Solid Earth Discuss.,
https://doi.org/10.5194/se-2020-50-AC1, 2020

Interactive comment on "Silica diagenesis-driven fracturing in limestone: an example from the Ordovician of Central Pennsylvania" *by* Emily M. Hoyt and John N. Hooker

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Received and published: 3 July 2020

Dear Dr. Guerriero,

Thank you for your interest in our paper and providing us with such constructive criticism. We have reviewed your remarks and will implement them to substantially improve our paper. We are currently visiting the structure, grammar, and background information issues that you mention and will be applying modifications to guarantee a cohesive and thorough presentation. We would also like to briefly address your primary concerns as follows:

1. Discounting a mechanism of tectonic strain and fluid overpressure

a. Clearly, we cannot categorically exclude tectonic strains and fluid pressure as important factors in the development of the fractures we are considering. However, elsewhere in the outcrop we find the classic limestone bedding-bound arrays of fractures, which are absent in intervening shales. Such a pattern is an excellent example of a set of fractures generated in response to tectonic stretching. Critically, these fractures are present within multiple stacked limestone beds, and again, are absent in intervening shales. In contrast, the horizontal fractures are present within individual limestone beds, over distances of many tens to hundreds of meters, and completely absent in over- and under-lying limestone beds. Granted, the horizontal fractures have a different orientation, but in the end, if they are driven by tectonic strains (assisted by fluid overpressures or not) we find it difficult to explain why these fractures should be so conspicuously bound to certain limestone layers. The consistently low silica contents in these fractured beds points us to a chemical mechanism for the fractures. See also response #3 below.

2. Terminology: fracosity

a. We understand the confusion that has arisen with the introduction of this term. Therefore, we would like to clarify that the use of this term is to emphasize the difference between fracture porosity, which is not our focus in this paper, and the total volume fraction of rock comprising fracture porosity and cement, which is. Our measurement is dimensionally identical to the P22 of Dershowitz and Herda (ARMA, 1992) in that it is the dimensionless ratio of fracture-area to unit rock area. This measure was called "fracture porosity" in that study because it is analogous to porosity measured in 2D thin sections, and indeed our measurement would be exactly the same as fracture porosity except that it is not porosity, because these fractures are essentially entirely filled by cement.

b. Part of the confusion stems from our scant description of our method of pointcounting field photographs. We will be improving our description of our method used to quantify the fracturing using point quantificationâĂŤthat is, gridded point counts overlain on field photographs–to better describe our method.

c. Fracosity does differ from the conventional method of scanlines used to calculate fracture intensity, in that fracosity is a point-count-based areal measurement of the host rock that is occupied by fractures. You remind us that this measurement, like scanlines, is not necessarily equal to the true P33 (volumetric fracture porosity, including fracture cement in this case), because the observation surface may lie at some low angle to fractures. Indeed we were remiss to neglect that point, and will clarify in our upcoming revision.

d. We therefore concede that our methods were too hastily described to adequately introduce a new term, and will decide whether to abandon the new term or to more thoroughly introduce it for the final draft.

3. Horizontal and vertical jointing

a. You bring up a good point, that joints lying parallel to their host beds can be thought of as an independent system of fractures, whereas bedding-orthogonal joints can be more reasonably expected to show similar systematics across multiple beds. Indeed, that is exactly what we see in the field, and one could argue that the presence of joints in one bed simply reflects that bed's physical characteristics, or even just the vagaries of tectonic strain. However, we again note the striking inconsistency of fracture abundance among beds having only subtle mineralogic variation (i.e., they are all limestones). Moreover, the fractures in question are quite short (i.e., they have small tip-to-tip distances). If the beds in question hosted a small number of very long fractures, then we could posit that chance alone resulted in the observed variation in fracture abundance. But the large number of fractures, many of them orthogonal to bedding, stongly suggests that something about those beds has primed them to undergo fracturing, and of course the XRD evidence suggests that that something is silica

diagenesis.

4. Strain energy analysis

a. We would like to clarify that we postulated an energy-balance scenario for different cases of vertical contraction that can be considered. You question whether SF and SC are compatible within the same deforming rock system. Indeed, principally the energy comparison is likely between SC versus G and HâĂŤthe energetic cost of layer collapse versus the cost of fracturing (G) and the benefit of collapse (H). We simply wanted to mention SF for completeness, as the opening of veins entails a shape change and thus some finite energetic cost. We agree that this cost is likely negligible compared to the other terms.

b. Furthermore, in a followup comment, you suggest a more specific mechanism of vertical pinning, whereby some portion of the rock mass is prevented from collapse, producing fractures within the remaining rock mass. We find this idea to be compatible with our energy balance approach: the prohibition from vertical contraction is, in essence, a large energetic cost to vertical contraction, SC. This is a good way to describe a potential pathway for the development of the fractures, and so we will incorporate this comment into our revision.

Again, we are most grateful to Dr. Guerriero, and Reviewer #1, for your hard work and excellent suggestions. We hope that these quick responses are satisfactory for now, as we work toward incorporating the comments into our final manuscript.

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