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Interactive comment on "Mapping the fracture network in the Lilstock pavement, Bristol Channel, UK: manual versus automatic" *by* Christopher Weismüller et al.

Christopher Weismüller et al.

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We thank William Dunne for the detailed and very constructive comments on the manuscript.

A major point of his comments is that the document needs to achieve a stronger alignment of its actual text with its purpose of comparing the manual and automatic methods, because the comparison is not sufficiently developed. We agree and carefully revised the manuscript to better develop this point throughout the whole narrative, particularly in the sections comparing the two methods.

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Further key matters that needed to be addressed are the following ones:

(1) actual presentation of data related to time required to perform each method.

Reply: In the revised version of the manuscript, we extended the narrative at several points to compare the different times required for both methods, discuss different parameters that influence the required time and provide estimates to map the complete outcrop using both techniques.

(2) a more effective utilization of fracture intensity (P21 in this case) as a discriminator of quality and/or match between the two data sets, including a careful explanation and use of the attributes that compose P21

Reply: We revised and extended the sections presenting and discussing P21. We now provide more details on the method itself, explain the attributes composing P21, how it can be applied to our dataset and what the results indicate with respect to the different methods. We have added an additional figure to show the differences of P21 for both methods and discuss them in detail. To further back the P21 analysis, we also included a preceding section where we introduce and discuss P20 (fracture trace densities) with additional figures as preceding section to the P21 section. Overall, we provide a more detailed explanation on the Pij system and compare and analyze the results of P20 and P21 with respect to the different methods and the structure of the data of fracture trace segments.

(3) avoid two unsupported interpretations in the Discussion;

Reply: We removed any unsupported interpretations throughout the manuscript and provided further explanations and citations for interpretations that are supported but were lacking the necessary arguments in the previous version of the manuscript.

(4) rebuild the Conclusions so that they are actually about the purpose of the manuscript and highlight key outcomes related to that purpose.

Reply: We revised the conclusions and added a short introduction to recap our work.

The bullet points were extended and rearranged, to first evaluate the raw data, then compare the aspect of time required for both methods followed by the differences and similarities (P20, P21) and pros and cons of both methods. Once the main key findings with respect to the different methods are addressed, more general points are listed that highlight the particular findings for the particular fracture network throughout the domains.

Detailed comments on the individual points raised by the reviewer are provided below.

Major Comments:

Section 3.2, Line 150 and elsewhere in the text - Repeatedly and with good reason, the point is made that the manual tracing of the fractures in the digital maps is very time consuming and limits a researcher's ability to effectively utilize the large data sets that can now be created through tools such as UAVs and digital imaging equipment, so the development of effective automatic characterizing protocols will greatly enhance the amount and quality of information for analysis by researchers. Yet, the manuscript does not offer any data to justify this statement. For example, stating the amount of time needed to create each of the five manual samples vs. the five digital samples should be simple and effective. Further, then a comment/short narrative could be added into the discussion about the amount of time that would be needed to characterize the entire "bench" automatically and how, for such a modest amount of time, one would have a much richer data set to tackle..... Consequently, the manuscript should be revised to explicitly document the difference in time usage between the two methods, and then should consider the implications of having the quicker, more powerful automatic approach in the discussion.

Reply: We agree that these points are very interesting for the reader. Therefore, we added a narrative in the methods parts explaining the required time under different aspects for each of the two methods in detail, incorporating the tracing itself and the time required for the removal of artifacts. Further points were added in the discussion giving

an estimate what time would be required to trace the whole dataset using either technique and discuss advantages and disadvantages of both methods with respect to the required time in different scenarios. Also, we have added a short explanation to highlight the pros and cons for someone who has never done fracture tracing following the suggestion of the other reviewer. Following the revisions throughout the manuscript, we revised the conclusions accordingly to better present the most important findings with respect to the time required using both methods.

Line 156 - It is very important to explicitly state that the manual data set is derived the digital imagery and was not collected in the field (Correct?). This point in the text is a good place to present this point clearly.

Reply: We agree and now state explicitly, that the data was derived from the digital imagery and that we used ArcGIS as requested by the other reviewer.

Lines 224 to 225, Fig. 4, and S1-P21 difference illustration - This comparison of fracture intensity between the manual and automatic data gathering approaches is presented as being a primary tool for relating the information and quality from the two data sets. Yet, this comparison is significantly underexplained. For example: (1) Why is a P21 comparison such an effective choice for comparing the two data sets? (2) Just how good is the match, particularly as nothing is said to explain and/or characterize the difference illustration in the S1 illustration? (3) Why is no basic explanation provided of what a reader is seeing in Fig. 4, such as the use of meter-square sample areas, or consideration of the sensitivity from P21 varying spatially from 0 to 18 m-1? (4) Why the lack of an actual narrative comparing the two sets of imagery qualitatively, particularly if locations exist where the match is poor and that needs explanation to, for example, show the overall strength of the approach?

Reply: We agree that the narrative was underdeveloped int the section and revised it carefully. Besides P21 we now also provide examples of P20. Both are now properly introduced along with explanations why we use them and what their results tell us about

the network. Explanations and examples are added for the new and existing figures to back the narrative and make it more comprehensive for the readers.

Lines 226 to 227 - An expectation is presented that a larger number of traces would generate a greater fracture intensity (P21) than a smaller number of traces. This expectation is not well rooted. Intensity P21 is a function of total trace length in a sample area, and that is a function of both the number of fracture traces AND their individual lengths (the authors show an understanding of this point in Lines 234/235, but have not utilized that understanding here). So, a fracture population with more traces may, in fact, be less intense because its traces are individually shorter than the other population with fewer but longer traces. Therefore, any expectation of differences in P21 between the two fracture trace populations would need to consider both the number of traces and some aggregate representation of the population of lengths, such as the mean length. Further, if the number of traces is thought to be the key parameter, a much more detailed presentation about the total number of traces in each sample window for each of the two sampling procedures is needed. Overall, the underlying logic of this comparison needs to be better developed and then more completely explained, if utilized.

Reply: We agree that our reasoning in the old version of the manuscript was not well presented one extended and clarified the statements, along with a more detailed narrative, additional figures and an extended Table 1. Besides P21 we now also provide examples of P20 (see the reply to the prior comment) to compare the different numbers of traces generated by both methods in the sample windows for a better comparison of the trace segments as they result from both methods. We now explain that we use P21 to compare the trace lengths present in the sample areas, which allows us to better compare the different traces generated by both methods with respect to their lengths representing the fractures, giving us better control over the interpretation of the results of both methods. This topic is now addressed within a whole sub-section to provide better and more extensive explanations on how we utilize Pij and P21 in that particular

section, and how we use it to compare the different methods.

Line 367 - Given that the discussion covers "classification into fracture generations" and "network analysis", it is not at all clear why "Passchier et al. (XXXX)" needs to be cited, particularly as it is a very shaky citation with no status or occurrence in the references.

Reply: In Passchier et al. (in prep.) we introduce the initial interpretations of the generations on a larger scale of the outcrop, which helped to identify the criteria on which we base our interpretation of the generations in this manuscript. However, the criteria we used and present in this work are self-sustained, explained in detail in section 3.4 and do not require the citation of Passchier et al. (in prep). We now refer to this citation as a companion paper only once and earlier in the manuscript and rewrote the narrative to clarify, that the interpretation of the generations is based on the criteria explained in this manuscript.

Sinuosity values vary so little from one sample window to another and with respect to the sequence of fracture development in the sample window patterns, would it not be better to eliminate all description/discussion of sinuosity from the manuscript, so as to simplify and focus it?

Reply: We agree that the differences of sinuosity, spatially or between the methods, are minor and not significant, thus, we eliminated sinuosity from the manuscript entirely, because it does not add valuable information.

Lines 411 to 413 - An important comparison of difference is made in this sentence, Yet, no evidence or citation from other work is provided to support that this comparison is correct. So, the statement is an unsupported speculation and really needs to be better than that for the purposes of this manuscript.

Reply: We infer that the automatic code at this stage represents a good option for creating an initial fracture trace map that only differs from a manual interpretation to a

degree that is comparable to the deviation of two manual interpretations of the same fracture network. This assumption is backed by e.g. Long et al. (2018), who compared different manual interpretations of fracture networks and is now cited in the revised version of the manuscript. The sentence was revised for clarity and a citation added to support our point.

Lines 419 to 421 - Here is another key point that is incompletely developed and explained. Particular examples of "human bias" should be identified with explanation. Then the highlighted text can be eliminated and replaced with text that has greater meaning and clarity. Further, the replacement text will need to be a few sentences rather than just one sentence, given the importance of this point.

Reply: We agree that is an important point. We extended the section and added an additional figure to provide several particular examples and more detailed explanations discussing human bias, e.g. several examples of non-unique interpretations to aid the narrative in the new section. The highlighted text was replaced by a more elaborate section.

Line 516 and Conclusions - Given the title of the manuscript and the setup of the abstract and introduction, these conclusions show a surprising lack of content related to comparing manual and automatic methodologies. The conclusion should be reorganized to begin with comparison outcomes (e.g., time usage, P21 comparison, managing manual input into automatic interpretation by parameter selection, etc.). It should delete any text related to superiority of manual to automatic unless a substantial addition is made to the manuscript about that matter. Then it can list particular outcomes for the samples of this particular fracture pattern in this particular location and geological setting, which are not the central focus of the contribution of the manuscript.

Reply: We have added a short introduction to the conclusion to recap our work presented in the manuscript. To account for this comment, we have also revised the bullet points. Former point 3 was reformulated and point 5 deleted. The bullet points were

extended and rearranged, to first evaluate the raw data, then compare the aspect of time required for both methods followed by the differences and similarities (P20, P21) and pros and cons of both methods. Once the main key findings with respect to the different methods are addressed, more general points are listed that highlight the particular findings for the particular fracture network throughout the domains. Throughout the conclusions we do avoid any text related to superiority of manual to automatic trace extraction that is not discussed in detail during the manuscript as advised.

Lines 423 to 425 - Again, examples with identification in figures are needed to support and document this point.

Reply: See comment to lines 419-421: We revised and supplemented this section by the addition of another figure to give more detailed examples and for a better documentation of the narrative.

Comments: Line 21 - As this paper has a focus on methodology, the abstract should briefly present an explanation here as to why automatic assignment of fractures into generations cannot yet be done.

Reply: We agree and added an explanation to the abstract to briefly explain the differences of the methods causing this circumstance.

Lines 31-32 - The fracture geometries are set and not "evolving" so the explanation for the connectivity increase needs to be replaced/improved.

Reply: We revised the sentence to clarify, that each domain has slightly different fracture network characteristics and greater connectivity occurs where the development of later, shorter fractures has been distorted less by the abundance of pre-existing, longer fractures as observed in our data.

Lines 51 to 53 - This sentence should be moved to the end of this section (Line 59), so that this paper's purpose and approach is stated completely first.

Reply: We moved the sentence accordingly.

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Line 52 - What is the status of this companion paper (it is not in the reference list)? Can it be cited or does reference need to be made an unpublished source? Or?

Reply: In Passchier et al. (in prep.) we introduce the initial interpretations of the generations on a larger scale of the outcrop, which helped to identify the criteria on which we base our interpretation of the generations in this manuscript. However, the criteria we used and present in this work are self-sustained, explained in detail in section 3.4 and do not require the citation of Passchier et al. (in prep). We now refer to this citation as a companion paper only once and earlier in the manuscript and rewrote the narrative to clarify, that the interpretation of the generations is based on the criteria explained in this manuscript.

Line 84 - Joints and not jointing are unfilled. Reply: We replaced “jointing” with “joints”.

Line 104 - "v" - The significance of the radial pattern to the NE is not provided, so this text is superfluous to the later part of this point. If the radial pattern has significance, it should probably be a separate "vi".

Reply: We assigned the radial pattern to an own bullet point, because the results highlight its significant impact on the fracture network connectivity. The position of the pattern we refer to in the domains and the bench is now clarified by referring to our domains NE1 and NE2.

Lines 132 to 140 - Text revised to create a narrative that more contrast imagery results for flight altitudes of 100m or 10m vs. 25m, including the removal of the green highlighted text.

Reply: All suggested revisions were implemented.

Lines 133 to 137 - This highlighted text as written breaks up the narrative flow. It should likely be added to the end of the text on Line 127.

Reply: We moved the text accordingly.

Lines 145 to 148 - This text should be moved up to the end of Line 127 to complete the general description of methodology. Thus, the subsection will finish with the determination of the optimal flight height and the creation of the overview.

Reply: We moved the text accordingly.

Line 154 and elsewhere in the text - Please remember that "this" and "these" are neither pronouns or nouns.

Reply: We reviewed the manuscript and corrected this mistake throughout the whole text.

Line 172 - The intensity belongs to the product, the fractures, and not to the process in this case (clearly, fracturing can be intense, but that is not the intended meaning here, as the description is of a "final fracture population".).

Reply: We agree and replaced “fracturing” with “fracture” for clarity.

Line 201 - Again, can this contribution actually be cited? What is its status? If it does not have an accepted or published status, what can be used as a citation in its place?

Reply: In Passchier et al. (in prep.) we introduce the initial interpretations of the generations on a larger scale of the outcrop, which helped to identify the criteria on which we base our interpretation of the generations in this manuscript. However, the criteria we used and present in this work are self-sustained, explained in detail in section 3.4 and do not require the citation of Passchier et al. (in prep). We now refer to this citation as a companion paper only once and earlier in the manuscript and rewrote the narrative to clarify, that the interpretation of the generations is based on the criteria explained in this manuscript.

Line 214 - Again, can this contribution actually be cited? What is its status? If it does not have an accepted or published status, what can be used as a citation in its place?

Reply: In Passchier et al. (in prep.) we introduce the initial interpretations of the gener-

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ations on a larger scale of the outcrop, which helped to identify the criteria on which we base our interpretation of the generations in this manuscript. However, the criteria we used and present in this work are self-sustained, explained in detail in section 3.4 and do not require the citation of Passchier et al. (in prep). We now refer to this citation as a companion paper only once and earlier in the manuscript and rewrote the narrative to clarify, that the interpretation of the generations is based on the criteria explained in this manuscript.

Line 222, Section 4.1 - This section would benefit from a revised title and the addition of two subsection headings to facilitate reader understanding: (1) The entire section is about P21 so change the title to be explicit about trace intensities rather than just traces. (2) 4.1.1 Intensity comparison between two methods (3) 4.1.2 Characterization of intensities for automated data - these two subsection titles clearly separate the purposes of these two portions of the text.

Reply: We agree that the section required a revision and rewrote the text to more clearly compare both methods and took special care to avoid possible confusion of which method we are referring to respectively. Since we also added an analysis using P20 the manuscript, the new sections were titled as follows: 4.1 “Fracture trace segments”, in which we discuss general statistics of the segments created by both methods along with a new figure as suggested by the other reviewer. The new subsections are titled 4.1.1 “Fracture trace segment densities“, which compares P20 for both methods, 4.1.2 “Fracture trace segment intensities”, which compares P21 for both methods was revised to better explain P21 as suggested in an earlier comment. Previously also included in 4.1 were the results of the network topology analysis of the automatic traces. They are now separated more clearly from the previous comparisons in a new section 4.2, that precedes the manual interpretation and network analyses.

Line 224 - Not everyone knows P21, so here is a good location to simply and explicitly define the term. Note: P21 tends to be our best available measure of fracture abundance for natural rock outcrops and does have wide usage, but it is not universally

known.

Reply: We revised the complete section (see replies to earlier comments) and now properly introduce the Pij system, in particular P21 and P20 to the readers along with more detailed explanations of why and how we use both to compare the segments of both tracing/extraction methods.

Lines 227 to 231 - If this text is meant to explain why the P21 intensity for the automatically collected data as compared to the manually collected data, it does not achieve that outcome. What is this text attempting to say? It is not clear?

Reply: This text was supposed to explain that the automatic trace extraction is expected to result in a larger number of segments, because fracture traces are segmented at intersections, while a manual interpreter traces complete fractures from tip to tip. We revised the sentences for claritiy and moved them out of the P21 section into the section providing more general differences of the networks resulting from the different methods to avoid confusion (also due to the restructuring of section 4.1). More clear comparisons of P21 are now provided in the new section, along with a new figure (previous supplement) to further help the narrative and better compare both methods of fracture trace mapping, also with an extended table 1.

Lines 231 to 233 - This sentence is not about the P21 comparison between manual and automate, but rather a description of the differences in P21 for the automated data set. It should be the first sentence of the next paragraph, which is about spatial variations in P21 for the automated data sets.

Reply: We have revised and restructured section 4.1 according to an earlier comment. This sentence belongs to the paragraph dealing with the P21 analyses, which are primarily used to compare both methods. The sentence commented on is separated out at the end of the paragraph to avoid confusion with the comparisons between the methods, because it describes differences in domains and not between methods. It now serves as connection to the following section which discusses the spatial variation

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within the domains.

Lines 239 to 241 - The description of maximum length needs to allow for censoring by the sample window perimeters. The identified maximum lengths cannot be stated to be the actual maximum length of any trace that is sampled in a window because of censoring. Now, it is possible to consider the maximum length of traces that are fully contained in a sample window, but that needs to be stated explicitly.

Reply: We agree, this is correct. We added sentence to clarify that maximum lengths may be censored by the sampling windows. This point is also examined later in the manuscript in the discussion chapter.

Line 254 and Figure "18" - To preserve order of figure citation, Figure 18 should become Figure 8, and Figures 8 to 17 should be renumbered.

Reply: We have added several new figures to the manuscript and updated the numbering accordingly. The figure referred to in this comment is presented earlier as suggested in the revised version of the manuscript.

Line 259 and new Figure 9 (old Figure 8) - This figure illustrates length-weight fracture trace abundance as a function of orientation, so it does not show "fracture strike" in any simple manner. The text is revised in this line to better describe what is being illustrated.

Reply: We agree and implemented the suggested revisions.

Lines 264 to 265 - This sentence is an interpretation of observations before the observations are fully presented, so it is out of place and should be deleted.

Reply: We agree and deleted the sentence.

Lines 265 to 266 - Redundant and unneeded sentence

Reply: We agree and deleted the sentence.

Line 281 - How are these "denser clusters" recognized or statistically defined? A reader must be able to use the criterion/criteria to identify the clusters themselves. If reproducible methodology does not exist, the statement about orientations modes for clusters should be deleted.

Reply: Our statement was based on a qualitative visual interpretation of the plot of fracture length vs orientation. We agree that this is not a good foundation to describe the distribution of gen. 5 and therefore deleted the sentence.

Line 288 and Line 289 - text revised in these two locations to more completely and correctly describe the pattern characteristic of the fractures in the NE1 sample window, and in the NE windows vs. the SW windows, respectively.

Reply: We agree and implemented the suggested revisions.

Line 289 - text revised to more simply and clearly describe the lack of a relative age relationship.

Reply: We agree and implemented the suggested revisions.

Lines 291 to 293 - Sentence revised to more clearly identify and state differences with citation of Table 4 being placed in the parentheses at the end of the sentence to not distract from sentence meaning.

Reply: We agree and implemented the suggested revisions.

Line 301 - Adding the word "evolution" to this sentence is important for clarity and meaning. Throughout the text – “mapping boundary” should be “map boundary”

Reply: We agree and added “Evolution” to the sentence and. We replaced “mapping boundary” with “map boundary” throughout the manuscript.

Lines 369 to 370 - Are these two sentences needed here? Their contents are not used immediately. Their content should be added where it is needed further into the document.

Reply: We agree and deleted the sentences at this part of the manuscript. References to Table 10 and the figure are placed at another position where they better complement the narrative further into the document.

Lined 373 - Cite published work that supports the lack of sampling bias and similarity of results for exposure of this quality for different operators. Solid Earth has a publication about this matter, for example.

Reply: Citations on this topic were already provided earlier in the manuscript. To better back our narrative in the lines commented on, we have also added the citations at this place.

Line 382 - "excessive" requires some more explanation and/or examples to assist reader comprehension

Reply: We added an explanation with examples to assist reader comprehension on the topic in the following line. Even more details on the topic are now discussed in the manuscript supported by an additional figure in chapter 5.2.

Lines 388 to 395 - Not convinced that this discussion of the comparison of P21 between the manually and automatically acquired datasets is particularly useful because it considers number of traces separately from the distribution of tracelengths, which is somewhat arbitrary.

Reply: In the revised version of the manuscript we now present P20 earlier in the manuscript to also consider segment density (number of traces/unit area) and provide a direct comparison of the numbers of traces in the revised Table 1. However, in the box-counting method for P21, the box considers the length of cut segments per unit area independently from the number of segments (graph edges) and the manually traced fractures have been pre-processed earlier to resemble the same data structure as the automatically traces ones. Therefore, we deem this to be a valid comparison. To avoid confusion, this is now clearly stated earlier in the manuscript.

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Lines 411 to 413 - An important comparison of difference is made in this sentence, Yet, no evidence or citation from other work is provided to support that this comparison is correct. So, the statement is an unsupported speculation and really needs to be better than that for the purposes of this manuscript.

Reply: The sentence was revised according to the other reviewer and we added citation of a work that compared manual interpretations of fracture networks to back our claim. We infer that the automatic code at this stage represents a good option for creating an initial fracture trace map that only differs from a manual interpretation to a degree that is comparable to the deviation of two manual interpretations of the same fracture network (e.g. Long et al., 2018).

Lines 426 to 438 - This paragraph needs an introductory sentence to establish its purpose and why three different characteristics are being "juxtaposed" in one paragraph. An example sentence is offered.

Reply: We implemented the example sentence as suggested.

Lines 452 to 453 - This one sentence paragraph is not really needed as written. A clause is added to the opening sentence about generation 5 to preserve overall narrative flow.

Reply: We agree and implemented the revisions as suggested.

Line 460 to 461 - Text revised and added, so as to achieve greater clarity with a more complete and needed explanation for readers.

Reply: We agree and implemented the revisions as suggested.

Line 464 to 466 - Text revised to more clearly explain situation and to more simply state examples of possible causes.

Reply: We agree and implemented the revisions as suggested.

Lines 467 to 473 - Recommend the elimination of this text because sinuosity is not a

distinguishing characteristic for this study.

Reply: We agree, the text commented on and the whole aspect of sinuosity was eliminated from the manuscript as suggested in an earlier comment.

Lines 504 to 505 - Interpretation is non-unique and unsupported, so it should not be included in the manuscript.

Reply: We agree that this is indeed an unsupported statement and deleted the interpretation from the manuscript.

Please see the annotated PDFs for the main text and figures for additional detailed comments about the syntax.

Reply: We would like to thank the reviewer William Dunne for the detailed remarks on the syntax provided in the annotated PDF, we have corrected the syntax accordingly to the comments and suggested revisions provided therein.

Captions: Figure 1 – Lines 724-725 states “The study areas on “the bench” that are mapped in detail are marked in 725 red.” Yet, the only red in the illustration are the red lines for faults. Is the color incorrectly identified or is something missing from this illustration?

Reply: The figure was revised prior to the version presented in the manuscript and the change of the captions was lost. We corrected the caption to state that the map domains are marked as the yellow (not red) squares in the figure.

Figure 2 - Line 731 - the object in 2a to 2e should be identified in the caption. Also, 2a to 2f should have scale bars even if they are approximate.

Reply: We added a reference to the persons in the images and scale bars for the images on the left.

Figure 4 - Line 737 - Please note suggested addition to the text at the end of the caption.

Reply: We implemented the suggested addition in the caption.

Figure 7 - the labels for the X and Y axes of the three sets of graphs should be larger, so that they are easier to read when viewing the entire figure.

Reply: We enlarged all labels on the axes for a better readability.

Figure 9 (10) caption improved by explicitly identifying that data belong to manually collected set and providing a better description of the rose diagrams.

Reply: We implemented the suggested revisions of the caption.

Figure 10 (11) Caption - Revise to match revised Figure 9 (10) caption. Eliminate the addition sentence because the network cannot be described as being "oriented NW-SE". The pattern for NE2 can be described as having a strong length-weighted orientation mode that trends NW-SE, but even that information is likely not needed in the caption here.

Reply: We revised the caption match the one of the associated figure, the numbering of the figures was updated to match the new order (now figures 14 and 16). In the second part of the caption, we were not referring to the orientation of the actual network, but the map domains themselves. We have revised the caption for clarity.

Figure 11 (12) - the key at the bottom of the figure should use larger dots so that the colors are easy for readers to distinguish. While these solid circles will be much larger than the actual ones in the plot, that is not an issue because assigning the colors easily to the generations for the readers is the goal.

Reply: We agree and enlarged the dots in the key of the figure.

Figure 13 (14) caption - make the change in the first sentence of the caption for Figures 14(15), 15(16), 16(17), and 17(18).

Reply: We made the suggested revisions for all mentioned figures and a remark was added for the NE domains that gen 3 fractures were not identified within these two

domains.

Tables - Orientation data in all tables - These data should be rounded off to the nearest integer. The use of two significant figures to the right of the decimal point is false precision, particularly for the manually traced lines.

Reply: We agree and rounded the orientation data in all tables off to the nearest integer.

Table 1 – Title expanded to explicitly identify that the characteristics stated in the table related to the automatically generated fracture network

Reply: We have added the characteristics of the manual interpretation to the table to provide a more direct comparison. The title of the table was revised according to the comment and the new content.

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