Solid Earth Discussions

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Comment on se-2021-85

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Referee comment on "Structural diagenesis in ultra-deep tight sandstones in the Kuqa Depression, Tarim Basin, China" by Jin Lai et al., Solid Earth Discuss., https://doi.org/10.5194/se-2021-85-RC2, 2021

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.

After reading I am left with numerous questions including:

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.?

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.

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.

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?

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?

Miscellaneous –

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.

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.

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

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.

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

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

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