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Interactive comment on "Formation of linear planform chimneys controlled by preferential hydrocarbon leakage and anisotropic stresses in faulted fine-grained sediments, Offshore Angola" *by* Sutieng Ho et al.

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The paper investigates the correlation between the distribution of near-surface fluid migration features and different kinds of polygonal and tectonic faults at a deep marine setting offshore Angola. The tectonism is primarily associated with salt diapirs. The authors document a range of fluid migration features in the area from which the most particular ones are linear chimneys. They propose a conceptual model that explains the orientation and distribution of gas chimneys by alteration of local stresses adjacent to polygonal faults. This paper include a compilation of observations published in the

framework of Sutieng Ho's PhD thesis, but here the authors focus on the effect of physical stresses on fluid dynamics. The data available for the study as well as the maps showing the fluid flow features are of high quality. The observations and thorough analysis of the geological controls on fluid flow in the region are highly relevant for the understanding of chimneys and shallow gas dynamics at other margins. The aims of the study are concrete and the introduction provides an excellent compilation of relevant references regarding stresses associated with fault planes. The cited studies goes from pioneering geomechanical concepts in the 80s to recent laboratory and modeling studies about shear and stain on sediments adjacent to fault planes. I must say, however, that the paper is very difficult to read, mainly because of the amount of observations presented in figures that are overloaded with insets, sub-parts and details. Some of the interpretation can be challenged. I came up with a few main points that I believe could be addressed to improve the manuscript. A list of detail comments annotated while reading through the paper is also provided.

Main points:

âĂć Polygonal faults: the core of the paper is the relation of shallow gas accumulations and chimneys with the presence of polygonal faults. Although the authors do reference key studies related to polygonal faults (identified in the area but also globally), I think that a little bit more emphasis on describing the main aspects of such faulting is needed in the paper. I usually think of polygonal faults as those faults forming "polygons" in fine-grained sediment sequences. I realize that in this paper there are also radial faults associated with the synclines next to the salt diapirs that are as well referred to as polygonal? Are these termed polygonal faults because the mechanism of formation is similar to the other ones? How exactly do they form? Do they really reactivate? Is it really meaningful to talk about foot wall or hanging wall if the faulted blocks can be one or the other depending on the reference fault plane? They do not form sub aerially right? Section 3.2 could concentrate all the relevant details about the types of polygonal faults observed here and what exactly are the main characteristics of such faults.

âĂć Stress distribution at polygonal fault planes: The use of the principle of particle motion and the distribution of stress at each faulted block is great for explaining migration pathways and leakage distribution. However, I wonder hoe meaningful is the terminology of footwall and hanging wall for polygonal faults. In cases where there are several parallel polygonal fault planes, one block may be the hanging wall with respect to a block on one side but it would be the footwall of the next fault. It is difficult to see that the shallow gas accumulations are exclusively at the lower part of the foot wall of polygonal faults (if I understood correctly the interpretation by the authors). I do see high amplitudes on what could be a hanging wall or a footwall depending on which fault segment for the polygonal set I choose. So I think it makes more sense to talk generally about focused regions of higher shear stress and dilation depending on the relative motion of the faulted blocks with respect to each other. In general, the discussion about stresses is hard to follow. I think it would help to use only one figure to project all the relevant stress vectors inferred at the local zones of fluid leakage, together with regional stress vectors from, for example, salt-tectonics. Where do the blue and red vectors in figure 4 and 6 come from? Are these measured orientations of principal stresses or inferred? Figure 10 says the vectors are local + in situ. What does in situ mean in this context, how are these stresses estimated? Information about regional and local stress fields are estmated in the region is missing. Also the figure captions should explain what those vectors signify.

âĂć Linear chimneys: Are the “linear chimneys” really chimneys? What is the definition of chimney used here? Aren’t these features fractures/small scale fault planes where the fluids literally escaped through and formed authigenic carbonate that together with trapped gas in the system creates the blanking in the seismic? Is there evidence of breciation, or hydrofracturing in the regions interpreted as linear chimneys? Actually, the illustration of the chimney features is not that great in the figures. And this brings me to the next concern. In the data section the authors mention that different stacks were

produced grouping angle of incidence. It is indicated that the seismic data presented in the paper is from the near offset stack. The seismic profiles shown in figures 3 and 4 are from which stack version? The character of what is indicated as chimney in panel e of figure 4 reminds me how gas chimneys look in undershooting data, namely along a stack using just a selected range of offsets. Two vertical blank regions appear to each side of a high amplitude zone; the separation between the two vertical blank regions increases with depth. The feature appears then as a double line on the maps. This is a bit confusing for a reader that is not familiar with the processing of the data. I wonder whether showing the character of the chimney on the full stack is more intuitive and straight forward. If the double pattern of the so called linear chimney is not due to processing, it would be interesting to her what causes such a particular feature (figure 4 a and b).

âĂć The PHAAs are interpreted as carbonates. Why would they always be associated with depressions rather than mounds? By analogy with carbonate mounds at present day seafloor, buried authigenic carbonate concretions within chimneys can get buried and appear as mounded features in the middle of a cavity with onlap of reflections at the flanks. The interpreted buried carbonate concretions don’t show positive morphologies in this case? Can it be related to the resolution?

âĂć The figures are of high quality. However, even if they are over loaded with insets, some times they lack explanations of features that seem relevant for the interpretation. For example, panel b in figure 4 shows a white band braking through a high amplitude reflection. What is that feature? It is really hard to link all the different insets. In figure 5 I don’t manage to identify where is the feature pointed with a yellow arrow on 5ai, on 5aiii. Is it correct that the seismic is NW to the right? It is important to find a way of simplifying these figures. Figure 5 could be split into 2 figures. I would suggest selecting 7-8 figures to show the main observations and to illustrate the conceptual models. Despite all the figures in the main text the authors still refer to appendix figures for observations that are key for the paper. The figures in the main text could be used in a more efficient way.

Please find below my notes while reading through the text; it includes a few typos. The L refers to the paragraph number and the P to the page number.

- L20/P3: minimum and maximum offsets? I assume these data sets are multi channel with long offsets? It is kind of important to provide this info before it is mentioned that the amplitudes vs. angle were used for verifying the seismic character of the observed features (a sort of undershooting?).

- L25/P3: typo: to map the linear. . .

- L20/P4: figure 6b referenced before 3, 4 and 5? Check the flow of the figures. It is difficult to see from figure 2b what is stated here: that studies chimneys occur primarily in syncline areas. Maybe indicate the syncline structure in 2B and relate better 2a and 2b?

- L25/P4 typo: relief instead of relied?

- L10/P5 typo: check the unit used is it 10 to 100 s, ms or m?

- L5/P6: The linear features shown in figure 4a-b are indeed strange features. Are these really along polygonal faults? (PFs?). Polygonal faults usually do not have a preferred orientation, but on the contrary, they consist of fault segments oriented covering the whole azimuth range (closing polygons), right? The linear features seem to follow the circular structures to the north of the syncline. There seems to be an overarching control on the orientation and distribution of these features rather than the polygonal faults as such. I guess I am missing a clear definition of what the authors are referring to as polygonal faults. For examples, are types 1-3 described by the authors termed polygonal faults because they all formed due to dewatering of fine-grained sediments? See main comment.

- L20/P6: typo, 19% FORM

- L30/P6: Consider making two different figures here. The figures have so many parts that it is actually a struggle to go through and understand everything. Is the statistical part of the figure really relevant? What do we do with the fact that 54% are intersecting the lower portion of PF? What seems most relevant in this paper is to get compared the orientation of the fluid flow related features with respect to the orientation local and regional faults and fractures, right?

- L10/P7: Check the use of tenses in this paragraph.

- L20/P7: Is the evidence by Sonnenberg et al., 2016 related to the polygonal faults in this present study? In that case, it would help to see a sentence hinting what is the observation that works as evidence. I got this advice recently and I kind of see now the need for bringing into the current study the key observations rather than referring the reader too often to the previous studies. This degrades the flow of the reading and makes difficult to follow the paper.

- -L30/P7: do polygonal faults really reactivate? How is the accommodation of such movement if the fault planes can converge to each other rather than been parallel? Aren't these kind of faults associated with diagenetic processes and are hence a kind of one-time event?

- -L20/P8: 60 m deep and 4.5 m wide pockmark??? That is quite deep compare to the with, it is almost a conduit rather than a pockmark.

- -L30/P8: so there is active gas release at the seafloor at present? Or you mean active in the sense that there is gas filling the near-surface systems through the gas chimney structures?

- -L30/P8: this model is hard to digest here since there are so many faults and pre-existing weak planes that one would think that the fluids would find preferential pathways without much effort and hence gas chimneys would not be favor?

- L5/P9: I could not find figure 6b. In general, it is difficult to find in the figures some of the observations regarding gas chimneys. Again, the figures could be simplified by selecting only key examples.

- L20/P9: The use of appendix figures to illustrate what seems to be the main conceptual model of the paper is not ideal. One figure in the main text should be enough to illustrate description of the model for fluid migration and development of chimneys. Figure 8a doesn't illustrate this, or did I miss something? When you mention PF tier here is it 1 or 2? It is very easy to get lost while reading, I think it is due to the fact that there are so many figures overloaded with details.

- L25/9: typo: the PRESENCE of. . .And please revise this paragraph. These aspects are not necessarily ruling out each other and a combination of them could be a precondition for explaining your observations. Consider reformulating the paragraph.

- L30/9: where do we see the gas accumulating at the foot wall? The foot wall of a major tectonic fault or are you referring to small faulted compartments resulting from the polygonal faulting? If so, is it really meaningful to talk about footwall if the blocks are somehow both footwalls and hanging walls with respect to each other?

- L5-10/P10: Why would these areas be subjected to "relative" compressional strain? What do the authors mean here? Would it be more appropriate to say "less" compressional state rather than relative? In analogy with the particle motion maps for earthquakes (focal mechanisms) one would expect that the lower part of the hanging wall and the upper part of the footwall would experience more compression while dilation would dominate the upper hanging wall and the lower footwall (which is indeed consistent with Barnett et al.,)

- L10/P10: again, no figure 6d and also the interpretation that the gas is accumulated in the footwall of polygonal faults is not easy to digest. A block can be considered a footwall or a hanging wall, depending on which fault plane is used as reference. I can see high amplitudes in both hanging and footwalls in figure 6c for example.

- L20/P11: Typo: BY. . .

- L20/P12: Again, the model of shear stress distribution through the four quadrants of the faulted blocks is very sounding for explaining the distribution of gas into more permeable zones. However, where these more permeable zones are entirely correlated with footwalls and hanging walls in these polygonal fault system is hard to assimilate. Is it really necessary to use this terminology? See main comment.

- L25/P12: So the chimneys grow episodically? You foresee that the growth occurred in several episodes of reactivation of the system? It is important to describe this more explicitly in order to be able of comparing to systems from other margins with comparable settings.

- L5/P13: typo: may BE because..

- L10/P14: typo: blocks

- L25/P14: point 6 in the discussion. Check the grammar here. The sentence has a problem. When are the chimneys circular in isotropic stress fields? And when are they linear, isotropic and anisotropic? Clarify.

- Figure 1: great figure. The use of a dip map to show all the elements of the study works extremely well, we can see the flanks of the salt domes and even the fine scale faults and fractures. However, isn't the present day bathymetry important to understand the stress regime?

- Figure 2b – typo: linear positive high amplitude. . .It is a bit difficult to read through the symbols of this figure. The idea of overlapping the symbols related to different fluid flow features on the seismic profile is great. However, it is not easy to see the actual seismic feature (in particular the high amplitude anomaly depressional network). I assume the location of the symbols just indicate the interval where each feature is observed rather than the actual feature? Maybe this can be hinted in the caption (as a help for the reader). Is the seismic section a compressed version of the geological section in 2a or only part of that transect?

- Figure 5: Can you really tell that the high amplitude analogies in inset ii are gas accumulations, without any clear sign of polarity change?

- Figure 6: Not convincing with the positive and negative bright spots interpretation. If you think it is key to differentiate between carbonates and gas for the discussion you may need to show a better indication for this, perhaps using wiggles and zooming into the anomalies?

- Figure A7 typo: Gas MIGRATION into the hanging wall apex WAS likely because of the increase (check the sentence in any case)

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