Reviewer #2

Comments on Seismic imaging across fault systems in the Abitibi greenstone belt – An analysis of pre- and post-stack migration approaches in the Chibougamau area, Quebec, Canada, by Saeid Cheraghi et al

This paper discusses the processing strategy to apply to vertical incidence seismic reflection data in order to get best subsurface image along crooked-line acquisitions. In that regard, I think the paper is excellent. The analysis it makes of the importance of CDP bin centers in relation to CDPs location and maximum offset, together with the need of undertaking cross-dip move out tests is crucial to get the best resolved image. However, I'm a bit disappointed about the interpretation of the data. I don't know if the goal of this paper is to present also a geological model of the area, as they don't really do it. At this point, I don't see a clear relationship between the faults and the reflectivity. As an example, the Doda fault does not seem to have a seismic response in the southern profile. The width of the reflectivity associated to the Guercheville and Barlow faults is much higher than the trace of the faults themselves. So what is the reflectivity responding to? Deformation or lithological contrast? Is the later related to Au mineralization or not? In relation to this, the map in figure 1 lacks information about dips and a cross-section where we can have an idea of the structure. Finally, to round up the conclusions, both profiles should be plotted overlapping the entire seismic profile, presenting the overall structure of the area. As it is now, the paper is a good technical work with limitations regarding the interpretation. Finally, even though there are native English speaking researches among the authors, I find the text awkward sometimes. Conclusions read like a telegram, and some parts of the text do not flow properly. So a revision of the grammar and style would be convenient (from my point of view).

Reply to comment:

First, we would like to appreciate the reviewer for their inclusive comments and mentioning the quality of our paper excellent. It is really encouraging us. As we mentioned in text the main concept of our paper is to address challenging associated with acquiring crooked seismic profiles in crystalline rock terrains. We mainly explained our research to optimize DMO and PSTM process. We also explained the interpretation of the seismic sections to provide more insight about the effect of the processing methods. Detailed interpretations about the kinematic of faults, providing geological sections or study the structures in regional scale is beyond the scope or study. The regional seismic section in Chibougamau area and its interpretations were recently published elsewhere by some of the co-authors of this paper and these are not the focus of this paper. We have cited this publication in our paper:

Mathieu, L., Snyder, D.B., Bedeaux, P., Cheraghi, S., Lafrance, B., Thurston, P., and Sherlock, R.: Deep into the Chibougamau area, Abitibi Subprovince: structure of a Neoarchean crust revealed by seismic reflection profiling, Tectonics, 38, 1–25, 2020.

Again, we would like to mention that the kinematic study of the faults needs field measurements and it is not the focus of our research here. We would like to mention that the kinematic of the Barlow fault is published by one of the co-authors of this paper:

Bedeaux, P., Brochu, A., Mathieu, L., Gaboury, D., Daigneault, R.: Structural analysis and metamorphism of the Barlow Fault Zone, Chibougamau area, Neoarchean Abitibi Subprovince: Implications for gold mineralization, Canadian Journal of earth Sciences, accepted, 2020.

Now, in section 6 we have provided more details about the interpretation of the structures and specially the Barlow fault, the Guercheville fault, and the Doda fault. Potential area for mineral exploration (orogenic gold) is also discussed in section 6.

Figure 1 has changed to present axis of the major anticlines and synclines in the Chibougamau area which provides a better taste about dip and strike of the regional structures. The legend in Figure 1 now presents a stratigraphic column with age of the major formations. The strike of the Doda fault on Figure 1 is updated based on finding of recent field work study by one of the co-authors (P. Bedeaux).

We believe that while the goals of regional and high resolution seismic studies are different there is no need to republish the regional image here.

Line 16-17: Would help to know what type of faults are them. Strike slip, normal or reverse? As there is not a proper stratigraphic column in the legend, the kinematics of the faults is difficult to infer

Reply to comment:

We mentioned that the kinematic studies are not the scope of our research (last paragraph of the introduction). How ever, more information about the Barlow fault is added to text based on recent field studies of P. Bedeaux (section 2. Geological setting, paragraph 3).

Line 23: In the northern?

Reply to comment:

text is edited (Abstract).

Line 24: structures or the key geological structure….

Reply to comment:

Text is edited (Abstract)

Line 83: Fig. 1 does not show …the NE portion of the Abitibi super-province. A regional scale map (at least as the inset in figure 1) where this province appeared will be much better.

Reply to comment:

Figure 1 has been edited regrading this comment. The inset on Figure 1 shows the Abitibi subprovince and the study area. The Canada map also shows the location od the study area.

Line 84: Same applies for the ages of rocks. Include them in the legend of Figure 1 and not only in the text so we can have a quick idea of the structure. Right now we don't know which ones are older or younger.

Reply to comment:

Now, the legend of Figure 1 shows the stratigraphic column and ages of the rocks.

Line 252: …various constant velocities between 5000-6500 m/s, with a step range…..?

Reply to comment:

Text has been edited (section 4. Dara processing and results, paragraph 2).

Line 258. Here you start presenting results but the whole thing is quite messy. A new paragraph (add inter-paragraph space as you do in other places, e.g., between lines 295 and 296) should start in line 258 and another one in line 264 (The design of the north….)

Reply to comment:

Text has been edited regarding this comment (section 4. Dara processing and results, paragraph 3 and 4).

Line 268: ….Labelled in Fig. 5, chn1…….

Reply to comment:

Text has been edited (section 4. Dara processing and results, paragraph 4).

Line 271. Those reflections project to the surface off the CDP line, so rephrase. Is not that they show no correlation with the surface geology. We don't see it. And the map you provide in Fig 1 lacks detail, but some could be related with the Burlow pluton southern boundary?

Reply to comment:

Text has been edited regarding this comment. We now interpret them as they could be related to southern boundary of the Barlow pluton (section 4. Dara processing and results, paragraph 4).

Line 282: I don't see chs5 and6 as subhorizontal. If something, chs5 has a hyperbolic geometry with high opposite dip to ch6 in its deeper part

Reply to comment:

Text has been edited and now we mention them as steeply dipping reflections (section 4. Dara processing and results, paragraph 5).

Line 272:….one kilometer…you are using km and numbers so it should be 1 km.

Reply to comment:

Text has been edited (section 4. Dara processing and results, paragraph 4).

Line 276: New paragraph again (interparagraph space)

Reply to comment:

Text has been edited (section 4. Dara processing and results, paragraph 5).

Line 284: I'd like that title to be more specific.

Reply to comment:

Text has been edited. Now it has been changed to "section 5. cross-dip analysis".

Line 289: Change to……When out-of-place CMP's scattered/reflected seismic waves from steep structures off the CDP line (cross-dip direction) exist, cross-dip analysis addresses…..??As it is now, the phrase does not read well. I think you make an excesive use of semi-colon when you could replace it by commas or new paragraphs.

Reply to comment:

Text has been edited to follow this comment (section 5. Cross-dip analysis paragraph 1).

Line 311: Remove…Table 3 shows…..segment. It is already mentioned in the previous paragraph

Reply to comment:

It has been removed from text (section 5. Cross-dip analysis paragraph 3).

Line 312: Remove…Table 3 shows…..segment. It is already mentioned in the previous paragraph.

Reply to comment:

It has been removed from text (section 5. Cross-dip analysis paragraph 3).

Line 314:……depths lesser than…..

Reply to comment:

Text has been changed (section 5. Cross-dip analysis paragraph 3).

Line 322: …40º to the south and features lesser continuity (Fig. 9c). You should also take into account the continuity of the reflection

Reply to comment:

Text has been changed (section 5. Cross-dip analysis paragraph 4).

Line 356: High resolution seismic profiles….

Reply to comment:

Text has been changed (section 6. Discussion)

Lines 435: Unconformities are identified in vertical incidence data when the reflections they truncate are visible???. In my opinion it is more likely that chn1 responds to lithological variations inside the Opemisca Group.

Reply to comment:

Text has been changed (section 6.2.1. Seismic interpretation along the north profile, paragraph 2): "correspond to internal structure such as an unconformity or small fault that is part of the Waconichi Tectonic Zone or lithological variations inside the Opémisca Group".

Lines 436: This interpretation of chn2 is incomplete. What is the structure of the Opemisca Group there? Why doesn't it respond to another change in lithology?

Reply to comment:

Text has been changed (section 6.2.1. Seismic interpretation along the north profile, paragraph 2):

Text has been changed: “Similar to reflection chn1, Reflection chn2 (Fig. 5, Table 3) correlates with local structure, i.e., small fault or mafic/ultramafic lithology in outcrops of Opémisca Group rocks.

Line 443 and fw: Rewrite, as there are articles missing. For instance:

The CDMO analysis around reflections chn3 (Fig. 8) would suggest a 0°-10° strike towards the east (Fig. 8c and 8d, Table 3). Furthermore, these reflections became weakly imaged assuming a CDMO toward the west (Fig. 8a 445 and 8b) or toward the east at dips greater than 10° (Fig. 8e and 8f). Finally, the CDMO analysis also indicates an eastward apparent dip for other upper crustal reflection packages of the north profile (chn1 and chn2, Table 3).

Reply to comment:

Text has been changed to follow this comment (section 6.2.1. Seismic interpretation along the north profile, paragraph 3).

Line 456:……provided insights….

Reply to comment:

Text has been changed (section 6.2.1. Seismic interpretation along the north profile, paragraph 5)

Linbe 457:…..they are potentially relevant….

Reply to comment:

Text has been changed (section 6.2.1. Seismic interpretation along the north profile, paragraph 5)

Line 456-480: You need to rewrite that part as you merely do a description, but not a discussion. So discuss, e.g., why CDMO should help in imaging diffractions given the geometry of the waves in the latter. Also, you can discuss what you think they represent. As it is now, there is no discussion in there.

Reply to comment:

Text has been changed to follow this comment (section 6.2.1. Seismic interpretation along the north profile, paragraphs 5-9).

Line 524-525: This is a really interesting problem. But there should be ways to address it. The south profile is oblique to the fault at the cross-point so in Figure 9c you are imaging an apparent dip. But apart from knowing the angle between the profile and the fault at that point, you also know that real dips are higher than apparent dips. So probably the best image of the fault is that where its reflection looks shorter and steeper. This should help you to provide the real geometry associated to that feature. Moreover, addressing your preferred image of the fault in figure 9 is part of what a discussion should be, instead of just saying that the fault has a complex geometry (something that is not clear from the map, as it looks subvertical and simple).

Reply to comment:

Text has been changed to follow this comment (6.2.2 Seismic interpretation along the south profile

, paragraphs 2-3).

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Lines 531: What is the dip of rocks at the surface??? This implies again the need of a geological map with layer dips and a cross-section.

Reply to comment:

Now, fold axis for all the folds known in the study area are shown in Figure 1

Line 536: If interpreted as a fault, reflection chs4 most likely correlates to the Doda fault?. But Doda fault projects at CDP 100 and these reflections project outside the profile! Even if dip changes and the fault becomes subvertical, you are imaging things at 2 km in the migrated section and nothing at the surface where the Doda Fault projects. It seems unlikely that chs4 represents that fault. Finally, at the cross-point with the Doda Fault, the profile is oblique, so you are seeing apparent dips. Does Figure 9 provide better insights about this fault? This should be better discussed.

Reply to comment:

Text has been changed regarding this comment (6.2.2 Seismic interpretation along the south profile

, paragraphs 5).

Line 541: Those reflections are not subhorizontal. They have opposite dips and suggest a syncline structure.

Reply to comment:

Text has been edited (6.2.2 Seismic interpretation along the south profile, paragraphs 6).

Lines 557-558:…. joint complex structure of the Guercheville fault as well as the Doda fault in the south are all imaged within the greenstone belt rocks of the upper….

Reply to comment:

Text has been edited (section 6.3 Potential for exploration of orogenic gold).

Line 559:…deep reflections: chn5 and chn6…..Do not mix reflectors and reflections.

Reply to comment:

Text has been edited (section 6.3 Potential for exploration of orogenic gold).

Conclusions: I don't see the Doda Fault anywhere in the seismic section. It projects around CDP 100 in the seismic profile and there, the strongest reflectivity is at 2-3 km. You need to discuss that in the discussion part, but it is not a clear conclusion with the present discussion.

Reply to comment:

Text has been changed regarding this comment. As we explained above the strike of the Doda fault has been edited on the map (Figure 1). We discussed the association of reflection chs4 to the Doda fault in text (6.2.2 Seismic interpretation along the south profile, paragraphs 5).

Table 2: Is it necessary to be that specific in step 6? Is not enough to say V2t?

Table 2 has been edited regarding this comment.

Does the time to depth conversion use velocities higher than migration velocities? Explain or change

Reply to comment:

Our bad to forget update Table 2 regarding our processing flow. The migration velocity is 5500 at surface (0 s) (based on first arrival velocities) and 6200 at 4 s (crustal velocity). Table 2 has been edited. Figures 5-6 are updated regarding migration velocity and then the sections are time-to-depth converted.

Figure 1: Geological map should have dips. Furthermore, a cross section along the profile should be presented. I'm sure there are has been plenty of structural geologists working on that.

Reply to comment:

Figure 1 has been edited to present axis of major anticlines and synclines. Presenting the geological sections is beyond the scope of our study. We explained above that some of the co-authors of our paper have been published articles recently which includes geological sections, tectonic studies, kinematic of faults.

Figure 4: Caption-……..shot and CDP locations are also……

Caption has been edited.

Figure 5, 6 etc: Add N and S in the edges of the profile. Although the reader can figure out the dip of reflections, it is faster to indicate the orientation in the profile itself.

Figures are updated to present N and S