

Review for „Reprocessed 2-D airgun seismic reflection data SALTFLU (salt deformation and sub-salt fluid circulation in the Algero-Balearic abyssal plain) in the Balearic promontory and the Algerian basin”

General Comments

This paper provides an interesting and unique collection of reprocessed multichannel seismic data from the Algerian basin and the Balearic promontory. The authors present a sophisticated processing flow enabling the challenging task of imaging the base of the Messinian. Through a broadband processing strategy, multiple attenuation, and iterative migration in the time and depth domain, the authors produce seismic images allowing an interpretation of the Algerian basin and the Balearic promontory from the Miocene up to the Plio-Quaternary strata. The study provides several interpretations of the intra-Messinian deposits, the salt tectonic system, fluid migration structures, and volcanic structures.

In my opinion, the data set and the presented processing scheme will be a valuable contribution to the community, especially since comparable data cannot be acquired in the near future due to the ongoing exploration efforts in the area. However, I recommend that the manuscript should be revised since I came across several major issues, which I list below before providing more detailed comments.

1. Structure of the manuscript

In the current version of the manuscript, the section ‘Results’ seems to be a mixture of a summary of the processing flow and the discussion. Technically, the results are already included in Chapter 3 ‘Methods’, presenting the results of the processing scheme. I suggest focusing Chapter 4 on the comparison of the reprocessed data and the vintage data since this is key to this study, which brings me to my next point:

2. Reprocessed vs. vintage data

In my opinion, a key aspect of the manuscript is that the new processing scheme provides new geological insights compared to the vintage data. However, this is hardly addressed in the text and it is not illustrated well enough in the figures, in my opinion. While Figure 6 shows two examples of a comparison of selected reprocessed and vintage sections, I think this important aspect of the manuscript could be strengthened by the inclusion of more examples, especially by showing more detailed figures (e.g., enlargements of the sub-salt). In addition, in my opinion, the comparison of seismic line SF09 in Figure 6 seems a bit unfair since the amplitudes of the vintage section seem to be weaker in general, which makes a comparison difficult. I am aware that the processing scheme improves the balance of the amplitudes but in order to enable a visual comparison for the reader, I recommend scaling the data similarly (e.g. an RMS scale or a Mean scale).

In addition, I recommend that the authors also upload the vintage versions of the profiles to the repository so that the reader can evaluate the improvements in the presented processing scheme.

3. Data Completeness

I realized that there are several issues with the data uploaded to the repository at zenodo.

- For SF09, the PSTM version and the velocity model are missing.
- In SF12, the data quality of the last third of the profile is very bad. Something clearly went wrong here, see Figure below:

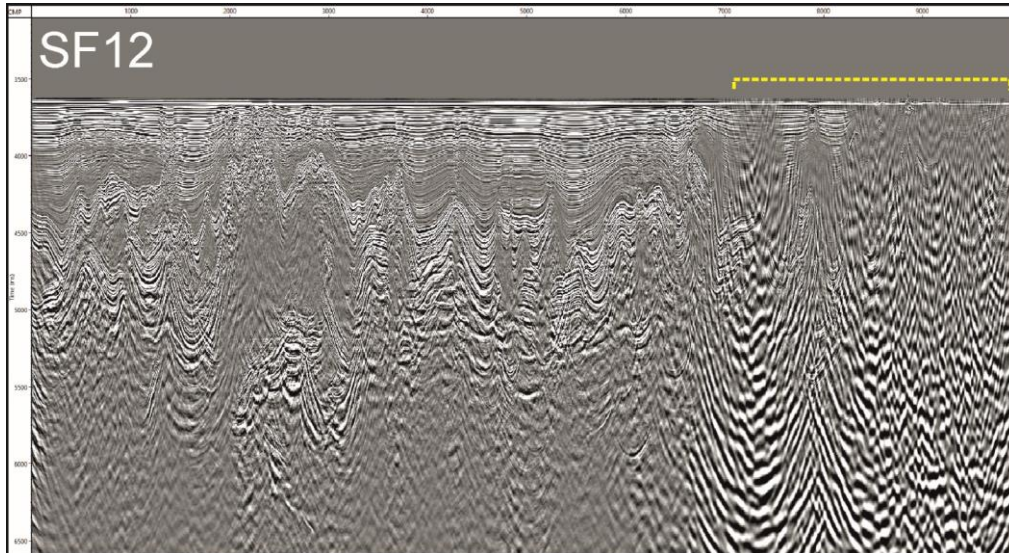


Figure 1: Profile SF12 (PSTM). The yellow line marks an area where the quality of the seismic section strongly deteriorates.

4. Figures

There are several figures, where it is very difficult for the reader to properly follow the reasoning of the authors. On the one hand, this is due to the limited resolution of some of the figures (e.g. Figs. 3, 4). On the other hand, several images are too small to properly assess the differences before and after processing steps (e.g. Fig. 3) or to follow the interpretation (e.g. Fig. 10). It would help if these figures were made larger and displayed in better resolution.

Also, I think the manuscript would benefit if the authors included more references to figures in the text and were more specific about where exactly the reader should look. Also, in some instances in the text, the figures are not referenced at all (e.g., Fig. 4e, Figure 7a-c). Further, I recommend being consistent with the figure captions, i.e. to always explain what the subfigures (a), (b), etc. show. This is not the case in Figures 1, 4, 8, 10, and 12. I think it would also be helpful if the authors provide some sort of horizontal scale along the seismic section so that they can better direct the reader's eye to specific areas of the profiles.

5. Data Quality

In the Review Criteria of ESSD, it says: “The data must be presented readily and accessible for inspection and analysis to make the reviewer's task possible. [...] The reviewer will then apply his or her expert knowledge and operational experience in the specific field to perform tests (e.g. statistical tests) and cast judgement on whether the claimed findings and its factors – individually and as a whole – are plausible and do not contain detectable faults.”

If I understand this correctly, the raw seismic data and navigation data should also be uploaded in order to make the workflow reproducible. In addition, as mentioned above, it

would be great if the vintage version of the data would be available to properly assess the improvement of your presented processing workflow.

6. Presentation Quality

In the Review Criteria of ESSD it says: "The authors should point to suitable software or services for simple visualization and analysis, keeping in mind that neither the reviewer nor the casual "reader" will install or pay for it".

I think this is something you should address in the manuscript. While this is of course challenging when seismic data are involved, I would recommend the following:

- You can point out free software packages that allow the reader to plot the seismic sections (e.g. Seismic Unix, SeisSee, etc.)
- You can provide high-quality images (e.g. PDFs) of all profiles so the reader can immediately assess the profiles and get an easy impression of the dataset.

7. Geological Interpretation

In general, I had major problems following the interpretation of the seismic profiles. I suggest the following modifications:

- The relation between reflectors (R1-R5) and units (UU, UU1, UU2, intra-UU) should be clearly defined at the beginning of Section 5.3 or 5.3.2. The text jumps between both nomenclatures and this is very confusing. Also, the labels in the Figures are not consistent (see comment on Figures 10 and 11 below). Please make sure that the colors used for horizons are consistent.
- Provide a horizontal scale along the profiles so you can specifically refer to the profile kilometer where the geological feature of interest is located. In many cases, I had to search for a specific area for a long time, which is very distracting from the line of reasoning in the text.
- In Figure 10 I strongly recommend placing the blow-ups in a separate panel below and to plot them larger. Otherwise, it is impossible to evaluate and understand the interpretation.
- Please make sure that all features indicated in the Figures are mentioned in the text, e.g. "LAV" in Figures 8 and 11, "gas pocket" in Figure 10, "salt lenses" in Fig. 12a, "intrusive sills" in Fig. 12c are not mentioned in the text at all.

8. Quantification of uncertainties

The authors mention that there are uncertainties regarding the final velocity model due to the limited offset. However, I strongly recommend addressing these uncertainties better in the manuscript and to discuss the resulting uncertainties in the depth of seismic reflectors, e.g. the base of the evaporites.

9. Referencing sections

The authors consistently refer to "Section 2", where it should be "Section 3". E.g. in Lines 237 or 244, the authors refer to "Section 2.4.1" or "Section 2.4.2", which do not exist in the manuscript.

10. Table 1 is missing in the manuscript.

Specific Comments

Figures

Figure 1:

- Map in (a) misses proper coordinates and information regarding the coordinate system.
- For the overview map in (b), I would recommend removing the coordinate lines and adding ticks to the axis instead.
- The Figure caption does not explain (a) and (b).
- The Fonts are very small in (b). The numbers of the drill sites are very difficult to see.

Figure 3:

I think that the quality of these plots should be improved. In order for the reader to properly evaluate the improvements in the processing, please provide larger Figures in (b) and (c). In addition, the frequency plots are very difficult to see and I would recommend providing larger versions of the plots. In addition, I strongly recommend deleting the horizontal and vertical lines since they are not consistent (some are missing?) and are not really necessary.

Figure 4:

- Half of the figure caption is missing.
- I like the panels in (a) a lot and the improvement of the deghosting is impressive!
- In (b) the inconsistent vertical dashed lines give the impression of a logarithmic scale. Please delete these annotations, they are very distracting.

Figure 5:

- While I really like the larger representation of the figure that allows the reader to properly assess the improvements of the demultiple, the legend is incomplete. The meaning of the orange line (base of evaporites, I assume) is not indicated in the legend.

Figure 6:

- While you state that the amplitudes are balanced better in the reprocessed sections, it seems that the amplitudes of the vintage data are much weaker in general. For comparison, it would be helpful to apply an RMS or mean scaling to better illustrate the differences between both versions.
- As mentioned above, I think you could really improve the story of the manuscript by providing more detailed illustrations showing the improvements of the processing flow, especially regarding the imaging of the sub-salt strata.

Figure 8:

- This is a very nice figure! The resolution is perfect here.
- The explanation for the abbreviation LAV is missing.
- Please add (a) and (b) for the upper and lower panel.

Figure 9:

- In the caption, it says: “(a) common reflection-point gathers with interval velocity overlay”. However, there is no interval velocity overlay in (a).

Figure 10:

- The colors of the horizons are not consistent. The base of the salt/evaporites has a different color in (a) and (c) compared to (d) and the legend.
- Please make sure the Figure caption is consistent. The explanation for panel (c) is missing.
- It is really difficult to link the text with the Figure. I would recommend placing the enlargements in a separate panel below and making them larger. In addition, it would greatly help to place arrows in the figures and a horizontal scale so that it is easier to follow your reasoning in the text. E.g., where are exactly are weakly reflective diapir contacts exactly? Where exactly are the fluid indicators? An experienced seismic interpreter can see this, but this might not be clear to other readers.

Figure 11:

This Figure does not allow the reader to understand the interpretation that is outlined in the text. It is not possible to identify the different reflectors (R5, R4, R3) since the markings are unclear.

In the caption, it says that reflector R5 is flattened, so I assume that this is the green dashed horizon, which is perfectly flat. However, this is not indicated in the legend. Then again, I only see one more marked horizon in black – is this R4 or R3? I don't see another marked reflector as there should be according to the legend. In the legend, it says R4 is the “top evaporites top surface”, which makes no sense to me, especially since the caption says R5 is the top of the Messinian evaporitic sequence.

I don't want to be too picky or too harsh here, but for me, this makes it impossible to follow your reasoning in the text.

Figure 12:

- (B): The interpretation of magma conduits is speculative and not necessary. While the interpretation of the irregular high-amplitude reflections as volcanic terrain is convincing, the seismic data do not allow to say anything about the internal structure of these edifices such as conduits.
- (C): It is not possible to identify the collapse structures you indicate in this figure. The amplitudes of the unit containing the evaporites are too strong to identify any internal structures here.
- (C): It is impossible for the reader to properly identify what is interpreted here as mass-transport deposits since the figure is way too small.
- (C): The interpretation of intrusive sills is very speculative and not addressed at all in the text.

Appendix B/C:

- Inconsistent use of “meters” or “m”
- Missing unit for the aperture?
- Please make sure that there is a space between the numbers and the units. This is not consistent in the tables.

Text

Line 12, 16:

- Your data was acquired with a streamer of 3 km length, which you term “short-offset” here. I understand that the offset-to-target ratio is not great, especially for the aim of imaging the sub-salt strata, but I disagree with this terminology. In the context of academic seismic surveying, where often only single-channel seismic data or streamers with lengths much shorter than 1000 m are available, the used streamer length of 3000 m is a lot. Also, a streamer length of 3 km is more or less the limit of what can be handled from research vessels.

Line 48:

- Table 1 is missing!

Line 55:

- It would help to include a figure here that highlights the weaknesses and processing challenges of the vintage data.

Lines 76-80:

- When you mention the occurrence of the ‘bubble pulse’, I think you should mention that for the survey, G.I. guns were used that are specifically designed to suppress the bubble signal. While this suppression is not 100 %, I think it is necessary to at least mention this here.

Line 110:

- I assume that you mean ‘common image gathers’ or ‘common reflection-point gathers’ instead of ‘coming midpoint gathers’ here?

Line 120:

- Otherwise, I really like the Introduction. It nicely sets the motivation of the study and gives a good overview.

Line 122:

- In Figure 1, you capitalize “Formentera Basin” and “Algerian Basin” but in the text, you use the lowercase version “Formentera basin” and “Algerian basin”. This should be consistent.
- The abbreviation EBE is only used once. I would recommend deleting it.

Line 132:

- The reference (Lofi, 2018) is not in the reference list. Should this be (Lofi, 2011)?

Line 148:

- I think you should refer to Figure 1b when mentioning ODP Site 975, which by the way is difficult to see in the small inlet.

Line 150:

- I was wondering, did you apply a topmute somewhere in your processing routine, e.g. after migration? The data looks like there has been some kind of topmute applied but this is not indicated in Figure 2 or mentioned in the text.

Line 169:

- How did you estimate 1511 m/s as the water velocity? I understand that ~1500 m/s makes sense, but 1511 m/s gives the idea of a precision that needs explanation.

Line 211-219:

- This paragraph should refer more thoroughly to Figure 4. Only Figures 4a and 4d are mentioned here, while the rest of Figure 4 is not mentioned at all. I think it is necessary to better match the text and the figures, otherwise, the reader is lost.

Line 279:

- In my opinion, it would make sense to place Figure 7 or another figure illustrating the velocity building scheme somewhere in this section.

Line 281:

- Here, you are using 1525 m/s as water velocity. Why not use 1511 m/s? Or why did you not use 1525 m/s before?

Line 288:

- What tomography code did you use? Is this included in the REVEAL processing software?

Line 302:

- It would be great to shortly discuss the derived value for the salt velocity. Is this a reasonable value compared to other studies?

Line 355:

- Please indicate that you used the $\lambda/4$ criterion here.

Lines 389-390:

- How did you calculate the notch frequencies? I recommend shortly explaining this.

Lines 399-400:

- Please indicate whether birds were used during the acquisition of the seismic data for depth control

Line 446:

- Please explain, why you “believe” they represent geology. I agree, especially since this is actually quite clear in Figure 8b due to the hummocky, irregular appearance of the internal reflector compared to R2.

Line 498:

- CMP gathers – This should probably be common reflection-point gathers.

Lines 449-450:

- The reference to Figure 9 seems misleading to me since Figure 9 does not show the over-migration of R2.

Line 459:

- You could mention the offset-target ratio here.

Line 460:

- What are the uncertainties in the velocities? Can you quantify this?

Line 501:

- This is very difficult to see. I think providing larger figures would definitely help.

Line 506:

- The low amplitudes and push-downs are not indicated in the figure.

Line 507:

- There is no Figure 8d

Line 509:

- Please refer to which reflector the reader should look here and mark where reflectors are pierced.

Lines 506-530:

- I have the feeling that this paragraph needs to be reformulated to be understandable by an inexperienced reader. I think it is necessary to guide the eye of the reader better and to state what features the reader should look for since this is not always clear in the figure. (e.g. by referring to arrows).

Line 530:

- Figure 10a indicates gas pockets. However, this is not included in the text.

Line 537 -576:

- It is extremely difficult to follow the line of reasoning here. Please make sure to refer to your figures more specifically to guide the reader's eye.
- In addition, it is quite confusing that the text switches between the Units (UU1, UU2, etc.) and the reflectors (R1-R5). I think it would be very helpful to clearly define how the units and reflectors relate to each other at the beginning of this section.

Line 545:

- As far as I can see, those faults lie above reflector R1 and not below.

Line 548:

- Please indicate the reflector truncations in the figure, it is really difficult to understand where the reader should look here.

Line 563-565:

- Since it is unclear where R4 is in this Figure, it is not possible to follow the reasoning here.

Line 568:

- It would be helpful to mark the Balearic margin in Figure 11.

Line 578:

- The abbreviation LU is not defined anywhere.

Line 583:

- The abbreviation FBI is only used twice in the text. I would recommend removing it.

Figure 607:

- The collapse structures are highlighted in Figure 12c. Therefore I strongly recommend referring to Figure 12c here to help the reader follow the line of reasoning.

Line 613:

- Vertical dimming is not shown in the figure or at least it is not clear here.

Line 615:

- In the figure, you indicate salt lenses, but don't touch on it in the text. This should be consistent.

Line 649:

- I disagree that the reprocessed data reveal these features. Rather than that, I would totally agree that reprocessing helps to image these structures in greater detail and more precision. Therefore, I recommend rephrasing this or providing examples that justify this claim.

Technical corrections

Line 103: window based → window-based

Line 164, 313, 320, ...: Sometimes you are not using a space between the numbers and the unit. Please check the entire manuscript again, this must be consistently avoided.

Line 184: Double space: “domain __ prediction”

Line 468: du to → due to

Line 469: limit → limits

Line 526: The → Since the

Line 594: that → than

Line 184: Double space? “similar __ to”

Line 612: Remove space after reference → (Bertoni and Cartwright)_.

Line 625: Missing brackets at the reference: Infante-Paez and Marfurt, 2017.

I am at your disposal for any questions.

Kind regards,

Jonas Preine, University of Hamburg

Email: jonas.preine@uni-hamburg.de