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Interactive comment on "On the path to the digital rock physics of gas hydrate bearing sediments – processing of in-situ synchrotron-tomography data" *by* Kathleen Sell et al.

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The authors describe pore scale imaging of gas hydrates in sediments and the processing of the obtained data and their use for numerical modelling. Especially the detailed explanation of image processing to yield a 3D segmentation of the sample components is of great value for future imaging studies of rock samples with and without gas hydrates. Further, it is a great addition to other publications of this dataset which focus more on the experimental setup (Chaouachi et al., 2015). Some questions remain about the numerical modeling section: Your images indicate that the hydrate does not cement the grains however your modelled P-wave velocities increase a lot for low hydrate saturations indicating a significant stiffening of the sediment which –

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Discussion paper

according to effective medium models – would only be achieved by cementing the grain contacts. Comparing your numerical modeling results to effective medium models (Dvorkin, Helgerud, Ecker) and laboratory data (by Priest, Kneafsey, Waite, etc.) might be a good benchmark for your numerical modelling results. This section could benefit from a more thorough discussion about factors causing differences between modelled and laboratory / field data. The authors conclude that this study enables to distinguish gas hydrate from a gas enriched system and gas hydrate from a free gas system based on their seismic response. However, the modelled velocities for both differ by just 40 m/s. That would actually indicate that both formation mechanisms lead to similar elastic properties. . Observed differences from the pore-scale imaging of these two gas hydrate types are not reported in the study. The study is certainly worth publishing but could be improved by relating modelling results to published velocity data.

Page 2 Line 20: “relies” instead of “relays” Line 22: “has been interpreted before” instead of “has been earlier interpreted” Line 27: I’m not quite sure what you mean by “habits” – it also occurs in the figure caption of Figure 1. Can you maybe rephrase it? E.g. hydrate distribution Page 3 Line 4: “systems” instead of system Line 12: “these” instead of “this” and “met” instead of “meet” Line 14: I’m not sure what you mean by “refractory” here (that may be my lacking knowledge of the terminology though) Line 24: instead of “followed” you could use “monitored” or “observed” Page 4 You’re mentioning the density differences between water and methane hydrate vs. Xenon hydrate. I think it would be helpful to include a table with densities for your sample components (grains, Xe hydrate, Xe gas, water) Page 5 In the first paragraph it sounds like you’re saying that Xenon gas and water could not be distinguished (and it sounds like that again on Page 8, line 14) yet in the second paragraph (line 11) you say you were able to distinguish between gas and water. Can you clarify this? Line 11: “commonly occurred” instead of “occurred most” Line 26: “prior to” instead of “prior” Page 6 Line 14: “number of iterations” instead of “number of iteration” Page 8 Line 3: “meets” instead of “meet” and a comma comma after “meets” Line 11: “then” instead of “than” Line 14: “water

or gas-filled" instead of "water of gas-filled" Page 9 Line 2: just "yielded" instead of "yielded in" Line 23 "obtained" instead of "sustained" Paragraph 2: I think it would be helpful if you mentioned the laboratory derived values by for porosity and permeability by Madonna et al. to compare to your numerically derived values Page 10: Line 21: "multiple" instead of "multiply" Line 24: Can you elaborate a bit more of what you mean by "benchmarked" here? Did they compare modelled and laboratory measured data? Line 31/32: voxel sizes are missing units Page 11/12

Note: most of the things I mentioned in my short comment are referring to these pages. What makes me wonder most is that your increase in velocities is really high for a hydrate saturation of 17% (for both tested formation mechanisms). So would you conclude that the hydrate significantly stiffens the sediment even though the hydrate does not appear to actually touch the grains? You could add some more detail here to your discussion. I think this is actually really interesting! Your images show that the hydrate doesn't follow any of the end-member models discussed by effective medium theory (pore filling, contact cementing etc.). So maybe one of your conclusions could also be that we need better physical models than the effective medium ones. It would also be interesting to discuss whether your images showed any differences in hydrate distribution for the two formation mechanisms (from free gas + water and from gas enriched water). The literature usually assumes the first one forms cementing hydrate while the latter forms pore filling hydrate. It seems like you didn't observe this difference – neither in your images nor your modelled velocities. That's an interesting observation and worth discussing! Line 17 to 21: If I'm not mistaken the conclusion from the studies your mentioning (Waite, Priest etc.) is usually that the velocity is higher for hydrate formed from free gas and water than for hydrate formed from gas-enriched water (especially at low saturations, like the ones you used for your experiments). Your model indicates something different. You could add some phrases to hypothesize why your model results differ from lab data.

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