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Interactive comment on "Control of pre-existing fabric in fracture formation, reactivation and vein emplacement under variable fluid pressure conditions: An example from Archean Greenstone belt, India" *by* Sreyashi Bhowmick and Tridib Kumar Mondal

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Dear Editor,

We are grateful to you as well as Prof. Francesco Mazzarini (Reviewer#1) and Prof. Christophe Pascal (Reviewer#2) for a detailed review and constructive suggestions on the manuscript se-2020-30, and for giving us an opportunity to revise the same. We believe that the comments have helped us to think more deeply and have helped in

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revising the manuscript considerably, which we hope will be to your satisfaction. In the revised manuscript, we have taken into account all the recommendations/suggestions provided by the two Reviewers and have tried to clarify our viewpoint for the benefit of the reader.

Please note that in the marked (revised) manuscript, the changes made on basis of comments of Reviewer#1 appear in RED, while changes based on comments of Reviewer#2 appear in BLUE color.

At first we outlined the main issues that we have addressed in the revision, followed by comment wise response to the specific points mentioned in the comments section. It may be noted that we have also responded the comments of Reviewer#1 and Reviewer#2 separately. However, we prefer to mention the same again and the responses are given below pointwise against the individual issues.

Response to main issues:

Issue 1: Better justification of considering BTS and minimum principal stress

We would like to thank you as well as reviewer#2 for raising this issue. The tensile strength of metabasalt was obtained from Brazilian Tensile Strength (BTS) studies which was further used to denote the magnitude of the minimum principle stress (σ3). Here we explain the rationale behind this assumption. It is interpreted that the tectonic stress was more dominant during the initial fracturing mechanism which was followed by episodic fluid pressure pulses leading to fracture reactivation and vein emplacement. The 3D Mohr circle diagrams in Fig.7 and Fig.8 (of the revised manuscript), represents the relative fluid pressure conditions only. We have provided the effective normal stress conditions separately in Fig. 11 (Schematic model in the revised manuscript). However, in order to address the Reviewers concern for σ3=12 MPa, we have added a few sentences in the main manuscript justifying the reason behind such a consideration. It definitely enhanced the quality of the manuscript. The magnitude of σ3 can also be estimated using the stress intensity factor (fracture toughness), KIC. KIC for mode-I fractures, can be determined using the following equation (Lawn and Wilshaw, 1975; Atikinson, 1989). KIC = σ3Y(πa)1/2, where σ3 is the minimum far field stress acting normal to the crack, Y is a numerical modification factor to account for the crack geometry and edge effect, and ‘a’ is the crack half-length. Microstructural investigation suggests that the metabasalts are generally fine to medium grained, massive and consists of plagioclase laths and altered pyroxene with minor chlorite, ankerite and quartz (Gupta et al., 2014). Within the metabasalts, variably oriented larger phenocryst grains range from 2 mm to 8 mm in length. It is evident that the large phenocrysts were more susceptible to generate the initial fractures as compared to the medium to fine grained groundmass in these types of rocks. Therefore, we have considered that the length of the initial crack ranges from 2 mm to 8 mm (Brace, 1964). KIC value for the metabasalts are found to be 1.069 (Donovan, 2003). Considering this KIC value and the range for fracture half-length (a), the σ3Y value for the metabasalt ranges between 9-19 MPa. From this strength range we considered that 12 MPa is a reasonable estimate for the in situ tensile strength (similar to the laboratory strength) of the corresponding lithology. It may also be noted that, previous studies by Mondal and Acharyya, 2018, conducted in Chitradurga Granite, in close vicinity of the study area also regarded the magnitude of σ3 $\sim$10 MPa, to be a good estimation. Combining these estimations with the results obtained from the present studies, we constrained the value for σ3 $\sim$12MPa.

Issue 2: Estimation of Pf condition

You have raised your concern regarding the estimation of Pf condition, which was also raised by the Reviewer#2. We would again thank the Reviewer for pointing out this problem. In Fig.7, we tried to quantify multiple fluid pressure pulses from the vein pole distribution data. Although, it is critical to differentiate various episodes of fluid ingression from a single large event. Initially we considered the girdle distribution of data points indicating, Pf > σ2 (Jolly and Sanderson, 1997; McKeagney et al., 2004; Mazzarini and Isola, 2007; Martinez-Poza et al., 2016). However, as the distribution of data points show three prominent clusters, we decided to extend our analysis to all the respective clusters and not only the WSW cluster (with highest cluster density). We have incorporated the analysis for the other two clusters as well (NE and SE clusters) in the revised manuscript, as also suggested by Reviewer-1 (see Fig. 8 in the revised manuscript). The number of obtained clusters can also be testified through mixed Bingham analysis using K vs BIC (i.e., the number of Bingham component of a mixed Bingham distribution vs Bayesian information criterion; Yamaji and Sato, 2011). We have found that the lowest BIC values are obtained when K=3 (number of possible clusters for the given data set), thereby, justifying the selection of the three clusters for the analysis. In each case, Pf values for the respective clusters were obtained, which is most likely to differ, as mentioned by the Reviewer. It is absolutely true that if we select a tighter cluster, thereby reducing the contour interval, the Pf value will be further reduced. However, field evidences suggest that most of the vein orientations representing the WSW cluster show a NW-SE to NNW-SSE trend. Also, veins along this orientation attained maximum thickness along with multiple median lines. Thus, we decided to extend the contour interval beyond the data points in order to incorporate the maximum range of vein orientations (θ) lying parallel/sub-parallel to the internal anisotropy (as evident from the anisotropy of magnetic susceptibility study) of the host rock. Also, the contour interval and significance level for each of the clusters were selected in such a way that maximum number of data points are included, in order to obtain a statistically viable data cluster. It is however difficult to quantify the lowest Pf value; we therefore intend to use the obtained Pf values from the respective clusters as examples of low Pf conditions denoting Pf fluctuation rather than quantifying the lowest Pf condition of the study area. We have obtained different shape values (ÑĎ) for the inversions, this is because of the variation in the magnitude of $\sigma 2$. Both magnitude and orientation of $\sigma 2$ changes from high to low Pf conditions as explained by the k2/k1 ratio, regarded as the stress ratio (ÑĎ), which is expressed as k1 $\approx$ k2, for clustered distribution and k1 « k2, for girdle distribution (k1, k2 are the concentration parameters of a Bingham distribution; Yamaji, 2016). We hope this provides a better explanation for the interpretation of episodic fluid pressure condition prevailing in the region. In the

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revised manuscript we have added a number of lines in section 4.3, which increases the clarity of the manuscript.

You have also suggested to include the new figure of the first revision (in accordance with reviewer#1) into the manuscript.

In the revised manuscript we have incorporated all the new figures related to the first revision.

Issue 3: Fault valve.

You have mentioned that " I consider your revision, especially the new photograph suggesting crack seal with two episodes. Please, better introduce and discuss the new proofs of fault valve mechanism both in the introduction and your result section. Also include the photographs into the new version of the manuscript (not as a supplementary material) and if possible, replace the close view with another photograph showing better evidences of more cycles into a same vein (here we can really see two episodes). It could be more convincing for the fault valve behaviour. I think to see more convincing cases with multiple adjacent branches in the part (a) of you new figure"

We would like to thank you for your kind words related to the first revision. We have included a few lines justifying the fault-valve mechanism both in the introduction and in the result section as you have suggested. We have also included the photographs into the main manuscript. We appended Figure 3g, with multiple median lines, where more than two cycles of fluid ingression are observed.

Response to the specific points:

Revise the sense of shear marked with all the arrows in the 3 bloc diagrams of Figure 10b, c and d, which are kinematically inconsistent with the wing cracks drawn. Also better align the yellow arrow with the T criteria in the riedel plane analysis. CORRECTED

Provide more justification in the discussion about the deformation mechanism related to the magnetic fabric. Can we interpret the magnetic fabric as non-coaxial (simple shear) or multi episodic deformation (2 poles on the stereogram), and then having a shortening oblique to the foliation ? CORRECTED and INCORPORATED the suggestion

Apart from the above we have also modified the manuscript in accordance with the comments mentioned in the annotated pdf.

With the above revisions we hope that all the questions raised by you and the Reviewers have been addressed. We hope the revised version is to your satisfaction.

Thanking you

Yours sincerely

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