearance of such an assemblage and the changing from hyperhaline to oligohaline or brackish water in western Mediterranean had already been explained by Hsu et al. (1978). Bonaduce & Sgarella (1999) and Giolzi (1999) confirmed that, during the latest Messinian, this caspi-brackish population entered the western Mediterranean as eastern Paratethyan water spilled into the Mediterranean.

But other points of view are rising. Bassetti et al. (2003), after the study of the "Lago-Mare" assemblages of northern Apennine outcrops (Sapigno section), found out that a little number of ostracode species are actually common both to Paratethys and western Mediterranean basins. The authors suggested that the rapid faunal spread from the Paratethys to the western Mediterranean is not that obvious, but, alternatively, it may be supposed that the similarity could depend on the evolution in the same setting (Lac-Mer/Lago-Mare). [Together with this observation it should be noticed that upper Messinian in Northern Apennine foredeep records both marginal and basinal settings; thus it is shown that the exposure and erosion of primary evaporite only occurs on basin margin, while the deepest part of the basin never underwent desiccation (Roveri et al., 1998, 2001; Ricci Lucchi et al., 2002).]

Within "Lago-Mare" facies the foraminifers and calcareous nannofossils are at time abundant but are considered by most of the researchers as reworked. Among them Monuzzi & Folador (1973) described a foraminifer assemblage from a north-eastern Apennine succession, composed of "recrystallized Globigerinids rarely abundant in number, and frequently very small in size" (< 125 µm). Colalongo et al. (1976) reported the finding of an association of small or poorly preserved to broken planktonic and benthonic foraminifers. Iaccarino & Pappalardo (1980) found a similar assemblage in the uppermost Messinian deposits of the north-western Apennine. In the Upper Evaporite Unit of Sicily, Bonaduce & Sgarella (1999) found benthic and planktic foraminifers stratigraphically and environmentally incompatible, together with abraded or with reddish specimens. All the authors agreed on the interpretation of these assemblages as reworked material. Iaccarino et al. (1998) documented at the very top of the Messinian "Lago-Mare" sequence at Site 975 (Leg 161, Balearic Basin) a paralic foraminifer assemblage which testifies the presence of marine waters before the Pliocene abrupt re-establishment of the open marine environment.

MARINE INFLUXES WITHIN "LAGO-MARE" FACIES

As said, most of the researchers working on the Messinian salinity crisis agree on the reworked origin of marine assemblages recorded in "Lago-Mare" deposits. This assumption matches with the idea that the Mediterranean became a completely unfit environment for marine species and was disconnected with the open sea until the base of the Pliocene.

Very recently, on the basis of the calcareous nannofossil association, several authors suggested the presence of repetitive marine incursions from the Atlantic within the "Lago-Mare" facies. Snel et al. (2001) and Popescu (2003) refer to repeated marine incursions from the Atlantic ocean to the Paratethys through the Mediterranean. Crescenti et al. (2002) studied an upper Messinian section from the central Apennine and found a rare autochthonous nannoplankton assemblage alternating with diatoms or ostracods.

Moreover, Aguirre et al. (2004) suggested that the "Lago-Mare" facies of the Nijar basin (Spain) represents marginal depositional elements of a marine basin. According to the authors, in fact, foraminifers and ostracods assemblage show a deepening trend towards the upper part of the succession, that means the basin underwent progressive transgression and brackish conditions were gradually substituted with marine one. The hypothesis advanced by Aguirre et al. (2004) is based on the assumption that even if brackish conditions lasted during the latest Messinian in marginal settings, the central part or at least several parts of the Mediterranean remained of marine environment. This interpretation was already proposed by Roda (1964) in the Crotone basin, where faunal and lithologic characteristics of the Upper Evaporite formation (Late Messinian) were considered similar to the Pliocene marine deposits (Cavaliere formation). The author suggested that the two formations could be deposited in lateral equivalent environments; in other words that a marine habitat was lasting during the uppermost Miocene.

At present, apart for the Nijar basin, on the basis of foraminifer assemblages, "Lago-Mare" deposits indicate typical brackish-water (biofacies 2 of Bonaduce & Sgarella, 1999) or fluctuating hyperhaline to brackish conditions (biofacies 1). Even Crescenti et al. (2002) confirmed that foraminifers are not clearly indicative of marine influxes because, as usual, they are very poor and badly preserved.

DISCUSSION

In this study we present three different cases of foraminifer presence within "Lago-Mare" deposits. Buttafuoco and Ogliastro sections both cross the M/P boundary; the Pliocene was dated through the finding of the first sinistral coiling shift of *Neoglobobulimina acostaensis* and the presence of *Sphaeroidinellopsis seminulina*, which indicate the presence of MP1 biozone (Cita, 1975, amended). Buttafuoco section and SCAB well are part of the same reconstructed stratigraphic section (fig. 2) from northern Apennines foredeep. In this area Roveri et al. (1998) identify a post-evaporite unit that stands over an unconformity and, in deep water setting, is floored by reworked evaporite. This unit is split into two sub-unit, p-e-1 and p-e-2; the latter, particularly, shows a cyclic stacking pattern climatically related (fig. 2). SCAB well comprises the 2nd and 3rd cycle, Buttafuoco the 4th. In Buttafuoco (fig. 4) samples the ostracods are much more abundant than in the other sections and their presence shows a decreasing trend toward the upper part. An opposite trend characterises the foraminifer abundance that became significant a few meter below the M/P boundary, pre-dating the Pliocene major marine flooding. Samples from SCAB Well (fig. 5) preserve very poor and sparse faunal assemblages, probably because of the little sample amount. The ostracods are present only in a few levels; the most important one (samples SCAB36) lies above a marsh deposits that stands on a paleosol. A second ostracod bearing level is at depth 12m were they are almost all pyritized. The foraminifers are even more rare, being present only in two levels; the lower one can be considered as a reworked presence, that coincides with a coarse sandstone bed. In the upper level (samples SCAB4 and 5) foraminifers are well preserved but small and rare. Most of the samples are avoid of organic components.

Stratigraphic and structural studies on the Crotone basin are being performed (Dominici et al., this session), during their fieldwork samples had been collected from several sections Ogliastro section (fig. 6) shows faunal assemblages very different and rich in well preserved and abundant planktic and benthic foraminifer.

CONCLUSIONS AND OPEN QUESTIONS

Observation on the >125 residues of the studied section together with quantitative analysis suggest different interpretations. In SCAB Well ostracods are rare but well distributed in different levels; foraminifers are rare and, as they are preserved at a unique level, a marine influxes can not be excluded. The other sections both represent the very upper part of "Lago-Mare" deposits; in Buttafuoco section we observe a progressive trend from brackish to marine condition (already suggested by Bassetti et al., submitted, from isotopic analysis). In Crotone basin foraminifers are common and well preserved, while ostracods are rare, so that a connection with marine water during the "Lago-Mare" event could be suggested.

A real conclusion cannot be drawn, more detailed studies are required to understand the vertical and lateral distribution of marine taxa within the "Lago-Mare" facies. In fact one of the evidences for marine connection, could be the cyclic or periodic presence of marine species. Moreover, as the problem involve Mediterranean scale processes, more data from different basins should be analysed, which, in turn, places the problem of the comparison between different areas; this operation requires the reconstruction of a common or comparable physical stratigraphic framework, in order to recognise coeval deposits.

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