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Comment on

# Marine reflooding of the Mediterranean after the Messinian Salinity Crisis predates the Zanclean GSSP. Reply to the ‘‘Comment on ‘Earliest Zanclean age for the Colombacci and uppermost Di Tetto formations of the ‘‘latest Messinian’’ northern Apennines: New palaeoenvironmental data from the Maccarone section (Marche Province, Italy)’ by Popescu et al. (2007) Geobios 40 (359–373)’’ authored by Roveri et al.

# La réinvasion marine de la Méditerranée après la crise de salinité Messinienne est antérieure au GSSP du Zancléen. Réponse au « commentaire sur ‘La Formation de Colombacci et le sommet de la Formation Di Tetto (« Messinien terminal » des Apennins septentrionaux) sont d’âge zancléen : nouvelles données paléoenvironnementales sur la coupe de Maccarone (Marche, Italie)’ par Popescu et al. (2007) Geobios 40 (359–373) » par Roveri et al.

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**Abstract**

After some deontological considerations, we confirm that evidence of Mediterranean reflooding by Atlantic waters occurs significantly below the formally defined base of the Zanclean Stage at 5.332 Ma, as shown by the lowest occurrence of the calcareous nannofossil *Ceratolithus acutus* (illustrated) in the lower part of the p-ev$_2$ Formation in the Maccarone section. This species can be detected only after prolonged investigations of the smear slides. Hence, the cyclostratigraphy of the Marche late Messinian requires revision.



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**Résumé**

Après quelques commentaires d'ordre déontologique, nous confirmons que la réinvasion du bassin méditerranéen par les eaux atlantiques est intervenue bien avant la base « officielle » de l'étage Zancléen placée à 5,332 Ma. Cela est notamment illustré par la présence du nannofossile *Ceratolithus acutus* (photographies à l'appui) dans la partie inférieure de la Formation p-ev$_2$ à Maccarone. La présence de cette espèce ne peut être établie qu'après une recherche au microscope plus longue que de coutume. La cyclostratigraphie du Messinien supérieur de la Province des Marches doit être révisée en conséquence.


*Keywords:* Pre-Zanclean transgression; *Ceratolithus acutus*; Stratigraphy

*Mots clés :* Transgression anté-zancléenne ; *Ceratolithus acutus* ; Stratigraphie

## 1. Introduction

Our reply to the comment of Roveri et al. is concise because our data are essentially self-evident. First, we wish to make a deontological observation. Roveri et al. in their Introduction wrote: ''Popescu et al. (2007) **derive palaeoenvironmental implications supporting the** Messinian salinity crisis **scenario proposed by the same Authors** group in previous papers (Clauzon et al., 2005)''. The two-step scenario for the Messinian Salinity Crisis (Clauzon et al., 1996) was proposed after comprehensive field observations in the Sorbas Basin and other Mediterranean peripheral basins where well-dated Messinian marginal evaporites are cut by a huge erosional surface overlain by lower Zanclean deposits (see also Gautier et al., 1994). Such a situation which clearly documents two successive sea-level falls, a moderate one corresponding to the marginal evaporites followed by an outstanding one that caused the central basin evaporites and an intense coeval subaerial erosion (including fluvial canyons) of the margins, is observed all around the Mediterranean and **does not necessitate an adjustment of the data as additional support** as suspected by Roveri et al. This assumption written by Roveri et al. curiously resembles that of Bertini (2006: p. 250, line 11): ''It is a fact that such event [i.e. ''an additional Lago-Mare event'' as indicated five lines above] **is indispensable to validate the two diachronous steps-model** proposed by Clauzon et al. (1996)''. Such assumptions seem to run counter to the deontological approach in science. Our concept of stratigraphy is to consider all the data and not merely select those in agreement with our so-called previously edified scenario. The alternative would allow any new data, even contradictory, to be integrated and serve to validate or modify our interpretation. It happens, however, that our two-step scenario (Clauzon et al., 1996) was fully accepted by a group of specialists of the Messinian Salinity Crisis during the CIESM Workshop in Almeria (November, 7–10, 2007), i.e. before submission of the comment by Roveri et al., an agreement recently published in a CIESM paper, the editing of which was curiously led by M. Roveri himself (CIESM Workshop Monographs, 2007; see especially its Fig. 4, p. 17).

## 2. The post Salinity Crisis reflooding of the Mediterranean and the Zanclean GSSP

Our contradictors are correct to emphasize that the marine records in the Di Tetto and Colombacci formations cannot be related to the early Zanclean Stage as clearly defined by the Zanclean Global Stratotype Section and Point (GSSP) at Eraclea Minoa (Van Couvering et al., 2000). The Zanclean GSSP is dated at 5.332 Ma in the Sicilian Series and has its echo in the Argille Azzurre overlying the Colombacci Formation in the Marche Series.

But the signs of marine reflooding of the Mediterranean prior to the Zanclean GSSP are not isolated, as they are also suggested in Morocco (Cornée et al., 2006), Calabria (Cavazza and DeCelles, 1998), Sicily (Londeix et al., 2007), Gulf of Lions (Bache, 2008), northeastern Aegean Sea (Clauzon et al., 2008), etc.

Our somewhat provocative title (Popescu et al., 2007) aimed to show again how greatly the Zanclean GSSP (Van Couvering et al., 2000) is compromised, given that it immediately follows a sedimentary hiatus on the Mediterranean margins and is complicated by a marine reflooding that is now known to occur in two steps. Can such a GSSP be appropriate when linked to such an exceptional succession of major events?

## 3. The Maccarone fossil records

Roveri et al. announce a more complete study of the Maccarone section by their group that is based on a dense sampling. We may expect very promising discussions arising from the paleobiological records and forthcoming geochemical measurements.

It is not necessary to repeat descriptions of the dinoflagellate cyst flora (Bertini, 1992, 2006; Popescu et al., 2007) recalled by Roveri et al. Additional new details on this flora are provided by Popescu et al. (in press). In any case, a complete understanding of ecological variations within Lago Mare facies as reflected in the dinoflagellate cyst record requires a detailed comparison with the type specimens from the Pannonian Basin, these being available only in Komlo and Lyon.

Foraminifers from the Di Tetto and Colombacci formations are considered by Roveri et al. as reworked, and they are rejected only on the weak argument that their presence is in contradiction with the ostracod record which has a freshwater signature. Such contradictory coexisting faunas are not exceptional in coastal environments within the Lago Mare context, as pointed out in Corsica (Casabianda locality) by Saint Martin et al. (2007) for sediments also containing *Ceratolithus acutus*, the marker of the nannofossil subzone NN12b (Popescu et al., 2007).

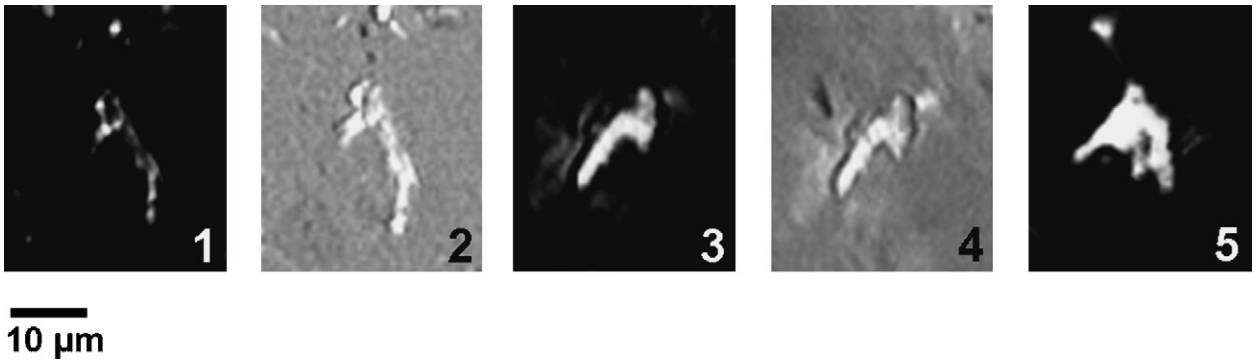


Fig. 1. **1**. *Ceratolithus acutus* Gartner and Bukry, sample 5 (Popescu et al., 2007), crossed nicols. **2**. *Ceratolithus acutus* Gartner and Bukry, sample 5 (Popescu et al., 2007), parallel light. **3**. *Ceratolithus acutus* Gartner and Bukry, sample 13 (Popescu et al., 2007), crossed nicols. **4**. *Ceratolithus acutus* Gartner and Bukry, sample 13 (Popescu et al., 2007), parallel light. **5**. *Ceratolithus acutus* Gartner and Bukry, sample 21 (Popescu et al., 2007), crossed nicols.

*C. acutus* is actually present, even if very scarce, in the Colombacci and underlying upper Di Tetto formations with similar morphology to that found in the Argille Azzurre deposits. Sediment caving cannot be invoked as we sampled in late August 2004, at the bottom of deep excavations made a few days earlier by the Roveri group. The presence of *C. acutus* almost continuously in our samples 5–15, and then episodically (samples 21 and 33) and finally continuously from sample 43, is fully consistent with the succession of bioevents recorded in the Maccarone section (Bertini, 1992, 2006; Popescu et al., 2007) as in many other peri-Mediterranean sections (Clauzon et al., 2008):

- at about 110 m from the base of the section, large increases in *Pinus* (indicative of more distal environment) and the coeval presence of foraminifers and marine dinoflagellate cysts;
- record of *Triquetrorhabdulus rugosus* from at least 130 m;
- first record of *C. acutus* at about 135 m;
- full marine conditions at 172 m (Argille Azzurre Fm.).

Roveri et al. argue that *C. acutus* is a very scarce species in the lower Zanclean of the Mediterranean where they mention it has been recorded only by Castradori (1998). This is inaccurate because the species was reported not only in several Mediterranean regions [i.e. at Capo Rossello by Cita and Gartner (1973), in the Aegean region (Acropotamos locality, northern Greece) by Snel et al. (2006b) and regularly by us everywhere in the Mediterranean Basin (Clauzon et al., 2008; Popescu et al., in press), as well as in the Paratethys (Dacic Basin: Mărunţeanu and Papaianopol, 1998; Snel et al., 2006a). In agreement with E. Di Stefano et al. (1996) who declare that ''Due to the rare presence of the species [i.e. *C. acutus*], in the Mediterranean sequence this bioevent [i.e. the First Occurrence of *C. acutus*] **can be identified only with a longer than routine investigation of the smear slides**, but its recognition at the base of the Mediterranean Pliocene sequence is extremely important'' (p. 408, lines 18–21), we performed a very careful analysis of each sample from the Maccarone section. Notably, the nannofossil *C. acutus* was recorded with very low frequency throughout the lower part of the studied section, where it is extremely rare (i.e., one specimen per more than 50 fields of view [FOV]) (Fig. 1(1–5)). Moreover, in the investigated sequence, it was not recorded in all samples. The absence of *C. acutus* in these samples is probably due to non-preservation, as its absence is coincident with those samples that yielded a poor or poor-to-moderately preserved nannofossil assemblages. A higher abundance of *C. acutus* (one specimen per 30–50 FOV) was observed towards the upper part of the section. However, a careful calcareous nannoplankton investigation could not omit specimens of *C. acutus*. On the other hand, the ''typical Pliocene species widely documented in Late Miocene (e.g. *Discoaster tamalis, Helicosphaera sellii*)'', according to Roveri et al., were not found by us in the Maccarone section.

Roveri et al. question our record of *C. acutus* at Maccarone on the basis of their cyclostratigraphy of the Colombacci Fm. This cyclostratigraphy is calibrated using two ages: that of the base of the Argille Azzurre Formation at 5.33 Ma which is reliable, and that at the boundary between p-ev$_1$ and p-ev$_2$ Formations at 5.42 Ma which is only speculative (see also Gennari et al., 2008). We conclude that our oldest specimens of *C. acutus* in the lower p-ev$_2$ Formation provide at last another reliable age (5.35 Ma: Lourens et al., 2004; 5.345: Raffi et al., 2006) for revising the cyclostratigraphic interpretation of the late Messinian in the Marche Province, taking also into account the radiometric age of the ash layer at 5.50 Ma.

## 4. Conclusion

Although there are many other aspects to counter assumptions made by Roveri et al., we consider that our detailed arguments are clearly sufficient to objectively establish the presence of early influxes of Mediterranean marine waters into the previously isolated Apennines foredeep. Such influxes occurred significantly before the formally-defined base of the Zanclean Stage, and resulted from what was probably an almost complete reflooding of the Mediterranean Basin significantly before 5.332 Ma. We appreciate the opportunity provided by Roveri et al. to reiterate our conclusions.

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