Reply to Reviewer 1

We sincerely thank the reviewer for his/her comments and constructive criticisms. We are confident that these suggestions will significantly help us improve our study.

Below, we provide a point-by-point reply to all the reviewer's comments. We appreciate the reviewer for also highlighting the paper's limitations and weaknesses, which we have carefully addressed.

Based on this revision, we will specifically reshape the Introduction and regional context to provide further evidence of the hydrothermal nature of the vent structures. We have strong evidence from both solid seismic observations and field geology analysis that supports assigning these subsurface structures to hydrothermal vents.

- To be clear, we organized this document following the main comment line by line, with the reviewer comments and suggestions highlighted in italic black and our answers in blue.

Main points of reviewer 1:

I reviewed your work with interest and on the back of comprehensive experience on both Equatorial Brazil and fluid-flow processes on continental margins.

Unfortunately, I found this paper not mature enough to be published. It seems also to be based on a thesis of some kind - either a MSc or PhD thesis, I am not entirely sure. This means that the paper is overly wordy, its introduction is unfocused, and quantification is lacking in this submission. I stress that just the (presumed) imaging of a vertical dim zone, or spot, in seismic data is not a sufficient condition to publish on Solid Earth. Compounding this limitation, there are interpretation errors in the paper that make me critical about the main conclusion of this work.

We appreciated the comments on our limitations from the reviewer. To conduct this research, we rewrote the Introduction to better explain hydrothermal vent systems, faults, and sedimentary basins that host these geological features to potential readers. However, we would emphasize that the corresponding surface and outcropping areas of our subsurface dataset have already been described and published in a paper by Menezes et al. (2019) (DOI: 10.1016/j.marpetgeo.2019.07.018). We now better emphasize these aspects in the Introduction section (Lines 125-127), and in the Geological Settings section, we describe this information in the last paragraph (Lines 191-202). This paper shows that hydrothermal silicifications have been mapped and characterized along the Afonso Bezerra strike-slip Fault System. They represent the fossilized structure of intense fault-controlled silicification, caused by the repeated upward migration and diffusion of hydrothermal fluids. In addition, we discussed this in lines 450-476.

LINE 1 - TITLE: *I am not sure if you are dealing with a hydrothermal vent complex in the study area, or just the remnant of an older complex. There are aspects in the interpretation (commented later on) that are puzzling to me, as a reviewer.*

As specified above, there are field structures that point toward the fossilized structure of intense fault-controlled silicification, caused by the repeated upward migration and diffusion of hydrothermal fluids. Therefore, by linking some subsurface seismic structures, we are confident in the seismic interpretation of the vents and the characteristics used to interpret these structures, based on several previously published papers. Below, we will address all the specific questions the reviewer raised.

LINE 32: *claims that all the vents are controlled by underlying structures. Yet, none of the maps presented in this paper undertakes a mapping of faults and other structures at depth. In other words, the link between structures and fluid-flow features is not established at all in this paper.*

We do recognize this limitation, and therefore we added in the Results a subsection to establish the link between structures and the fluid-flow features, which is called '4.3 Structural and geometric analysis of the wipe out zones'.

In Figures 2A and 2 B, we present a map of the basin fault system that we relate to our subsurface data interpretation, the Afonso Bezerra Fault System (ABFS). As shown in Figures 4, 5, and 7, all the faults we interpreted on the seismic profiles align with the ABFS NW-SE trend. The normal faults are in the root zone of the vents.

In addition, we measured the main elongation and the major axes orientation of the vents, demonstrating their alignment with the fault zone.

Finally, we added a subsection in the Discussion '5.1 Geometry of the hydrothermal vents complex and fault systems' to clarify this relationship better.

LINE 33: *mentions processes such and hydraulic fracturing and boiling (?), but none of these processes can be corroborated by only interpreting seismic data. Such a statement is speculative.*

We agree with the reviewer that evidence of hydraulic fracturing and boiling processes cannot be obtained solely from the seismic section. We rely on a previous paper published by some of our co-authors (Menezes et al., 2019). We refer to this paper in the Discussion section, the evidence of hydraulic fracturing in the outcrop data and thin sections. Also, we discuss the significance of the main architecture and development of those vents in the paragraphs (455-471; 478-489), linking what was observed on the surface by Menezes et al. (2019) with our study, which used seismic sections. Additionally, we also acknowledge the limitation of our seismic study, and corresponding to '5.2 Seismic data limitation in the vents characterization', which agrees with the main concern of the reviewer

LINES 46-47: *I am not at all sure what the first sentence in the Introduction means. It means nothing as currently written.*

Done. We have rewritten the entire sentence to clarify its meaning. Lines 46-48.

LINE 50-52*: These lines (and many others after this part) confuse igneous intrusions with hydrothermal vents. Vents are seeps of volatiles and fluid. Intrusions are, essentially, formed by viscous hot magma that forces its way into the surface, or into a sill, lacolith or other intrusive igneous body. The two processes should not be mixed.*

Thanks for the correct comments. We know that magmatic rocks and hydrothermal vents are different geological features. To make it clear, we deleted the confusing sentence to ensure the meaning of the complex sentence is understood (Lines 53-59). We would like to emphasize that the hydrothermal vents are, in any case, mostly associated with igneous intrusions or volcanic structures. Hydrothermal vents—by definition—are pipe-like structures created by fracturing, transport, and eruption of hydrothermal fluids and/or volcaniclastic material. Planke et al. (2005), when introducing the concept, explicitly place hydrothermal vents in volcanic domains, especially in relation to sill complexes, and recent studies show that vents frequently coincide with fault systems that focus and channel hydrothermal fluids. That is exactly the structural configuration we observe here. The fact that we do not observe the source of those vents (intrusive dyke or volcanic features) does not exclude their nature. We do have a surficial constraint, and we will make sure it is better linked to our subsurface interpretation.

5- *Volcanic or magmatic? Volcanic processes imply the formation of volcanoes at the surface.*

Done. We changed the term to 'magmatic', and added at the end of the phrase 'oil and gas' to better explain the type of reservoir (Line 59).

LINE 57: *What reservoirs? Magma reservoirs? Fluid reservoirs?*

Done. We added the word 'Fluid' to specify it (Line 60).

LINE 61: *is redundant.*

Thank you for your suggestion. We deleted the redundant sentence.

8- *I do not know what is post-mortem seismics. Surely many a seismic survey and marine geology campaign have sampled and surveyed ACTIVE hydrothermal seeps.*

Done. We deleted the referred 'term' to clarify the sentence (Line 66). We want to emphasize that none of them appear to show active hydrothermal seeps.

LINES 66-68: *This statement is incorrect as Chris Kirkham, C. Roelofse and other authors have concluded on the mechanisms that lead to the nucleation an propagation of vents. There are many papers from Marine Geology surveys that explain these same processes too.*

The papers by Kirkham and Roelofse describe mud volcanoes. However, our seismic interpretations are not linked to mud volcanoes or methane cold seeps, as are those described in the referenced papers. In our study area, there are no seal bypass triggered by an overpressured hydrocarbon reservoir. To clarify this point, we have rewritten the sentence to ensure that hydraulic fracturing is associated with the hydrothermal vents (Lines 69-70).

10- *Page 4 reads as a literature review.*

We appreciated the reviewer's criticisms, but we think it is important to make a summary of the literature review to provide context for our study.

LINE 102-115: *mention aspects, and results, that are not novel at all. Your attribute-based methods have been used for decades, so they cannot justify the publication of this paper alone. What are the geological research questions you intend to address?*

The novelty of this paper is not the methodology, which several of us know (e.g., D. Iacopini, A. Torabi) know very well and have contributed to developing over the last 15 years across pre-salt, North Sea, and fault structures. The main novelty of the paper is that we link clear subsurface vent architecture and its amplitude expression to the surficial expression of several hydrothermal silicifications guided and aligned by a fault system.

Lines 116-124: *If these are research questions of your interest, there are three main processes indicated in this paragraph which, for better or worse, cannot be addressed by seismic data alone. They are completely out of the scope of this paper.*

We do agree that seismic interpretation may produce ambiguous observations. But we still would like to emphasize that our paper is a follow-up study focusing on seismic data. In the literature, the papers by Santamaria & Cartwright (2015) and Mastrelli et al. (2017), have discussed these aspects, suggesting that wipeout zones may be the result of the hydrofracturing process, rather than a simple capillarity process,. We can distinguish the hydrothermal vents that exploit existing faults from those that simply intrude across the overburden without exploiting faults. In the first case, the process reuses fault discontinuity as a pathway. In the second, it has to intrude into the overburden to create its pathway and the hydrofracturing may have played a role.

LINE 130: *reveals that your dataset is very small. Twelve fluid-flow features are not a hydrothermal vent complex. Actually, only 3 of these features are (tentatively) interpreted as vents.*

We do recognize that the seismic dataset can be considered small, and the 12 features do not represent the largest dataset in the literature, but each of our interpretations was based on rigorous parameters already cited in the literature. Aiming this, we found not only the disturbed zone of the amplitude signals, but the Inflection Point (indicating that the fluid it was not a gas), Wipe out Zone (WZ), Dead Mixed Zone (DMZ), Lateral Brightness (LB), High Amplitude Reflectors (HAR), and Coherent Reflector (CR), and a continuous Root Zone contains in all the 12 fluid flows. They represent a portion of a larger area affected by several hydrothermal silicification events, as already documented in our previous study (Menezes et al., 2019) (DOI:10.1016/j.marpetgeo.2019.07.018).

Lines 191-192: *A silicified fault zone is evoked here. Yet, none of the maps and surfaces shown (nor the seismic profiles) show an unequivocal fault zone. The paragraph on this page 9 calls no figures or data to corroborate the presence of such a fault zone.*

We added figure (2B), corresponding to the fault zone referred to by the reviewer. We added new references where this fault has been mapped in this fault zone. In Figure 2, we present a new map with the fault zone located. In the referred paragraph, we did refer to the Menezes et al. (2019) paper (DOI:10.1016/j.marpetgeo.2019.07.018), which is located exactly in same area as our study, and that probably could have guided the reviewer toward the correct context. So we refer to mapped, sampled, and precisely characterized hydrothermal features (petrography, mineralogy, geochemistry, fluid inclusion, petrophysics) in the same area of the dataset. To better clarify this point, we added to this part of the text the lines 204-206.

15- MAJOR ISSUE: *being the features on Figure 4 interpreted as vents and pipes, why have they completely flat tops? As (rightly illustrated by Figure 1, you should see craters, domes, eye-shaped, onlapping, divergent, etc., etc. geometries above your vents. Yet, the seismic data in Figure 4 show completely flat continuos reflections across the putative vents and pipes.* Moreover, the seafloor is flat.

We do have an inland seismic dataset. However, if we look at Figures 5B–C–D and 7B–D, we do observe that the vent top is not flat: the interpreted brown layer unfortunately obscures subtle but important irregularities at its top surface, creating the mistaken impression of a flat top. That top geometry is visible; it shows a mound structure with pull-up effect (as expected), and any artificial flattening may result from reprocessing of the shallow seismic section, smoothing the surficial part.

16 – *Some of the faults in the profile may actually be artefacts and or push-down and pull-up acoustic features.*

We revisited all our interpretations, selecting sections where the vents exploit fault or produce the disturbed zone.

17 – *Figure 5- Another example of completely flat tops for the putative vents + continuos reflectors across them. Please, compare your features with those documented by Chris Kirkham and Chantelle Roelofse. Figure 6 show more flat tops. Are you in the presence of dim zones, rather than vents and pipes?*

Those are seismic flat artefacts that appear to be associated with static issues on inland seismic. But the position of the IP may represent the top of a mound, with the rest of it poorly imaged above it. The onshore contrast cannot be compared with the seafloor expression of offshore good-quality data. A dim, wipeout or dim spot represents a local, low-amplitude anomaly in a seismic reflection and is usually associated with the presence of fluids (hydrocarbon replacement water). Here, however, we do not observe any hydrocarbon migration, but rather a wipeout zone on top of the vent structure.

18- *The remainder of the paper is well illustrated, but none of the figures is based on a solid interpretation work. Also, structural maps are lacking to tie the deeper structures to the imaged dim zones. These are dim zones, not pipes and vents, in my opinion. Unless you had an issues during seismic acquisition and acoustic signal was lost at some point - or there are carbonate/hardened features on the seafloor that 'dim' the strata below. The bottom line is that these are dim spots and zones, not fluid vents and pipes that have forced their way onto the seafloor, which is flat and undisturbed by this putative fluid flow.*

We appreciated all the criticism from the reviewer. All the interpretations were precisely revised and discussed. As we explained before, we made sure to interpret the faults not only in the middle of the vents, but also to avoid being affected by them. The seismic data used are onshore with no seafloor. We have solid seismic observations, linked to field geology, that allow us to assign these subsurface structures to the hydrothermal vents.