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Title: Comment on "Orbitally forced climate and sea-level changes in the Paleoceanic Tethyan domain (marl-limestone alternations, Lower Kimmeridgian, SE France)" By S. Boulila, M. de Rafélis, L.A. Hinnov, S. Gardin, B. Galbrun, P.-Y. Collin [Palaeogeography, Palaeoclimatology, Palaeoecology 292 (2010) 57-70]

Article Type: Discussion

Keywords: Oxfordian-Kimmeridgian; Marl-limestone alternations; Calcareous nannofossils; Basin-platform correlations; Carbonate production

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Abstract: A recent paper by Boulila and al. (2010) reports on orbitally-forced cycles recorded as marl-limestone alternations in one Lower Kimmeridgian section, Chateauneuf d'Oze (SE France, Tethyan domain). In an attempt to illustrate the in situ (i.e., pelagic) origin of carbonates in marls and limestones, the authors challenged the results of previous work concerning sections from other Tethyan areas of similar age, which demonstrate that nannofossil abundance is originally higher in marls than in limestones. Boulila et al. (2010) present data acquired with optical and Scanning Electron microscopes estimating nannofossil contribution to the rocks. However, their selected illustrations do not support a high contribution of the nannofossils to the carbonate fraction of their samples or their interpretation of the finest fraction of the rocks (micarbs). Furthermore, according to their data on carbonate content of the rocks, they did not analyse true marl-limestone alternations, but slightly argillaceous limestones and limestones. Boulila et al. (2010) also criticize earlier work providing a sequence stratigraphy interpretation of the Chateauneuf d'Oze section. However, contrarily to these earlier works, they did not consider platform-to-basin correlations that are essential in order to understand the sedimentary dynamics at the basin-wide scale. This comment challenges the work by Boulila et al. (2010) that largely underestimates the role of carbonate production on shallow platforms and its subsequent export basinwards as a major mechanism controlling the sedimentation in epicontinental basins.

Dear Professor Finn Surlyk,

We would like to submit to Palaeogeography, Palaeoclimatology, Palaeoecology our revised version of the Comment article Re: PALAEO5606. Title: Comment on "Orbitally forced climate and sea-level changes in the Paleoceanic Tethyan domain (marl-limestone alternations, Lower Kimmeridgian, SE France)" By S. Boulila, M. de Rafélis, L.A. Hinnov, S. Gardin, B. Galbrun, P.-Y. Collin [Palaeogeography, Palaeoclimatology, Palaeoecology 292 (2010) 57-70].

We have revised our manuscript and figure strictly following the remarks of reviewers (mainly Reviewer #2) and yours. The corrections following Reviewer #2 comments are in red, while the corrections following your comments are in green in the "Revision, changes marked" file. A few corrections we also have made to update the cited references are marked in blue. The only criticism raised by Reviewer #2 we did not integrate in the new version of our revised MS is about the references cited at page 3, line 73, where Reviewer #2 ask us to quote some other references (namely, Beltran, 2006, PhD thesis Paris VI; Turpin et al 2008, Bull. Soc Géol Fr 179, 231-244; Minoletti et al. 2001, Bull. Soc Géol Fr 172, 437-446; 2005, PPP 216, 119-137). However, we refer to a sentence of Boulila et al. (2010) that only quote two reference papers. We have thus respected their citations, otherwise we should also cite several other papers dealing with micarbs.

You will find as submitted files this letter also containing the Revision Notes explaining how and where each point of the Editor's/Reviewers' comments has been addressed, the "Revision, changes marked" file, clean version of the revised manuscript, and the Fig. 1 where the size of the scale has been enlarged. We hope that this revised version of our manuscript is now suitable for the Palaeogeography, Palaeoclimatology, Palaeoecology standard.

Yours sincerely,
Emanuela Mattioli
(on the behalf of all the co-authors)

COMMENTS FROM EDITOR (Professor Finn Surlyk, Editor) AND/OR REVIEWERS
This Comment can be accepted after minor revision taking into account the remarks of the reviewers. 34, 109: indent not line spacing at new paragraphs.
DONE

Delete 'data' 37: 'interval' refers to time, not to rocks, so you cannot have an 8.5 m thick interval.
DONE

42, 114: Please use UK English throughout: ...palaeo..., metres.. etc.
DONE

48-49: I do not find this difference 'little'. In Upper Cretaceous chalk-marl cycles it is commonly much smaller, still showing marked differences in various proxies.
‘Little’ has been deleted, even if

60: 'largely'? Do you mean 'much'?

‘largely’ has been changed into ‘much’

71: is based on a few studies only ... I think that is what your mean?
Text has been changed accordingly

83, 96, 134, 139 etc.: En-dash between period names
CHANGED
111:... on the Upper Jurassic succession... (the studies were certainly not performed more than 150 million years ago) Refrences: En-dash between page numbers
‘performed in’ has been changed into ‘dealing with’

Captions: It is Fig. 1. etc., not Figure 1 - and in bold Figure: Scale has to be larger and legible
The size of the scale has been enlarged

Best wishes Finn Surlyk

Reviewer #1: Dear authors, I have read your Discussion paper providing a different view of that expressed in the Boulila et al. (2010) ms. I find your discussion paper generally brief, to the point, well written and you provide reasonable evidence why you disagree with Boulila et al. (2010). My personal view, but I might be wrong, is that the truth is perhaps somewhere in the middle. Obviously, platform-derived clay/marl input depends on numerous variables that may include orbital forcing, but also hydrodynamic level, the type of hinterland, river discharge, transport of sediments within the basin etc. etc. It seems clear, that different groups have worked in these outcrops and obviously came to different conclusions. Science lives from disagreement and discussion and I believe that your contribution is a valuable step in this direction. Not everything we observed is orbitally controlled and not everything is the result of regional or local features. It is via this type of disagreement and discussion that we learn to understand the geological record. In my view, there is still a long way to go.

Reviewer #2: Dear authors, Below you will find some minor comments on your comment of the Boulila et al (2010) publication in PalPalPal. You very politely show that the criticism given by Boulila et al (2010) is not completely correct and that the database used by Boulilal et al. is very limited. The limitation of the Boulila et al (2010) dataset casts severe doubts on the conclusions made in their manuscript. You clearly show the weaknesses in the Boulila et al. mansucript and even show additional evidence that supports your own interpretation of the outcrop. All in all ample evidence is given to severly doubt the criticism raised by Bouililа et al (2010) on the work of the authors of this comment.
Editorial comments 1/19 works should be work.
CHANGED

1/22 acquired in should be acquired with.
CHANGED

1/22 skip for.
DONE

2/27-28 change "express criticism about earlier works" to criticize earlier work
DONE

2/30 change the basin scale to at a basin-wide scale.

DONE

2/44 change ..in.. to ..with a..
DONE

2/47 change ..they analyse.. to ..they analysed..
DONE

2/48 change ..in only.. to ..only in..
DONE

2/48 What are the maximum and minimum values in the entire Chateau d'Oze sequence?
Fabienne Giraud has studied an interval longer than that analysed by Boulila et al., namely from the Late Oxfordian (Planula Zone, Galar subzone) to the Early Kimmeridgian (Platynota Zone; Orthosphinctes, Desmoides and Guilherandense subzones). The samples studied by Boulila et al. correspond to the Guilherandense subzone. The CaCO3 values that Fabienne Giraud measured are comprised between 58.5% and 84.5%. But we don't know if it is useful to add this information to the new version of the MS.

2/50 change Is.. to We doubt that..
DONE

3/1 erase question mark and replace by end of sentence point.
DONE

3/2 field should be fields
OK

3/2 at should be with
OK

3/3 at should be with
OK

3/55 due either should be either due
OK

3/56 change ..they also make reference.. to Boulila et al. (2010) refer..
OK

3/58 change But other.. to Other reference papers, however,..
OK

3/61 change ..they.. to ..Boulila et al. (2010)
OK

3/68-70 I do not understand the meaning of thi sentence. Please rephrase.
We have changed this sentence into: 'The comparison of pictures of samples Oz 216 (73% $CaCO_3$) and samples Oz 220 and 222 (97 and 92% $CaCO_3$, respectively; plate 1) shows that

nannofossil abundance is higher in the sample with 73% $CaCO_3$ than in the samples with more than 90% $CaCO_3$.'

3/71 Their to The Boulila et al. (2010)
DONE

3/73 Micarbs .. Paris VI work of Beltran (2006, PhD thesis Paris VI), Turpin et al (2008; Bull. Soc Géol Fr 179, 231-244) and Minoletti et al. (2001, ull. Soc Géol Fr 172, 437-446; 2005, PPP 216, 119-137)
Boulila et al. (2010) only quote two reference papers. We have thus respected their citations, otherwise we should also cite several other papers dealing with micarbs.

4/95 change ...in marls and limestones the Upper Oxfordian-Lower Kimmeridgian of... to ...Upper Oxfordian-Lower Kimmeridgian marls and limestones of ...
DONE

5/112 change ...was subsequently... to ...subsequently was...
DONE

5/118 add a to They made a precise...
DONE

References/194-195 peri-vocontian should be Peri-Vocontian. .
OK

Comment on "Orbitally forced climate and sea-level changes in the Paleoceanic Tethyan domain (marl–limestone alternations, Lower Kimmeridgian, SE France)" By S. Boulila, M. de Rafélis, L.A. Hinnov, S. Gardin, B. Galbrun, P.-Y. Collin [Palaeogeography, Palaeoclimatology, Palaeoecology 292 (2010) 57-70]

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Keywords: Oxfordian–Kimmeridgian; Marl-limestone alternations; Calcareous nannofossils; Basin-platform correlations; Carbonate production

Abstract

A recent paper by Boulila and al. (2010) reports on orbitally-forced cycles recorded as marl-limestone alternations in one Lower Kimmeridgian section, Chateauneuf d'Oze (SE France, Tethyan domain). In an attempt to illustrate the *in situ* (i.e., pelagic) origin of carbonates in marls and limestones, the authors challenged the results of previous work~~s~~ concerning sections from other Tethyan areas of similar age, which demonstrate that nannofossil abundance is originally higher in marls than in limestones. Boulila et al. (2010) present data acquired with optical and Scanning Electron microscopes ~~for~~ estimating nannofossil contribution to the rocks. However, their selected illustrations do not support a high

contribution of the nannofossils to the carbonate fraction of their samples or their interpretation of the finest fraction of the rocks (micarbs). Furthermore, according to their data on carbonate content of the rocks, they did not analyse true marl-limestone alternations, but slightly argillaceous limestones and limestones. Boulila et al. (2010) also criticize earlier work providing a sequence stratigraphy interpretation of the Chateauneuf d'Oze section. However, contrarily to these earlier works, they did not consider platform-to-basin correlations that are essential in order to understand the sedimentary dynamics at the basin-wide scale. This comment challenges the work by Boulila et al. (2010) that largely underestimates the role of carbonate production on shallow platforms and its subsequent export basinwards as a major mechanism controlling the sedimentation in epicontinental basins.

The work by Boulila et al. (2010) presents magnetic susceptibility, geochemical ~~data~~ (wt% $CaCO_3$, Mg content, carbon and oxygen stable isotopes), and micropalaeontological (calcareous nannofossils) results from a 8.5 m thick interval of the Chateauneuf d'Oze section (Lower Kimmeridgian, SE France). These authors show orbitally-driven cycles expressed in the lithology and in the geochemical signal. They infer a depositional model of combined climate and sea-level cycles forced in concert by Earth's orbital parameters, and suggest an antagonism between marine surface productivity (i.e., nannofossils) and detrital flux. The aim of micropalaeontological analysis of the Boulila et al. paper is to have a rapid estimate of the nannofossil contribution to $CaCO_3$ content in marl-limestone alternations. The semi-quantitative analysis of calcareous nannofossils they performed with an optical microscope reveals that the contribution of nannofossils is higher in marls than in limestones. The authors consider that this difference is essentially the result of a stronger diagenesis, and a higher fragmentation of nannofossils in limestones than in marls. But, they analysed calcareous nannofossils only in twelve samples with poorly contrasted lithologies, namely from ~72 to 97% $CaCO_3$, with average values for marls at 78% $CaCO_3$ and for limestones at 90% $CaCO_3$. We doubt that this ~~little~~ difference in wt% $CaCO_3$ is important enough to have a significantly different fragmentation during sample processing. Boulila et al. (2010) document abundances of 107 nannofossils in 25 fields of view (FOV) under optical microscope in a sample with 87.5 wt% $CaCO_3$, and 194 nannofossils per 25 FOV in a sample with 84 wt% $CaCO_3$. Does this mean that a 3.5% difference in $CaCO_3$ is important enough to have a ~50% reduction of nannofossil abundances either due to diagenesis or to fragmentation during sample preparation?

Concerning the preservation of nannofossils, Boulila et al. (2010) refer to one single paper stating that the presence of clay minerals exerts a protective function against dissolution and overgrowth of nannofossils (Busson et al., 1997). Other reference papers, however, point to an optimal preservation of nannofossils in lithologies with 40 to 55% carbonate by weight (Thierstein and Roth, 1991; Erba, 1992), which are values much below those of the samples analysed at Chateauneuf d'Oze. Furthermore, Boulila et al. (2010) infer that the particles shown in their plate 1 (SEM photos 1d and 1e) are represented by strongly altered coccoliths, where only central openings and distal tubes are still visible. This is very hard to believe when looking at those pictures. Coccoliths are undoubtedly present in the studied samples but they do not constitute the bulk carbonate (see for instance pictures 5 and 6 from sample Oz 212). The comparison of pictures of samples Oz 216 (73% $CaCO_3$) and samples Oz 220 and 222 (97 and 92% $CaCO_3$, respectively; plate 1) shows that nannofossil abundance is higher in the sample with 73% $CaCO_3$ than in the samples with more than 90% $CaCO_3$. So a primary (not diagenetic) negative correlation between nannofossil content and $CaCO_3$ is indicated by Boulila et al. SEM pictures.

The Boulila et al. (2010) interpretation about the nature of micarbs is based on a few studies only (Cook and Egbert, 1983; Busson et al., 1997) that indicated a biologic (nannofossils or small foraminifers) origin for the micarbs. Some fragments shown in the plate 1 (photos 1f and g) are actually the product of mechanical fragmentation of coccoliths. However, precipitation of cement within the pores of the *Schizosphaerella* valves can form euhedral micarbs (Bour et al., 2007), which closely resemble to those shown in the plate 1 (photos 2, 5 and 6). A third type of micarbs (Bour et al., 2007), characterised by a variable and irregular shape (similar to those shown in the pictures 1 to 6 of plate 1), can be the result of bio-induced precipitation via bacterial activity (Raiswell, 1988). The isotopic signature of these particles, which can be different from that of nannofossils, further supports a non-nannofossil origin for some micarbs (Minoletti et al., 2004).

Boulila et al. (2010) shed doubts on the nannofossil abundances presented by Pittet and Mattioli (2002) for the Upper Oxfordian–Lower Kimmeridgian of the SW German Basin. They state "… we suspect that the nannofossil abundance curve of Pittet and Mattioli (2002) produced through optical microscope analysis, could reflect a preservation rather than a coccolith productivity curve." They ignore the fact that in the section studied by Pittet and Mattioli (2002), as well as in the sections analysed by Pittet et al. (2000), nannofossil abundance is not only greater in marls than in limestones, but also in condensed, calcareous intervals. Bartolini et al. (2003) showed that both oxygen and carbon isotopes of bulk rock have different values in marls (where nannofossils are abundant) and in limestones (bearing rare nannofossils). This set of evidences clearly indicates that pelagic (i.e., nannofossils) carbonate production plays a major role in the carbonate accumulation in the basin only in times of low carbonate-mud export from shallow platforms.

Pittet and Mattioli (2002) and Olivier et al. (2004) showed a different assemblage composition and different-sized coccoliths in Upper Oxfordian–Lower Kimmeridgian marls and limestones of the SW German Basin. Namely, the limestones bear larger coccoliths and more abundant *Schizosphaerella* (a large nannolith). These results are not consistent with the hypothesis of mechanical fragmentation during powdering limestone samples (Boulila et al., 2010; chapter 4.3.1), because larger coccoliths and nannoliths should be preferentially destroyed. Furthermore, based on new nannofossil data that one of us (F.G.) acquired in a longer interval of the Chateauneuf d'Oze section, when comparing nannofossil quantity in samples with wt% $CaCO_3$ lower and, respectively, higher than 70% (in order to make effective comparison with the Boulila et al.' data), an important difference in nannofossil abundance is recorded (Fig. 1). Even if nannofossils are overall poorly-preserved, they are still recognizable and the largest specimen is found in the more calcareous sample (Fig. 1A), implying that none, or little, mechanical fragmentation occurred during powdering. Micarbs are often larger in the more calcareous sample than in the marly sample, and their size (Fig. 1A) seems to be incompatible with a nannofossil-fragmentation origin.

Boulila et al. (2010) also challenge numerous previous studies ~~performed in~~ dealing with the Late Jurassic of the Vocontian Basin and the surrounding shallow-water platforms, which indicate that carbonate mud originated in platform environments and subsequently was exported towards the basin (e.g., Gaillard, 1983; Bernier, 1984; Dromart, 1989; Colombié and Strasser 2003). How their model (only based on 8.5 metres of one single basin section) can be representative of the sedimentary dynamics at the basin scale? Colombié and Strasser (2003) performed very detailed field, macro- and micro-facies observations leading to a sequence-stratigraphy interpretation of the Kimmeridgian marl-limestone alternations of the Châteauneuf d'Oze section. They also made a precise correlation of this section with two other sections from the Vocontian Basin and three sections from the Swiss Jura in order to validate their sequential interpretation. These platform-to-basin correlations showed that the quantity of carbonate mud that accumulated in the Vocontian Basin was largely dependent on cyclical variations of carbonate production in shallow-marine environments of the Swiss Jura, and subsequent export toward the basin. Colombié (2002) also estimated the accumulation rate of clays in the basin by systematically dividing the thickness of marly interbeds by the thickness of marl-limestone alternations. Clay accumulation rates confirm that the detrital input probably played a subordinate role in the formation of the Lower Kimmeridgian marl-limestone alternations in the Châteauneuf d'Oze section, in contrast with Boulila et al. (2010) assumptions.

All these observations rule out the Boulila et al.' model to explain the genesis of marl-limestone alternations in the Chateuneuf d'Oze section. Finally, it has to be noted here that, at a time-scale longer than that needed to form a marl-limestone couplet, sedimentation of clay-dominated intervals in the Vocontian Basin occurred systematically when carbonate crisis affected the surrounding platform environments. This is the case of the Callovian–Oxfordian (Terres Noires; Artru, 1972; Dromart et al., 2003; Cecca et al., 2005), the Valanginian (Reboulet et al., 2003, Gréselle and Pittet, 2010), or the Late–Aptian and Albian (Marnes Bleues; Bréhéret, 1997; Masse et al., 1999). The same pattern is recorded in other basins for different time intervals, such as the Toarcian in the Umbria-Marche and Lusitanian Basins (Mattioli and Pittet, 2002, 2004; Suan et al., 2008), the Oxfordian–Kimmeridgian of the SW German Basin (Pittet et al., 2002), or the Nahr Umr Basin in Oman (Aptian–Albian; Immenhauser et al., 2002). All these observations support the idea that carbonate export from shallow-water platforms basinwards played a major role in the formation of marl- *vs.* carbonate-dominated intervals in epicontinental basins, and for the marl-limestone alternations as well.

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Legend of figure

Fig.~~ure~~ 1. Optical microscope, polarized light micrographs of two simple smear slides from the Chateauneuf d’Oze section. Samples were prepared as homogeneously as possible, so that particle density in different slides is comparable. (A) Sample CHO 127b (85% $CaCO_3$; Late Oxfordian: Planula Zone, Galar Subzone). (B) Sample CHO 149-150 (58.5% $CaCO_3$; Early Kimmeridgian: Hypselocyclum Zone, Hippolytense Subzone). White circles indicate coccoliths.

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Abstract

A recent paper by Boulila and al. (2010) reports on orbitally-forced cycles recorded as marl-limestone alternations in one Lower Kimmeridgian section, Chateauneuf d'Oze (SE France, Tethyan domain). In an attempt to illustrate the *in situ* (i.e., pelagic) origin of carbonates in marls and limestones, the authors challenged the results of previous work concerning sections from other Tethyan areas of similar age, which demonstrate that nannofossil abundance is originally higher in marls than in limestones. Boulila et al. (2010) present data acquired with optical and Scanning Electron microscopes estimating nannofossil contribution to the rocks. However, their selected illustrations do not support a high contribution of the nannofossils to

the carbonate fraction of their samples or their interpretation of the finest fraction of the rocks (micarbs). Furthermore, according to their data on carbonate content of the rocks, they did not analyse true marl-limestone alternations, but slightly argillaceous limestones and limestones. Boulila et al. (2010) also criticize earlier work providing a sequence stratigraphy interpretation of the Chateauneuf d'Oze section. However, contrarily to these earlier works, they did not consider platform-to-basin correlations that are essential in order to understand the sedimentary dynamics at the basin-wide scale. This comment challenges the work by Boulila et al. (2010) that largely underestimates the role of carbonate production on shallow platforms and its subsequent export basinwards as a major mechanism controlling the sedimentation in epicontinental basins.

The work by Boulila et al. (2010) presents magnetic susceptibility, geochemical (wt% $CaCO_3$, Mg content, carbon and oxygen stable isotopes), and micropalaeontological (calcareous nannofossils) results from a 8.5 m thick interval of the Chateauneuf d'Oze section (Lower Kimmeridgian, SE France). These authors show orbitally-driven cycles expressed in the lithology and in the geochemical signal. They infer a depositional model of combined climate and sea-level cycles forced in concert by Earth's orbital parameters, and suggest an antagonism between marine surface productivity (i.e., nannofossils) and detrital flux. The aim of micropalaeontological analysis of the Boulila et al. paper is to have a rapid estimate of the nannofossil contribution to $CaCO_3$ content in marl-limestone alternations. The semi-quantitative analysis of calcareous nannofossils they performed with an optical microscope reveals that the contribution of nannofossils is higher in marls than in limestones. The authors consider that this difference is essentially the result of a stronger diagenesis, and a higher fragmentation of nannofossils in limestones than in marls. But, they analysed calcareous nannofossils only in twelve samples with poorly contrasted lithologies, namely from ~72 to 97% $CaCO_3$, with average values for marls at 78% $CaCO_3$ and for limestones at

90% $CaCO_3$. We doubt that this difference in wt% $CaCO_3$ is important enough to have a significantly different fragmentation during sample processing. Boulila et al. (2010) document abundances of 107 nannofossils in 25 fields of view (FOV) under optical microscope in a sample with 87.5 wt% $CaCO_3$, and 194 nannofossils per 25 FOV in a sample with 84 wt% $CaCO_3$. Does this mean that a 3.5% difference in $CaCO_3$ is important enough to have a ~50% reduction of nannofossil abundances either due to diagenesis or to fragmentation during sample preparation?

Concerning the preservation of nannofossils, Boulila et al. (2010) refer to one single paper stating that the presence of clay minerals exerts a protective function against dissolution and overgrowth of nannofossils (Busson et al., 1997). Other reference papers, however, point to an optimal preservation of nannofossils in lithologies with 40 to 55% carbonate by weight (Thierstein and Roth, 1991; Erba, 1992), which are values much below those of the samples analysed at Chateauneuf d'Oze. Furthermore, Boulila et al. (2010) infer that the particles shown in their plate 1 (SEM photos 1d and 1e) are represented by strongly altered coccoliths, where only central openings and distal tubes are still visible. This is very hard to believe when looking at those pictures. Coccoliths are undoubtedly present in the studied samples but they do not constitute the bulk carbonate (see for instance pictures 5 and 6 from sample Oz 212). The comparison of pictures of samples Oz 216 (73% $CaCO_3$) and samples Oz 220 and 222 (97 and 92% $CaCO_3$, respectively; plate 1) shows that nannofossil abundance is higher in the sample with 73% $CaCO_3$ than in the samples with more than 90% $CaCO_3$. So a primary (not diagenetic) negative correlation between nannofossil content and $CaCO_3$ is indicated by Boulila et al. SEM pictures.

The Boulila et al. (2010) interpretation about the nature of micarbs is based on a few studies only (Cook and Egbert, 1983; Busson et al., 1997) that indicated a biologic (nannofossils or small foraminifers) origin for the micarbs. Some fragments shown in the plate 1 (photos 1f and g) are actually the product of mechanical fragmentation of coccoliths. However, precipitation of cement within the pores of the *Schizosphaerella* valves can form euhedral micarbs (Bour et al., 2007), which closely resemble to those shown in the plate 1 (photos 2, 5 and 6). A third type of micarbs (Bour et al., 2007), characterised by a variable and irregular shape (similar to those shown in the pictures 1 to 6 of plate 1), can be the result of bio-induced precipitation via bacterial activity (Raiswell, 1988). The isotopic signature of these particles, which can be different from that of nannofossils, further supports a non-nannofossil origin for some micarbs (Minoletti et al., 2004).

Boulila et al. (2010) shed doubts on the nannofossil abundances presented by Pittet and Mattioli (2002) for the Upper Oxfordian–Lower Kimmeridgian of the SW German Basin. They state "… we suspect that the nannofossil abundance curve of Pittet and Mattioli (2002) produced through optical microscope analysis, could reflect a preservation rather than a coccolith productivity curve." They ignore the fact that in the section studied by Pittet and Mattioli (2002), as well as in the sections analysed by Pittet et al. (2000), nannofossil abundance is not only greater in marls than in limestones, but also in condensed, calcareous intervals. Bartolini et al. (2003) showed that both oxygen and carbon isotopes of bulk rock have different values in marls (where nannofossils are abundant) and in limestones (bearing rare nannofossils). This set of evidences clearly indicates that pelagic (i.e., nannofossils) carbonate production plays a major role in the carbonate accumulation in the basin only in times of low carbonate-mud export from shallow platforms.

Pittet and Mattioli (2002) and Olivier et al. (2004) showed a different assemblage composition and different-sized coccoliths in Upper Oxfordian–Lower Kimmeridgian marls and limestones of the SW German Basin. Namely, the limestones bear larger coccoliths and more abundant *Schizosphaerella* (a large nannolith). These results are not consistent with the hypothesis of mechanical fragmentation during powdering limestone samples (Boulila et al., 2010; chapter 4.3.1), because larger coccoliths and nannoliths should be preferentially destroyed. Furthermore, based on new nannofossil data that one of us (F.G.) acquired in a longer interval of the Chateauneuf d'Oze section, when comparing nannofossil quantity in samples with wt% $CaCO_3$ lower and, respectively, higher than 70% (in order to make effective comparison with the Boulila et al.' data), an important difference in nannofossil abundance is recorded (Fig. 1). Even if nannofossils are overall poorly-preserved, they are still recognizable and the largest specimen is found in the more calcareous sample (Fig. 1A), implying that none, or little, mechanical fragmentation occurred during powdering. Micarbs are often larger in the more calcareous sample than in the marly sample, and their size (Fig. 1A) seems to be incompatible with a nannofossil-fragmentation origin.

Boulila et al. (2010) also challenge numerous previous studies dealing with the Late Jurassic of the Vocontian Basin and the surrounding shallow-water platforms, which indicate that carbonate mud originated in platform environments and subsequently was exported towards the basin (e.g., Gaillard, 1983; Bernier, 1984; Dromart, 1989; Colombié and Strasser 2003). How their model (only based on 8.5 metres of one single basin section) can be representative of the sedimentary dynamics at the basin scale? Colombié and Strasser (2003) performed very detailed field, macro- and micro-facies observations leading to a sequence-stratigraphy interpretation of the Kimmeridgian marl-limestone alternations of the Châteauneuf d'Oze section. They also made a precise correlation of this section with two other sections from the Vocontian Basin and three sections from the Swiss Jura in order to validate their sequential interpretation. These platform-to-basin correlations showed that the quantity of carbonate mud that accumulated in the Vocontian Basin was largely dependent on cyclical variations of carbonate production in shallow-marine environments of the Swiss Jura, and subsequent export toward the basin. Colombié (2002) also estimated the accumulation rate of clays in the basin by systematically dividing the thickness of marly interbeds by the thickness of marl-limestone alternations. Clay accumulation rates confirm that the detrital input probably played a subordinate role in the formation of the Lower Kimmeridgian marl-limestone alternations in the Châteauneuf d'Oze section, in contrast with Boulila et al. (2010) assumptions.

All these observations rule out the Boulila et al.' model to explain the genesis of marl-limestone alternations in the Chateuneuf d'Oze section. Finally, it has to be noted here that, at a time-scale longer than that needed to form a marl-limestone couplet, sedimentation of clay-dominated intervals in the Vocontian Basin occurred systematically when carbonate crisis affected the surrounding platform environments. This is the case of the Callovian–Oxfordian (Terres Noires; Artru, 1972; Dromart et al., 2003; Cecca et al., 2005), the Valanginian (Reboulet et al., 2003, Gréselle and Pittet, 2010), or the Late–Aptian and Albian (Marnes Bleues; Bréhéret, 1997; Masse et al., 1999). The same pattern is recorded in other basins for different time intervals, such as the Toarcian in the Umbria-Marche and Lusitanian Basins (Mattioli and Pittet, 2002, 2004; Suan et al., 2008), the Oxfordian–Kimmeridgian of the SW German Basin (Pittet et al., 2002), or the Nahr Umr Basin in Oman (Aptian–Albian; Immenhauser et al., 2002). All these observations support the idea that carbonate export from shallow-water platforms basinwards played a major role in the formation of marl- *vs.* carbonate-dominated intervals in epicontinental basins, and for the marl-limestone alternations as well.

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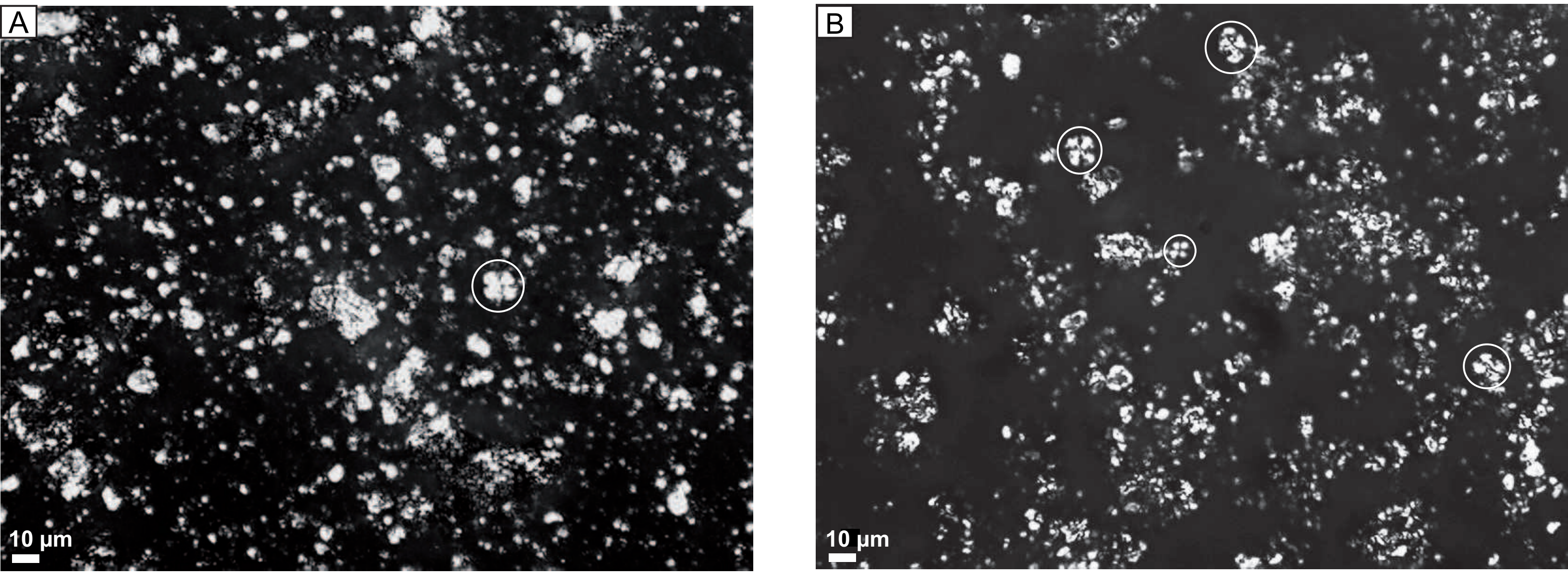
Legend of figure

Fig. 1. Optical microscope, polarized light micrographs of two simple smear slides from the Chateauneuf d’Oze section. Samples were prepared as homogeneously as possible, so that particle density in different slides is comparable. (A) Sample CHO 127b (85% $CaCO_3$; Late Oxfordian: Planula Zone, Galar Subzone). (B) Sample CHO 149-150 (58.5% $CaCO_3$; Early Kimmeridgian: Hypselocyclum Zone, Hippolytense Subzone). White circles indicate coccoliths.

Figure



Mattioli et al. - Figure 1