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Interactive comment on "Response of a low subsiding intracratonic basin to long wavelength deformations: the Palaeocene–early Eocene period in the Paris basin" *by* J. Briais et al.

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1. There are two periods of negative accommodation :

-Between T3 and T4 :

The accommodation is negative because there is an emersion (calcrete) at the top of Mortemer calcareous. This negative accommodation is also recorded in the belgian basin by a forced regression wedge. No erosion and incision is recorded in the Paris basin probably due to the fact that incision was difficult to develop over this flat profile. The erosion of the Provins clay and at least its sedimentation occurs after this event

and is more related to Sparnacian facies.

-Between Y3 and L1 :

This negative accommodation is associated to erosion. We would not be able to determine the amount of deposition and further erosion using present-day thickness if we would not have any data on the sedimentary geometry, but in the case of the last Ypresian interval, our correlations are showing that the palaeogeographic trend (proximal distal) is along a south to north direction and that there is no erosion in the Northern part of the Paris basin (Figure 5 and Figure 6), while the occurrence of an erosion in the southern part is evidenced by truncation below UN L1 (Figure 5 and 6). The thicknesses of eroded ypresian series to the south are thus estimated from the preserved thicknesses to the north. It can be a slight overestimation (of a few meters) as depositional thicknesses in the former intervals are usually higher in the northern more distal part (Figure 5).

2. The color problem in figures

Ok we will increase the contrasts in Figures 1, 5 and 10.

3. Figure 3

We prefer to keep this figure (cited three times in the text) because it is very important to show the stratigraphy on the border of the subsiding basin (onlapping parts). This figure allows us to propose an age (by correlation) for tertiary sediments on the border. But if you find it not relevant in the manuscript we can move it to the supplementary material.

4. Depositional profile:

-We think a new figure showing the different depositional profiles is not really necessary because three depositional environment would need to drawn, so quite a heavy document, while only one the lower Ypresian one is somewhat original. thanetian (wave dominated profile) and Ypresian one (protected marine) are classical deposi-

SED

7, C1886–C1895, 2016

tional profiles extensively documented in the literature. – (1) facies are grouped into depositional environment in the manuscript (Figs. 5 and 10) and – (2) Figure 10 shows three palaeographic maps which correspond to three Thanetian-Ypresian typical landscapes, we think this presentation is sufficient.

-Calcareous lacustrine contains charophytes and fresh water oysters, we will precise this in the text.

-The transition between lacustrine and brackish environment could corresponds to a large plain of florida (modern example); this lacustrine plain is open on marine-brackish environment. This transition can also be identified on current deltaic plains. In the Paris basin, the basal ypresian palaeogeography is also favored by a profile flat. However, the limit (defined between two wells) between lacustrine and brackish environment is probably more complex than that drawn on the map (Figure 10), but we cannot be specify the palaeogeography between wells.

5. Stacking pattern

The supplement S5 shows the method of stacking pattern. We have added to this figure the cycles. Our stacking pattern and identification of third order sequence was done on a reference borehole. On this 1D section sequences are identify basing on depth variations, major MFS being the deepest (most open marine) levels. MFS T2 was chosen as a major surface for the cycle Ct because it records a deeper environment compared to MFS T3 on the Cuise-la-Motte Well.

We know it is surprising that this surface does not correspond to the maximum flooding of marine facies which takes place within MFST3 that is why we mentioned this as a paradox. Our interpretation of this case, is that the evolution of the flexure (mainly its relaxation) produce a change in the steepness of the depositional profile, which is steeper at the beginning of the cycle i.e during T2 (shortly after the maximum deformation) and flatter at the end of the cycle (during T3), therefore even if the sea level is higher during T2 transgression on a steeper surface leads to a less important ex-

SED
7, C1886–C1895, 2016

tension of the marine flooding . Thus, there is a tectonic control on the expression of the Thanetian sedimentation. We have identified several times the same kind of figure within the paleogene of the Paris Basin, and plan to publish it in a paper in preparation, using other examples in the lutetian and bartonian sedimentation. That is why we did not develop this aspect in the present paper. If you think it need an explanation may be we could just give a short explanation and refer to this paper (in prep).

6. Unconformities vs. MRS

Unconformities and MRS are now differentiated on the figure 2 as on the figure 5. The MRS into a regressive third order is an unconformity.

7. 4th and 3rd order cycle

The Ypresian cycle (Cy1) is a third order cycle (2.1 Ma); we did not identified 4th order for the basal ypresian period; thus this cycle is now removed.

8. Fluvial aggradation vs. Local subsidence

The increase of the accommodation in the south part of the basin (Figure 6) occurs during the transgression of the cycle Cy1. This sea level rise does not explain the thickness increase. This thickness is controlled by a local subsidence. The sedimentary supply is sufficient to fill the available space by the subsidence (A/S: 1 = fluvial aggradation). The sedimentary supply probably comes from the Morvan (Blanc-Valleron and Thiry, 1993), The Massif Central (Tourenq, 1968 and Blanc-Valleron and Thiry, 1993), or the Hurepoix block.

9. Local tectonics and activity of hercynian faults

The section 5.3 concerning the control of inherited variscan structures on Palaeogene deformations is now more developed.

“5.3. Control of inherited variscan structures on Palaeogene deformations. Our study demonstrates a reactivation of crustal variscan faults but also evidences that this play

SED

7, C1886–C1895, 2016

is limited, except for Sparnacian times. Fault reactivation do not significantly affect the palaeogeography and thickness distribution, and on the north south transect crossing Bray and Belou faults accommodation variations exist but are low below 10 m/ My. Long wavelength deformations are thus not affected by crustal faults reactivation but seem to imply a thicker part of the lithosphere. On the contrary during Sparnacian times Seine, valpuiseaux, and loire faults are bounding the hurepoix block which is strongly reactivated at that time. Sparnacian tim is also the period during which maximum accommodation variations are measured over Bray and Belou faults. Interestingly, Sparnacian deformations are of smaller (medium) wavelength affecting a thinner part of the lithosphere and related to a different geodynamic event. During Thanetian (Ct cycle) and Ypresian (Cy2 cycle) times, depocentres were located north of the Bray Fault or on both sides of the same Bray Fault (Fig. 1). This subsiding domain is limited toward the SE by the St Martin-de-Bossenay Fault (Fig. 1). Maximum subsidence areas are located along the Belou Fault. This domain corresponds to the location of the remnant Variscan subducted slab (Averbuch and Piromallo, 2012), which could be the control of the long-term subsidence of the Paris Basin, rather than a Permo-Triassic extension that does not exist in this area (Delmas et al., 2002)."

Question in the text:

-P3591 L17 What was the origin of the subsidence during this period?

The origin of the subsidence of intracratonic basins is usually considered as flexural subsidence of thermal origin inherited by extension period (Permo-Trias extension) (Perrodon and Zabeck, 1990)

-P3591 L22 How was recorded this deformation? A generalized uplift (and tilting?) of the basin ?

This deformation is recorded by an uplift of the western (Armorican) and northeastern (Artois) margins of the basin and by a medium wavelength flexural regime trending NW-SE (Guillocheau et al., 2000)

SED

7, C1886–C1895, 2016

-P3593 L21 A figure with these depositional profiles would be usefull in particular to understand how the authors consider the transition between lacustrine and brackish environments during the basal Ypresian.

For this reply, see comment 4

-P3593 L23-26 Did the authors have cored drills in the central part of the basin to support the well-log interpretations in subsurface ?

There is no cored drills in the central part of the basin (see supplement S1). Only two cored drills have been described (Craie 701 and 702, around Provins) but they are on the margin of the basin. This study is based on (1) outcrops, (2) stratigraphic wells (with cuttings) and (3) well-log signature.

-P3594 L1-2 This method is questionable for the Cy.1 cycle since fourth and third order cycles have the same duration in the figure 2. The authors explain that fourth order cycles are difficult to evidence because of the reduced accommodation. In this case fourth order cycles should not be represented.

For this reply, see comment 7.

-P3594 L23 What ?

Yes, this sentence is unclear, we propose to rewrite it as follow: “Palaegene deposits are dated by biostratigraphy and chemostratigraphy, but the latter is more reliable from the PETM onwards”

P3595 L8 Then what is the resolution?

Data are usually from calcareous nannofossil, and mainly dinocysts and wetzieliellaceae, resolution of these two latter biozones is around 1 My (figure 4), thus using both scales, resolution can be considered as below 1My.

-P3595 L17 Figures 2 and 3 are not called before in the manuscript. Please number figures in the order of the text.

SED

7, C1886–C1895, 2016

The figure 4 is just cited in the section 3.2 (methodology) but it is explained in the section 4.2 (results). This figure shows the age model which is a result of this study, consequently we prefer keep this figure in the result part. However, the citation of this figure is not essential in the methodology, we can remove it.

-P3595 L28 Not in the reference list.

Yes, we add this reference as follow: Basin subsidence quantification: impacts back-stripping parameters and geological inputs – Terra Nova - O. Dauteuil, C. Robin, F. Guillocheau, B. Linol, G. Calvès, F. Moreau

-P3596 L15-16 No erosion was envisioned and/or estimated?

Eroded thicknesses are estimated using extrapolation of preserved thicknesses in a part of the basin, see comment 1. We can add the erosion in the section " Palaeodepth/palaeoelevation measurement".

-P3598 L9-17 Why not an oxygen depleted offshore environment?

An offshore environment is not possible because the clayey sands and glauconitic facies are observed very near from the coastal plain while the profile is very flat and no well-sorted sand package that could be interpreted as shoreface deposits is encountered. Clayey sands interpreted as protected environment contains nummulites, gastropods and bivalves which is more compatible with bay environment than offshore deposits.

-P3598 L29 Oysters are mentioned in the table 1

Yes, see comment 4

-P3600 L4-5 FA ?

We add FA1 to complete this sentence.

-P3600 L8 This surface is problematic in the Figure 2. In the legend this kind of surface

SED

7, C1886–C1895, 2016

corresponds to unconformities and maximum regressive surfaces. Then it should be located at the end of a regressive phase. In the Thanetian 3rd order cycle an unconformity is located into a regressive hemicycle but does'nt correspond to a 3rd order maximum regressive surface (basinward shift of facies). This comment is also valid for the first 3rd order Ypresian cycle. Unconformities and maximum regressive surfaces are differentiated in the figure 5. It should also be the case in the figure 2.

Yes, see comment 6.

-P3600 L16 Please insert a figure showing results of the stacking pattern method. Why was the T2 surface chosen as 3rd order MFS and not T3?

Yes, see comment 5

-P3602 L1-2 But they are indicated in the Figure 2. This representation is problematic here since one 3rd order cycle consists of one 4th order cycle and then durations of both cycles are similar. What are the arguments allowing to propose a 3rd order cycle between T4 and Y2 ? Why not a 4th order cycle bounded by exposures during a period of low accommodation?

See comment 7

-P3604 L19 analysed time slice?

We have corrected this sentence.

-P3605 L4 south ?

No, the accommodation is very important toward the North during thanetian period. It is during sparnacian period that the accommodation is high toward the south.

-P3605 L8-9 Then forced regression and erosion occured locally. Was it evaluated ? For this question, see comment 1

-P3605 L14-18 Why ? This point is not really discussed in the text. Is it due to an

SED

7, C1886–C1895, 2016

increase in the subsidence or to an important aggradation of fluvial deposits in the proximal parts of the margin?

See comment 8

-P3609 L12 How is interpreted this distribution ?

This distribution is interpreted by a short wavelength tectonic control, in particular near Bray and Belou faults for the transgressive trend of Cy1 cycle.

-P3609 L16-19 This total inversion is a little surprising. Are the correlations or datings robust in this area ?

The correlations are available in supplement S5. The Paleocene-Eocene limit is dated in the Chelles well by ERADATA (to be added to figure S1). This dating allows to have a relevant constraint in the central part of the basin. Moreover, lithostratigraphic correlations are available from stratigraphic wells (Brie 1, 2, 3, 4, Craie 701, Craie 702) in the southeastern part of the basin see supplement S1.

-P3610 L8-9 3rd order MFS ?

See comment 5

-P3610 L11-12 What was the paleogeographical configuration which allowed the lateral transition between lacustrine and brackish lagoonal environments ?

See comment 4

- P3612 L10-11 In the figure 11, accommodation space is important in the southern area. What is the origin of this important accommodation? The drawing of the figure 11 suggests that the area was more subsident. If so how do the authors explain the local high sedimentation rate which counterbalanced the subsidence and allowed the persistence of continental deposits in the most subsiding area ?

See comment 8

SED

7, C1886–C1895, 2016

-P3614 L22 In my opinion, this chapter should be developed since the impact of local tectonics is not discussed before.

See comment 9

-Table 1 : Fresh water oysters

-Type? Meandering? Anatomosing? : This data is from the literature and we don't have more details. However, the signature well-log (bell-shape) and coarse sand frequently described in boreholes suggests meandering channel.

-Figure 1: To place in the caption of the figure a :We remove the ECORS profile as ask by the other reviewer.

All the requested changes on the figures were taken into account.

Interactive comment on Solid Earth Discuss., 7, 3587, 2015.