Dear Dr. Maria Mutti, Dr. Federico Rossetti and reviewers:

Thank you very much for your constructive advices on my manuscript **SE-2021-85** (**Structural diagenesis in ultra-deep tight sandstones in Kuqa depression, Tarim Basin, China**) submitted to your journal "**Solid Earth**".

We have carefully revised the manuscript considering the remarks made by the two reviewers and the editors, and would like to re-submit it for your consideration. We have addressed the comments raised by the reviewers, and the amendments are highlighted in red or blue in the revised manuscript. We are indebted to you and the two anonymous reviewers for your constructive comments, which improve the manuscript significantly.

We also download some papers recently published in **Solid Earth**, and revised the references format carefully. Further some papers published recently in your journal have been cited in the revised manuscript (highlighted in blue in the references lists).

The point by point responses to the two reviewers' and Editor's comments are listed below.

Below, the original comments are in black, and our responses are in blue.

1. Comments of Editor

Dear Authors,

When posting your author comments (ACs), you can choose between new comments or co-listing of existing ones. Please also consider replying to community comments (CCs) from the scientific community.

Reply:

Thank you for your constructive comments.

You - as the contact author - are requested to individually respond to all referee comments (RCs) by posting final author comments (ACs) on behalf of all co-authors no later than 27 Dec 2021 (final response phase). We have provided detailed responses to the two reviewer's comments and revised the manuscript according to the reviewer's comments.

Thank you for handling my manuscript and tireless works.

Reviewer #1: Sven Maerz, 07 Nov 2021,

This publication adresses the role of fractures in influencing porosity and permeability development and distribution by tectonically-induced diagenetic modification of the Lower Cretaceous Bashijiqike Formation in the Kuqa depression, Tarim Basin, China. The relationship between fracture generation and diagenetic alteration of pore space by dissolution and/or cementation has been analyzed by using different methodological approaches such as thin section and SEM observations, numerous well logs, and image logging.

Reply:

Dear Dr. Maerz,

Thank you for your constructive comments.

1. However, the study only covers the mechanism of pore system alteration by fracture-induced diagenesis, but misses a comprehensive debate about the paragenetic diagenetic history of the studied rocks. This is critical, since it gives the impression that fracture generation is the only mechanism amplifying the diagenetic alteration of pore space and thus enhancing or decreasing petrophysical properties. However, even if fracture-induced diagenesis is the main diagenetic mechanism presented in this study, its processes and products are explained insufficiently. This is mirrored in "Chapter 4.5: Dissolution and cementation along the fracture surface".

Reply:

Thank you for your constructive comments.

We are sorry for this misunderstanding. Actually, this study only briefly describes the diagenesis type and degree, and the paragenetic diagenetic history of the studied rocks is also briefly mentioned. However, the diagenesis modifications, diagenetic evolution and porosity evolution histories are discussed in detailed in our previous studies Lai et al., 2017a (Lai J., Wang G., Chai Y., Xin Y., Wu Q., Zhang X., and Sun Y. 2017a. Deep burial diagenesis and reservoir quality evolution of high-temperature, high-pressure sandstones: Examples from Lower Cretaceous Bashijiqike Formation in Keshen area, Kuqa depression, Tarim basin of China. AAPG Bulletin, 101(6): 829–862).

Lai et al. (2017a) has discussed the diagenesis, diagenetic minerals as well as diagenetic evolution of the Bashijiqike Formation of Kuqa depression, and now it has got a total of 95 Google Scholar citations, and has been selected as an ESI highly cited paper.

Therefore in order to avoid repetition and redundancy, the diagenesis type and degree, and the paragenetic diagenetic history of the studied rocks are also briefly mentioned. However, in order to avoid this misunderstanding, we have added a sentence in the manuscript (Section 4.2 and 4.3) that for the paragenetic diagenetic history of the studied rocks, please refer to our previous studies (Lai et al., 2017a). Thank you for your consideration.

Thank you for your constructive comments.

2. Again, it is recommened to take into account all stages and mechanisms of diagenetic modification during pore system evolution in order to demonstrate that no other mechanisms other than fracture-generation is the main trigger for pore system alteration. Although the authors do mention different types of cements (i.e., calcite, dolomite, quartz, clay minerals) in the text, they do not deliver a detailed explanation about the origin of these cements. It would be interesting to know to which extent and volume fracture-induced cementation contributes to the total extent and volume of cementation, and if fracture-induced diagenesis is present only locally or if it is present throughout the entire formation. This is of highest importance, since according to the authors, the aim of this study is to better understand the structural and diagenetic processes, and to reduce the uncertainty for reservoir quality prediction of the Bashijiqike Formation (as written in "Chapter 1: Introduction") ".

Reply:

Thank you for your constructive comments.

We are sorry for this misunderstanding again.

All stages and mechanisms of diagenetic modification during pore system evolution as well as the origin of these cements are also described in our previous studies Lai et al., 2017a.

As you can see from Figure 18 and other figures, the fracture-induced diagenesis is present only locally or if it is present throughout the entire formation.

In order to avoid this misunderstanding, we have added a sentence in the manuscript (In Section Introduction) for dominance of fracture-induced diagenesis in the whole formation, however, the impact of diagenesis and diagenetic minerals on reservoir quality are described in our previous studies (Lai et al., 2017a).

The impact of diagenesis and diagenetic minerals on reservoir quality are well described (Lai et al., 2017a), while little is known about the fracture-induced diagenesis, which is present throughout the entire Bashijiqike formation.

Thank you for your consideration.

Thank you for your constructive comments.

3. Since the main focus of this study is the structural diagenesis of the Bashijiqike Formation, all diagenetic processes and its product should be better constrained to highlight the possible importance and dominance of fracture-induced diagenesis. This could have been included/integrated in "Chapter 5: Discussion". Usually, in this chapter, the methods applied, the concepts and new findings are critically discussed

and compared to previous studies. Unfortunately, in this manuscript, most of the discussion is a repetion of findings already presented in "Chapter 4: Results" and a summary of the findings in respect to other wells. "Chapter 5: Discussion" needs therefore to be highly improved. It is also not clear how this study may contribute to previous work in the study area, and if it can be applied in other (analogous) settings.

Reply:

Thank you for your constructive comments.

In Results section, we mainly present the lithology, pore systems, type and degree of diagenesis, diagenetic minerals and their controls on porosity. Then the fractures are interpreted from core and image log interpretation, and fracture-diagenesis is discussed, and in addition the in situ stress magnitudes are calculated using well logs.

In Discussion section, we mainly discuss the impact of in situ stress on compaction, and links fracture with dissolution, and then the variations of diagenesis and fracture for various structure patterns are discussed.

About the improvements of Discussion section, we have added a sentence: In this section, we mainly discuss the impact of in situ stress on compaction, and links fracture with dissolution in single wells, and then the variations of fracture-diagenesis within various structure patterns are discussed.

The new findings include two parts, one is the integration of continuous well logs to unravel the in situ stress magnitudes in single wells, and describe the variations of compaction and presences of fracture controlled by in situ stress (Section 5.1). Then in Section 5.3, we have links the facture-diagenesis within structure patterns.

Therefore the new findings in this study con contribute to previous work in the study area due to the integration of continuous petrophysical well log data, and if it may provide implications for similar sandstones. We have added these in the Conclusion parts.

Also, in Section 5.2, we have clarified that the Fractures are mainly encountered in fine-medium grained sandstones, while the conglomerates and mudstones have rare fractures. In addition, the dissolution pores are also commonly detected in the fine-medium grained sandstones. This new findings are different from Results section.

Thank you for your constructive comments.

4. Although the manuscript is very well structured, and the figures and their captions are very good, it includes numerous typing errors and inconsistencies in spelling and punctuation which results in difficulties in reading the text.

Reply:

Thank you for your approval of the structure of our manuscript.

About the mismatching of the figure caption and text as well as typing errors and inconsistencies in spelling and punctuation, we have doubled checked through the whole manuscript to avoid these mistakes.

Also we have asked a colleague who is fluent in English to improve the English grammar.

Thank you for your constructive comments.

5. As a final comment, I would like to highlight the approach and the methods applied for the study. However, due to the very weakly constrained diagenetic history, and its processes and products, as well as the lack of a critical scientific discussion of the gained results and the high abundance of technical errors, I recommened to reconsidered this study for publication after major revision.

Reply:

Thank you for your approval of approach and the methods applied for the study.

We have revised the manuscript according to your constructive comments, and have provided detailed replies to your comments about the diagenetic modifications and paragenetic histories. The technical errors are eliminated by careful checking. The discussion is improved to improve the implications of your studies. We hope the revised manuscript can meet your approvals.

Thank you for your constructive comments.

Reviewer #2: Dr. Sara Elliott

1. This paper discusses the structural diagenetic history of the Lower Cretaceous Bashijiqike Formation within the Kuqa depression, Tarim Basin, China. The paper focuses on remnant pore types within various lithologies caused by varying degrees of compaction based on calculated horizontal stress differences, as well as mechanical fracturing and dissolution.

This paper claims to have done a comprehensive structural diagenetic study, but it appears they focused more on the structure and less on the diagenesis. Specifically, this paper lacks a thorough petrographic-diagenetic analysis, and as such lacks paragenetic sequences through time in relation to tectonics and structural events.

Reply:

Thank you for your constructive comments.

This comment is similar with the comments of reviewer's comments, and I have provided detailed responses to the comments. This study only briefly describes the diagenesis type and degree, and the paragenetic diagenetic history of the studied rocks. This is because that the diagenesis modifications, diagenetic evolution and porosity evolution histories are discussed in detailed in our previous studies Lai et al., 2017a.

Lai et al. (2017a) has discussed the diagenesis, diagenetic minerals as well as diagenetic evolution of the Bashijiqike Formation of Kuqa depression, and now it has got a total of 95 Google Scholar citations, and has been selected as an ESI highly cited paper.

Therefore in order to avoid repetition and redundancy, the diagenesis type and degree, and the paragenetic diagenetic history of the studied rocks are also briefly mentioned.

Thank you for your consideration.

Thank you for your constructive comments.

After reading I am left with numerous questions including:

2. How does lithology compare with depth, pore types, and cement composition/abundance? The authors made it clear that fracture abundance increases in areas of low horizontal stress, but does fracture abundance also change based on

lithology? Did fracturing occur throughout diagenesis, e.g. did fracturing stop before the late-stage calcite infilled primary porosity? And, therefore, when exactly did the fractures act as conductive fluid pathways? How variable is the cement fill within fractures? What are the cement morphologies and textures? When did dissolution start within the diagenetic sequence? Where did all of the diagenetic calcite originate? Does all of this calcite cementation occur after dissolution is complete, or is there also evidence of dissolution of late-stage cements? Was some other mechanism partially responsible for porosity reduction or gain besides fracturing and horizontal stresses? How does compaction, cementation, fracturing & porosity change with regard to sample structural position, e.g. anticline hinge vs limb etc.?

Reply:

Thank you for your constructive comments.

①We have added a Figure (Figure 2) to show the lithology variations with depth. In addition, the fracture abundance within various lithologies (Figure 7) is also added.

②Fracture is actually changing with lothologies, and the fine-medium grained sandstones have the highest abundance of fractures (Figure 7).

③ Fracturing actually occur throughout diagenesis (Figure 18-20). There is no doubt that the open fractures act as conductive fluid pathways, while the calcite-filled fractures have non contribution for fluid flow.

④ How variable is the cement fill within fractures? What are the cement morphologies and textures?: The variable cements are common within fractures, and the cement morphologies and textures are described in the previous studies Lai et al., 2017a, Lai et al., 2017b.

⑤ When did dissolution start within the diagenetic sequence? Where did all of the diagenetic calcite originate? Does all of this calcite cementation occur after dissolution is complete, or is there also evidence of dissolution of late-stage cements? : Dissolution can occur due to meteoric water flushing and can be caused by charging of organic-acid rich fluids. Diagenetic calcite is mainly due to the high paleo salinity. Thin section observation shows that there is no evident dissolution of late-stage cements (Lai et al., 2017a).

⑥ Was some other mechanism partially responsible for porosity reduction or gain besides fracturing and horizontal stresses? The answer to this question is that the structure patterns may also affect the fracture assemblages and then the fracture-diagenesis

⑦ The change of compaction, cementation, fracturing & porosity with regard to sample structural position, e.g. anticline hinge vs limb is already discussed in section 5.3. The structural position will affect the horizontal stress differences, and the relationships between compaction, fracturing and horizontal stress differences have been discussed in Section 5.3. We have added this sentence in Section 5.3.

Thank you for your constructive comments.

3. The answers to some of these questions may be sprinkled throughout the paper, but they should really be brought together in the discussion section to form a more comprehensive structural-diagenetic history of the study area. The authors are missing

discussion of numerous diagenetic processes and, thus, paragenetic sequences, which are essential in a structural-diagenetic study.

Reply:

Thank you for your constructive comments.

The issues (diagenetic processes and, thus, paragenetic sequences) you mentioned have been fully discussed in our previous studies Lai et al., 2017a, and we have cited these previous works. However, Lai et al., 2017a has not linked diagenesis with structure patterns, fractures and in situ stress, and in this study, we focused on the structural diagenesis analysis.

Thank you for your consideration.

Thank you for your constructive comments.

4. In section 4.2. Diagenesis type and degree: Various authigenic (diagenetic) minerals and cements are mentioned including calcite, dolomite, quartz, and clays, yet throughout the results and discussion the only cement mentioned is calcite. Therefore, it appears that there is only one diagenetic mineral obstructing porosity in these rocks, even though it's mentioned that others are present. It would be nice to have some volume numbers here for the various cements to prove that calcite is the most volumetrically important, and perhaps include some closeup images of these cements as well. What are their textures and morphologies? Cement texture can provide a lot of structural information, and various cement morphologies affect fluid flow differently.

Reply:

Thank you for your constructive comments.

We have added in the Section 4.2, and SEM images are presented to show the quartz cements and clay minerals of illite and smectite mixed layer (Fig.5I, 5J).

From the aspect of volumetric abundance, the carbonate cements are the most important, while other cements such as quartz cements and clay minerals have less impact on reservoir quality.

The quartz cements occur as small authigenic quartz crystals (Fig.5I), while the mixed-layer illite/smectite clays occur as pore filling fibrous or webby morphologies (Fig.5J).

Thank you for your consideration.

Thank you for your constructive comments.

5. COPL-CEPL: I agree that there appear to be no trends with depth regarding COPL & CEPL, but I wonder if lithology has something to do with lack of depth trends. I also wonder if all mentioned diagenetic minerals were considered cements and including in "CEM" when calculating CEPL, rather than just the calcite cement. If not, then their CEPL calculations will probably underestimate cementational porosity loss. I wonder this because nowhere do the authors discuss where the compositional data they used to calculate COPL-CEPL came from, i.e. did they point count thin sections? Use previously published numbers? Visual Estimations?

Reply:

Thank you for your constructive comments.

As can be seen from Fig.6, the COPL and CEPL show no evident relationships with burial depth, and this is attributed the complex structural diagenesis the sandstones experienced.

In addition, as we can see from the Figure 2 of the revised manuscript, the lithology has no evident variation in the vertical direction, and the lithology is mainly fine-medium grained sandstones, therefore the lithology has little effect on COPL and CEPL.

We have taken all the diagenetic minerals into consideration as cements including in "CEM" when calculating CEPL, and CEPL is true values.

All the data used in the COPL and CEPL calculation are derived from point counting, and mainly 300 points are selected per thin section.

Thank you for your constructive comments.

6. SEM data: Pg 8: Text reads "SEM (scanning electron microscope) (secondary electron image) coupled with an energy dispersive x-ray analyzer was used to detect the various types of clay minerals and recognize the micropores within clay minerals." Nowhere again throughout the paper was SEM data mentioned or shown in any way. Neither do the authors ever comment on the clay mineral compositions they supposedly detected with EDS. What were the secondary electron images used for?

Reply:

Thank you for your constructive comments.

First of all, we have added two SEM images (Figure 5 of the revised manuscript) in the study.

The energy dispersive x-ray analyzer was used but the data are not presented, and therefore we deleted the descriptions about EDS. Thank you for your consideration.

The secondary electron images are used to detect the pores and clay minerals associated with the freshly broken rock surfaces.

The SEM images are used in Section 4.2 to show the quartz and clay minerals.

Thank you for your constructive comments.

7. Miscellaneous –

7.1. It's evident to me that there are dark cement rims on many of the framework grains within these rocks (possibly iron oxide rims, but most likely clay rims from feldspar dissolution, see figure 3B & E), and not once is this discussed. Is this lithology-specific? Depth related? Are any of the open fractures lined with similar minerals? Authigenic mineral rims on framework grains often inhibit cementation into the intergranular pore space. The authors claim their rocks are mostly compaction-dominated, but perhaps their compactional porosity loss calculations are overestimated if they're ignoring some diagenetic cements.

Reply:

Thank you for your constructive comments.

In our previous studies, we actually found this type of grain-coating clay minerals (Lai et al., 2017a). Clay minerals (mixed-layer illite/smectite) thinly coating framework grains help to preserve reservoir quality by forming barriers to quartz cement nucleation (Lai et al., 2017a). Therefore we have added in the section 4.2 to show this type of clay minerals.

In the original manuscript, we have revealed the presence of this kind of clay minerals: "In addition, the pore-line grain contacts also suggest a limited degree of compaction Thank you for your constructive comments (Fig.5C)." In the revised manuscript, we further added the descriptions about the grain-coating clay minerals.

Actually, there are evident dark cement rims (mixed-layer illite/smectite) on many of the framework grains within these rocks (Fig.4B, 4E), and the presences of authigenic mineral rims on framework grains can inhibit cementation into the intergranular pore space (Lai et al., 2017a).

Thank you for your constructive comments.

7.2. Figures 4G & 4H (especially 4H) are not of high enough quality to portray the dissolution features the paper describes. Recommend taking new images or toning down the highlights/contrast as well as adding arrows to make feature recognition easier.

Reply:

Thank you for your constructive comments.

We have replaced Figure 4H (in the revised manuscript, it is Fig.5H) in the revised manuscript, and the dissolution features are evidently captured. Fig.5G is a evident moldic pores, and it is still kept in the revised manuscript. Thank you for your approval.

Thank you for your constructive comments.

7.3. Pg 6, Line 13: Text reads “Cathode Luminescence (CL) microscopy,” correct term is Cathodoluminescence (CL) microscopy.

Reply:

Thank you for your constructive comments.

We have changed the text in section 3. Data and methods.

Thank you for your constructive comments.

7.4. Pg 3, Line 13: Text reads “SEM (scanning electron microscope) (secondary electron image) coupled with..” There is no reason for ‘secondary electron image’ to be in parentheses.

Reply:

Thank you for your constructive comments.

The SEM images are actually taken by secondary electron image, and the rock freshly broken surfaces are analyzed. Please kindly see Fig.5I and 5J.

Thank you for your constructive comments.

7.5. Perhaps include a stratigraphic section of the Bashijiqike Formation to clarify lithologies vs depth?

Reply:

Thank you for your constructive comments.

We have added a Figure 2 in the revised manuscript to clarify lithologies vs depth.

Thank you for your constructive comments.

7.6. Aside from the numerous grammatical, spelling, and sentence structure errors, the paper is highly repetitive and could easily be pared down.

Reply:

Thank you for your constructive comments.

We have revised the manuscript according to your constructive comments and the comments of Reviewer 1. The technical errors are eliminated by careful checking. We have also double checked the manuscript to avoid any mistakes.

Thank you for your constructive comments.

7.7. The authors are missing discussion of previous structural diagenetic research in the area and how their contribution ties in, so there are some references I think the authors should consider:

Ukar, E. and Laubach, S.E., 2016. **Syn- and postkinematic cement textures in fractured carbonate rocks: Insights from advanced cathodoluminescence imaging**, Tectonophysics 690, Part A, 190-205, doi: 10.1016/j.tecto.2016.05.001

Wang, J., Zeng, L., Yang, X., Liu, C., Wang, K., Zhang, R., Chen, X., Qu, Y., Laubach, S.E., Wang, Q, 2021. **Fold-related fracture distribution in Neogene, Triassic, and Jurassic sandstone outcrops, northern margin of the Tarim Basin,**

China: Guides to deformation in ultradeep tight sandstone reservoirs. Lithosphere (Special 1), 8330561. https://doi.org/10.2113/2021/8330561

Baqués, V., Ukar, E., Laubach, S.E., Forstner, S.R., Fall, A., 2020. **Fracture, dissolution, and cementation events in Ordovician carbonate reservoirs, Tarim basin, NW China.** Geofluids, v. 2020, Article ID 9037429, 28 p. doi: 10.1155/2020/9037429

Ukar, E., Baqués, V., Laubach, S.E., Marrett, R., 2020. **The nature and origins of decameter-scale porosity in Ordovician carbonate rocks, Halahatang oilfield, Tarim Basin, China.** Journal of the Geological Society, 177, 1074-1091. doi:10.1144/jgs2019-156

Reply:

Thank you for your constructive comments. We have downloaded the paper your recommend and read them carefully, and cite these references in the manuscript accordingly at the appropriate places. These references are actually about the structural diagenesis and are related to our studies.

Thank you for your recommendation.

Above are the point by point responses to the two reviewers' comments.

Once again, thank you very much for your comments and suggestions which improve the manuscript significantly.

We hope that the revised manuscript is now acceptable for publication in your journal. We appreciate for Editors/Reviewers' warm work earnestly, and hope that the corrections will meet with approval.

We look forward to your information about my revised papers and thank you for your good comments.

With best wishes,

Yours sincerely,

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