Solid Earth Discuss., 7, C1875–C1883, 2016
www.solid-earth-discuss.net/7/C1875/2016/

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.

J. Briais et al.

j.briais@brgm.fr

Received and published: 18 January 2016

Specific comments:

1. The part concerning "the Late Cretaceous-pre-Thanetian period" will be deleted in abstract and in the "basin scale data" part. However, we propose to explain these deformations in the geological setting (2.3 sedimentary infilling) and in the discussion (5.2 Meaning of the Paris basin deformations at Europe-scale). The Figure 7A will be removed, however we propose to keep figures 7b and 8a and 8b. We will modify the text as follow:

Within Geological setting in "sedimentary infilling": -we will highlight the evidence of two strong stratigraphic lacunae (from bibliography), at the transition from (1) Upper Cretaceous to Middle Danian and (2) Upper Danian to Thanetian.

Within Discussion in "Meaning of the Paris basin deformations at Europe-scale": -Major long wavelength deformations with formation of the present-day ring shape sealed by ypresian sediments (Fig. 7b) -Differential erosion of the chalk indicating an uplift of Artois domain before Thanetian period (Fig. 8b) -Facies of danian sediments show an open marine environment, but the danian is located in isolated areas. -Changes in the subsidence distribution between Danian and Thanetian periods show two deformations phases (Fig. 8a and 8b). Our aim is to highlight the fact that sedimentary record evidences.

2. We propose to simplify the text 4.2 by : "The lithosphere of the Paris Basin is inherited from the Variscan Mountain Belt resulting from the carboniferous collision of the Avalonia and Gondwana plates and the closure of the RHEIC Ocean (Matte, 1986). The suture of this ocean corresponds to the Bray – Metz Fault (Autran et al., 1994 – Fig. 1 A). Recent studies based on the P-wave seismic tomography (Averbuch and Piromallo, 2012) suggested the occurrence of a subducted slab beneath the Bray Fault (Fig. 1 B). On the Gondwana side, the pattern is complex with a major fault system, the Seine Fault, corresponding to a magnetic anomaly, the AMBP (Magnetic anomaly of the Paris Basin); the origin of which is controversial (Palaeozoic rift: Autran et al., 1986; fossil slab: Averbuch and Piromallo, 2012). The Seine, Rambouillet and Loire Faults represent the eastern limit of the Cadomien (para-autochthonous block) and the Hurepoix Block, bounded by the Seine, Valpuiseaux and Rambouillet Faults, forms a distinct block as evidenced by geophysics (Autran et al., 1994). After the collision, the mountain belt collapsed with the growth of numerous Permian basins located along the major faults; the exact location of these basins is unknown (Mégnien and Mégnien, 1980; Mascle, 1990; Perrodon and Zabeck, 1990; Delmas et al., 2002)".

We would like to keep the Figure 1 which shows the geological characteristics of the

Paris basin and the main tectonic units of the Variscan basement. This figure is essential for the geological context because it allows to discuss the inheritance of the Paris basin in the section 2.1 and the inheritance control on the sedimentation in the section 5.3 (part that we will develop to show the minor role of major faults in the development of the Paleocene deformations with exception of the faults bounding the Hurepoix block Seine Loire Valpuiseaux) see below. The figure S1 (supplementary material) presents the data base (outcrops, wells, transects) used. We suggest keeping this figure of data base in the supplementary materiel. Furthermore, wells are already shown in figure 5b, 9 and 10.

Some modifications for figure 1: -ECORS profile will be removed - we will add our North-South transect

3. Estimating decompacted thickness : We agree that burial of these sediment is relatively low, however compaction exists. Burial reaches around 200m (around 180m of Lutetian to Rupelian series are measured), as reduction of volume during compaction is major within the first 500 m, we think it is necessary to estimate decompacted thicknesses as we did it.

4. Depositional model : 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 unique, thanetian (wave dominated profile) and Ypresian one (protected marine) are classical depositional 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.

5. Cycle Ct : 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 extension 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. P3609 L3 This comment concerns the last interval of Ypresian, between MFS-Y3 and UN-L1 which is partly eroded. Indeed 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.

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).

7. Figure 10

I would prefer to keep palaeogeographic maps in the basin scale section because it includes all maps (3D) whereas the section 4.2 or 4.3 includes 2D results (2D transect and 2D accommodation). 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.

P3588 L8: Indeed European basement is not properly a craton, however even if it is not the most appropriate term we would prefer to keep the term "intracratonic basin" or "intracratonic sag" because it is the most used to define such basins.

P3588 L24 : Yes there are deformations in Scotland and overall western europe at that time that Ziegler attributed to pyrenean convergence, however the origin of these deformations have been largely debated since and influence of atlantic opening and mantle dynamic have been proposed (Doré et al., 1999, Anell et al., 2009). That is why we prefered to only cite southern France where this relation with convergence is clear.

P3589 L16 : Indeed, we will say "during the studied period"

P3589 L23 : Ziegler, 1990, Doré et al., 1999, Larmache et al., 2003, Anell et al., 2009

P3590 L17 : we will cited Matte (1986) instead of Ballèvre et al. (2009)

P3590 L18 : ok

P3592 L11 : ok " ..carbonate-marl during Jurassic.. "

P3592 L18 : we will cited Guillocheau et al. (2000)

P3594 L3 : We corrected this sentence by :

-Three orders were defined, around x100 to 400 Kyrs (4th), 400 Kyrs to 5 Ma (3rd) and more than 5 Ma (2nd). This choice is based on Haq et al., (1987) and Stasser et al.

(2000). The latter proposes that multiples of x400 Kyrs correspond to third order cycle.

P3595 L22 : "a maximum flooding (deepest facies) has to be a warm peak (chemostratigraphy) whose the record corresponds to a proxy of decrease of the ice volume and an increase of the sea level (Cramer et al.,2011); a maximum flooding has to be a high eccentricity period (orbital solutions); the reverse is found for the maximum regressive surface."

P3599 L23: assuming a duration of 3.4 Ma (not multiple x400) for the thanetian cycle, it should be associated with 3nd order. There is still a controversy on the third order cycle, depending on the authors duration is between 0.5 and 3 or 1 to 5Ma, as well their origin may be climate-eustatic or tectonic, if the control is purely eustatic it would be a multiple of eccentricity cycles (multiple of 400 Kyrs) has evidenced for example by Strasser et al. (2000). However if tectonics influence this cycle, its duration would be more erratic. This yield to quite different possible sequences origin and durations which is frequently a problem when identifying third order sequences. Here we choosed to consider that sequences which display a duration higher that a multiple of 400 and a duration below 5 My are third order sequences (we proposed to change this explanation see P3594 L3).

P3600 L8 : The unconformity is represented by a blue line between T2 and T3.

P3601 L9: yes "coastal plain marshes" correspond to "organic rich marshes", I change this sentence.

P3601 L14: "a sharp transition between brackish lagoon environment and subaqueous fresh water environment (organic rich marshes – FA8b)" I change this sentence.

P3602 L16 : Yes, I use a diachronous surface (Erosion surface - Unconformity). The MRS surface is merged with Erosion surface.

P3603 L23: Ok, I delete this sentence

P3604 L9: As for Cuise-la-Motte well, the curves of figure 6 have an error interval (in grey) which take different compaction rates into account.

P3604 L14: The cumulated accommodation space (Fig. S8 in the supplement) does not correspond to the regional accommodation space, but it is the sum of increments of the space created for each interval measured in each well along the N-S regional transect.

P3604 L18: We do not understand this comment: Figure 6 which concerns accommodation velocity along the N-S transect does not show that present-day setting (stacked dishes) of the basin is already acquired because the amplitude (ring shape) is larger than the N-S transect, e.g. this does not show that Jurassic sediments are tilted. However, figure 7b shows that the southern and eastern part of the Paris basin is tilted before ypresian. Consequently, we prefer to keep this figure (7b) to explain these deformations.

P3604 L26: "The highest rate (60 m/Ma) is probably unlikely. This results from poorly constrained UN age (T1). The maximum rate is probably lower".

P3606 L1-L6: Some details are provided for this sentence

Transgressive-regressive cycles are controlled by A/S ratio, Accomodation being the sum of subsidence and eustatism and S being the sedimentary flux. Thanetian and Ypresian 2 cycle record higher accommodation during transgression lower accommodation during regression, they are thus mainly control by accommodation space variations. On the opposite during Ypresian 1 cycle, accommodation do not change significantly between transgression and regression, thus it is likely that the observed transgression-regression cycle is driven by variations in the sedimentary flux.

We can rephrase as follow: "Considering that transgression regression are controlled by A/S ratio, we can propose from our accommodation measurement that: the Thanetian (T1-T4) and Ypresian 2 (Y2-L1) cycles are clearly controlled by accommodation space variations, which are positive and "higher" during the transgressive period and

positive (low) to negative at the end of the regressive hemicycle. On the opposite, the Ypresian 1 cycle (T4-Y2), with low accommodation variations between the transgressive and regressive hemicycles, is probably more controlled by an increase in the sedimentary flux during the induced regressive trend."

P3606 L14: We will not cite Lacombe and Obert (2000) because they identified brittle and faults structures after the Lutetian period (affecting Lutetian carbonates), thus after the studied period.

P3606 L24: ok

P3607 L10: I remove this unclear sentence

P3607 L15 : ok, I will change "Artois anticline" by "South eastward prolongation of the weald boulonnais anticline".

P3607 L17 : Within supplementary material, I will include a list of the faunas identified in the 9 danian samples and the conclusions about ages and environment.

P3607 L25 : ok

P3610-11 : We will simplify the text by removing "These curves are based. . .from the long-term subsidence curves (New Jersey Margin, Miller et al., 2005)."

P3611 L16-19: This sentence is moved in the section 3.1.

P3614-15: This section is now more developed and the title is "Control of inherited variscan structures on Palaeogene deformations."

We corrected all technical corrections except for the figure 3. We prefer 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.

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