Response to James Evans (Reviewer #2) Comments

Ref: se-2020-81

Title: Structural control on fluid flow and shallow diagenesis: Insights from calcite cementation along deformation bands in porous sandstones

Journal: Solid Earth

Major comments	
Comment	**Response author**
I fill in the specific review criteria below, after some detailed comments on the text. Overall this is a good contribution, with detailed observations of structures and cementation patterns. I suggest a slight recasting of the paper to the topic of the dbs and cementation, dropping a bit of the tectonic implications. I also have a few editorial changes that I will provide via written edits on the manuscript – sorry to go old school.	We appreciate very much the constructive comments and excellent suggestions of the reviewer that we think deeply improved the first version of our manuscript. Suggested edits have been implemented and they are tracked in the revised manuscript. Please, consider that the track-changes Word tool created some problems with line numbering and its jumping on the annotated manuscript. Line numbering of the "revised manuscript version with changes tracked" and "manuscript without tracked changes" may not coincide. The line numbering we use in this document (Author Response to Reviewer #2) refer to the revised manuscript with tracked change file. We have moved some of the main text to the Suppl. Mat. without altering the main message of the paper. This is because both reviewers asked for keeping the focus on the paper on the DBs and their control on fluid flow and diagenesis. See also responses below. Also the introduction has been rephrased, and now it is more focused on DBs and cementation.
Specific Comments	
Lines 15- 20 can be edited a bit; edits attached.	Ok suggestion taken and implemented (lines 15-19). The term "string mapping" has been kept (line 19). The field map in Loiano has been produced by building a network of strings on the outcrop surface, that was used as a reference frame for detailed mapping. We do not intend "scanline mapping".
Line 33 – Wilson and Goodwin (2006) discuss these sorts of processes, as does Parnell et al, (2004 – j sed research);	The reviewer is right. These papers address important issues regarding the hydraulic behavior of DBs and their role on diagenesis. They have been referenced later in the Introduction, when we focus on DBs, as also in the discussions. (Wilson et al. 2006: lines 90, 146, 930, 1163; Parnell et al., 2004: lines 135, 146). When you mention "Wilson and Goodwin, 2006", maybe you mean "Wilson et al., 2006". Am I right?
Lines 53 -55; Min et al., 2001, and Shipton et al., 2002 provide data on db fault permeabilities; Petrie et al, 2013 show alteration / mineralization/ cementation patterns in db faults	Shipton et al. (2002) and Petrie et al., (2014) were added as suggested by the reviewer (lines 98-99). We have a reference to Main et al. at line 143.
Lines 50-85 – could this be trimmed somewhat?	We have rephrased the introduction.

Line 170-175, Figures 3 and 4. It is a statistically stronger way to examine the data as vector data; decimating into histograms is ok, but better to determine mean vector of the poles to the dbs, with dispersion statistics.	Do you mean Figs. 1 and 2? Am I right? We thank the reviewer for his comment. We replaced the frequency histogram of DBs azimuth with azimuth frequency rose diagrams (Figs 1d and 2d). This representation is similar to the one shown in Fig.1 in Del Sole et al. (2020 – MPG). Here, the stereoplot reports the best-fit gaussian curves for each DB's population found by the software (Daisy3; Salvini, 2004) and calculated from the corresponding frequency distribution (histogram data). The values reported on the right side of the azimuth frequency rose diagrams (Figs. 1d and 2d) are the mean orientation (strike; N±90°) and the standard deviation (±sd) for each population.
186-187 – rephrase – cementation is a process, and you are describing here the distribution of zones, pods, etc., that reflect that cementation.	Ok corrected (lines 369-370).
Through the text, thee are sentences with phrases such as "more tabular", etc., but we don't always get what the more is relative to.	Ok, these sentences have been corrected. We hope the sentences are clear now. (lines 392-393 and Suppl. Mat. S1).
307-308. Figure 9 doesn't really report porosity data; the data are in Del Sole and Antonellini, 2019; and the porosity data are derived from microscopy, so it's a bit of an indirect measure.	Ok corrected (line 517). The reviewer is right, these data are in Del Sole and Antonellini (2019). We think, however, that this has already been specified in the caption of Fig.9 (line 583).
309 – oversized relative to what?	The term "oversize pores" indicates those (secondary) pores that are larger than the average pore size of primary porosity and also a larger diameter than that of adjacent grains (e.g. Schmidt et al., 1977 Bulletin of Canadian Petroleum Geology, 25(2), 271-290). E.g. oversized pores are due to dissolution of detrital grains (e.g. carbonate clast, feldspar).
428-431, Figure 12. On figures like this, usually the negative numbers decrease upwards along the y axis...and I prefer the axes to be one the left and bottom like a normal graph - the origin will not be 0, 0 but that doesn't matter for delta values. And the text here can be tighted a bit, I think;	Thanks for this comment. We would like to keep the diagram of Fig. 12 as it is, following some of the most commonly used $\delta^{18}O$- $\delta^{13}C$ isotope diagram in literature (referenced in the manuscript: e.g. Hudson, 1977; Moore, 1989; Nelson and Smith, 1996; Pizzati et al., 2020). Regarding the diagram axis issue, we would like to keep them like this, since we are showing only the negative field/portion (-x, -y) of the diagram (references as above). The text in the legend was tightened as suggested by the reviewer.
Cement from the nodules of the Loiano samples have δ13 C values between -7.68 and -1.47 ‰ (V-PDB) and δ18 O values between -4.42 and -1.35 ‰ (V430 PDB) (Figure 12). The DBs-related nodules is characterized by isotope compositions between -5.41 and -1.47 ‰ (V-PDB) for δ13 C, and between -4.42 and -1.40 ‰ for δ18 O (V-PDB). The bedding-parallel nodules has isotope compositions between -7.68 and -5.94 ‰ (VPDB) for δ13C, and between -2.09 and -1.35 ‰ (V-PDB) for δ18O.	We have revisited and shortened the text according to the reviewer suggestions typed here in the comment (lines 663-667).
460-490 – I am not sure how much of this is needed. The focus of this paper is on the outcrop and microstructural observations and interpretations and	We did the edits suggested and moved the paragraph 7.1, along with the references therein, to the Suppl. Mat. S1 and re-numbered the other paragraphs in the

the regional tectonics do not seem to be the main point	main text accordingly. We created a Reference list in the Suppl. Mat. where we added the refs. that are cited only here and not in the main text.
505 not clear what the meaning of the orange is here – do you mean orange cements? And orange color is redundant	Ok corrected. We hope it is clear now. (lines 788-789).
510-515 – I am sorry – I got a little lost here with the terms like “likely preserved”; “suggest that cement dissolution..” “suggesting that cementation postdate...” There so many solid observations in this paper that I think you can state your interpreations more forcefully.	Thanks for this comment. Ok corrected. Now, the sentences you mention should be more solid (lines 788-794).
519 and elsewhere – evidence is never plural evidences is not a word	Ok corrected along all the manuscript (lines 374, 545, 706, 801, 842, 1030)
520. 800-1000 m	Ok suggestion taken and implemented (line 802)
530-535 - are these bed parallel nodules basically related to diagenesis of some sort	If I understand well the reviewer point, yes. We think that bedding-parallel nodules are related to cement precipitation from flow focused along bedding, and in particular they are related to flow within sand levels (lines 810-837). In this Section (now Sect. 7.1) we discuss their occurrence, morphology, and a possible relationship with sandstone grain size. In Sect. 7.3 we also discuss the formation of bedding-parallel nodules considering the data available from this study and from literature.
540-560 This is not very clearly written – please see written edits on the text	We implemented the suggested edits and rephrased the paragraph. We hope it is clear now. (lines 840-857).
570- 715 – need to break this into paragraphs; Shorten, and see edits. I suggest separating the facts, and observations, and then discuss your interpretations; read through this section and eliminate all the clauses at the beginning of many of the sentences; In this section, look for all the ‘coulds’ in this section. My apologies – I think I am having COVID brain issues, but this section is pretty hard to read. I think it takes away from your work by not being a bit shorter, clearer, and organized.	The lines of this comment (570-715) refer to both Section 7.3 (now 7.2) and 7.4 (now 7.3). Considering the comments here at the left and the written edits on the manuscript, we believe, instead, that the reviewer refers only to Section 7.4 (now 7.3). We accepted the edits suggested by the reviewer. We have broken this Section 7.3 in paragraphs, reorganized and shortened the text. When possible the “coulds” were replaced trying to make the discussion in this section more solid.
593 594 – Precipitation occurs when the reaction is out of equilibrium. “slowing” flow could push fluids to be closer to equilibrium with the host rocks, thus, less likely to precipitate	-We thank the reviewer for the comment, this is an interesting point. We added a possible explanation in text (lines 947-949). Below, we will discuss more about the reviewer point. -At lower flow velocities the precipitation reaction has more time to proceed before the fluid leaves the system. We added 2 references where the effect of flow hydrodynamics on kinetics of precipitation was studied. -We think that if fluids are enriched in constituents needed for calcite precipitation (Ca and bicarbonate), then the “equilibrium” you mention e.g. could just be reached through cement precipitation. We propose that a “slow down” of the flow could kinetically favor cement precipitation. -As argued by the reviewer, at low flow velocity, the

	residence time could be long enough allowing the fluid to equilibrate with the host rock. In this case, the equilibrium between host rock and the percolating solution could be reached not far from the upstream side of the DB. This could support the asymmetric distribution of cement with respect to the DB, as observed in the field. –At higher flow velocity, there would be a higher and continuous supply of reagents, but the reaction would be disfavored. In fact, for most rock-forming minerals at ambient temperatures, chemical reactions at the solid surface are slow and thus rate limiting. If flow is fast, the reaction might not have time to occur. This is true if the fluid did not reach carbonate saturation (low saturation index). -In our case, it is also important to keep in mind, that the growth substrate is made mostly by quartz and feldspar, hence the mineralogy has a limited control over the process of mineral nucleation and growth [e.g. Pin and Singer, 2005, Geochimica et Cosmochimica Acta, 69(18), 4495–4504]. The precipitation of calcite over a silica substrate would need more time to occur when compared to a carbonate substratum (Stockman et al., 2014, Geochimica et Cosmochimica Acta,135, 231–250). -Another simple reason that supports our hypothesis is that nodules preferably occur along DBs where the porosity and permeability are lower than the surroundings and where the net flow is slower. Accordingly, the host rock is higher in porosity and permeability; here, the net flow is faster and the cement is absent or poor. This possibliy mean that the flow velocity has a role in the precipitation process, or at least to its initiation (See refs in line 949).
What aspect(s) of this work / interpretation(s) address, or apply to, db faults-fluid flow questions in general?	-Here, we bring some field evidence that show how DBs affect the flow pattern and control the distribution of diagenetic heterogeneities, i.e. nodules. -We also argue about different potential mechanisms that drove cement precipitation within and around the DBs (Section 7.2). Most of the past field-based works were focused on the occurrence and the distribution of the cement, whereas cementation mechanisms received less attention. -The mechanisms commonly employed to explain cementation within DBs (e.g. lines 141-147) are appliable and limited to specific conditions and need that the DB behaved as “conduits” (147-150). However, a lot of works demonstrate that commonly DBs reduce permeability and baffle the flow (lines 99-104). -We discuss some mechanisms that are pertinent also in late-stage diagenesis (post-DBs formation) and in saturated conditions (phreatic environment), and that

	are of more general validity in low-permeability DBs Conclusions (bullet point 6).
Suggest moderate revisions.	