

Interactive comment on “Burial-nutrient feedbacks amplify the sensitivity of carbon dioxide to changes in organic matter remineralisation” by R. Roth et al.

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The paper by Roth et al. is well written, clearly structured, and a pleasure to read. It illustrates the importance of benthic processes for the long-term evolution of ocean chemistry and atmospheric pCO₂. More specifically, it shows that a shift of POM degradation to larger water depths has a strong impact on seawater composition and atmospheric pCO₂ when sediments are included in the model set-up. The paper is very nice and innovative. However, I find it very difficult to evaluate the model results since the benthic model is not fully explained. Even though I read the accompanying paper by (TSCHUMI et al., 2011) which provides more detail on the benthic model, I have a

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number of questions that should be addressed in the preparation of the final version:

1. The model excludes the burial of neritic carbonates at continental shelves and uses a low estimate for pelagic carbonate burial (only 0.096 Gt C/yr, Tab. 1). On the other hand, the global POC burial rate is quite high and apparently includes POC burial at continental margins (0.181 Gt C/yr, Tab. 1). The authors should explain how their model distributes POC burial between the deep-sea (>1000 m water depth) and the continental margins (<1000 m water depth). Sedimentary data show that about 80 - 90 % of global POC burial occurs at continental margins while the deep-sea contributes only about 0.01 – 0.05 Gt C/yr to the total POC burial rate (BERNER, 1982; BURDIGE, 2007; BURWICZ et al., 2011; HEDGES and KEIL, 1995; MIDDELBURG et al., 1993; WALLMANN et al., 2012). Does the model reproduce and consider these important observations?

2. In the real ocean, the benthic turnover of phosphorus and organic carbon are partly decoupled and do not follow Redfield stoichiometry. The mean molar ratio between POC and total P in deep-sea sediments is not 106 but rather 20-30 since phosphate released from organic matter forms authigenic minerals in sediments and adsorbs to iron oxides and other sediment surfaces (BATURIN, 2007; WALLMANN, 2010). Moreover, a decrease in bottom water oxygen tends to enhance POC burial (BURDIGE, 2007) while less P is buried under low oxygen conditions (VAN CAPPELLEN and INGALL, 1994). I do not fully understand how these opposing trends are considered in the benthic model. Does the benthic model assume Redfield stoichiometry? How does bottom water oxygen affect the burial efficiency of POC, P, and POM?

3. Towards the end of the transient model runs, the global POM burial rate relaxes to the steady state value determined by the constant riverine phosphorus flux (s. Fig. 3f) while the depositional rate of POM (= POM rain rate to the seafloor) is maintained at an elevated level by the deepening of the remineralisation depth (s. Fig. 3d). The burial efficiency of POM =burial rate/rain rate is thus reduced at this stage (50 – 100kyr) compared to the control run. The authors should explain how their benthic model

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facilitates this change in burial efficiency. Is this change related to the changing oxygen contents of ambient bottom waters? Where does this change happen: in the deep-sea or at continental margins? What is affected: POC, P or both (POM)? The POM deepening experiments result in a dissolved oxygen depletion at the deep-sea floor and an oxygen increase in shallow waters (<1000 m water depth, s. Fig. 5d). Are these changes responsible for the overall decrease in POM burial efficiency and -if so- what model assumptions are made?

4. As far as I understand, the burial efficiency is a key model parameter since it exerts a strong bottom up control on the final steady state results attained in the model runs (including atmospheric pCO₂). The authors should thus carefully explain how their model controls the POM burial efficiency and how the burial efficiencies generated by their benthic model compare to benthic observations.

5. The authors should try to discuss to what degree a mismatch between the predictions of the benthic model and benthic observations would affect the major conclusions of their study. The paper should definitely be published but it needs a more detailed presentation and critical discussion of the benthic model module. Further minor comments are given below: Page 486, bottom: "The adjustment to a new equilibrium takes longer for the phosphorus inventory, co-governing POM burial than for the alkalinity inventory, co-governing calcite burial." should be replaced by: "The adjustment to a new equilibrium takes longer for the alkalinity inventory, co-governing calcite burial than for the phosphorus inventory, co-governing POM burial." Page 488 line 20: "The results" should be replaced by "These results"

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