Responses to comments by reviewer #2

Miller Zambrano (Referee)
miller.zambrano@unicam.it
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Measuring hydraulic fracture apertures: a comparison of methods: This is my first time reviewing this manuscript. The topic is of remarkable interest, and it has been widely investigated from different points of views implementing several techniques and approaches. Therefore, the expectations from this manuscript are quite high. In general, the manuscript describes a series of methods for estimating the hydraulic aperture and makes a comparison among them. I have just some considerations that can improve the quality of the manuscript:

We sincerely thank Miller Zambrano for his constructive comments and valuable suggestions of additional literature, which greatly helped to improve the manuscript. In the following, we provide a point-by-point response to the comments, where comments are in black, and our responses are in blue. In addition, any changes regarding ''author responses to reviewer #2'' applied in the revised manuscript are also colored in blue.

(1) Revised some missing literature (classic and recent) that could impact on the motivation (lines 58-60) and the general definition of the state of the art (lines 28-60). A short list is offered but I suggest expanding it considering the related literature.

Response: We have implemented the suggested literature in the revised manuscript, including Tsang (1992), Brown (1995), Isakov et al. (2001), Ogilvie (2003), Ogilvie et al. (2006), Corradetti et al. (2017), and Zambrano et al. (2019). This work's main goal is to evaluate the reliability of three different methods for the determination of hydraulic aperture and thus fracture permeability. Flow-through experiments can generally provide the most reliable hydraulic results, which we therefore used as a baseline for the comparison with the results obtained by the other two (portable) methods (i.e., the Tiny Perm 3 transient airflow permeameter and a microscope camera-based image analysis). Although fractures can be more precisely characterized using other methods such as surface scans, laser scans, and X-ray computed micro tomography, these methods cannot be employed on a large amount of fractures in outcrop studies. In the present study, our motivation was to investigate how reliably hydraulic fracture properties can be determined under very limited general requirements (e.g., from fracture profiles). In this regard, the ***introduction section*** has been improved by adding the suggested literature and the motivation of the present work was clarified.

(2) Consider revising the grammar and the composition of some sentences that are difficult to understand (e.g. line 23-24).

Response: The manuscript has been checked throughout and revised accordingly.

(3) Concerning the use of the portable permeameter, the discussion and methodological considerations could be improved considering for instance the work of Filomena et al. (2014). These authors found differences of 37% of the permeability measurements between confined and plug samples.

Response: This is a valuable comment. The work by Filomena et al. (2014) is now included and discussed in the manuscript in ***Lines 250-259***.

(4) This work could take benefits of including other approaches for describing roughness and aperture. For instance, evaluating the roughness in terms of wavelength and asperity height distribution can better describe the surfaces (or profiles) of the fractures (see Brown, 1995). In addition, a description of the mismatch of the fracture walls can be also of interest due to their impact of permeability (see Zambrano et al., 2019). Similar to your work, these authors considered open fractures with normal (similar to FF3) and parallel displacement (similar to FOF1 and FF2).

Response: We certainly agree, but the application of the listed other approaches was beyond the scope of this study as outlined in our response to your comment (1) above. Moreover, regarding your second point, a qualitative measure of surface roughness and fracture aperture intensity was used (Fig. 1). For this study, this should prove sufficient because, again, the main goal was to investigate the reliability of different methods for determining the hydraulic aperture of fractures with varying surface roughness and aperture distribution. However, the ***introduction section*** was updated regarding both comments in ***Lines 57-62*** and ***Lines 71-73***.

(5) Concerning the description and the discussion of the results, I consider some statistical validation should accompany some expression like "well-matched", "excellent agreement", "better agreement", "better matching". Also, a better description of the graphs is needed.

Response. We agree. Quantitative statements are now made in ***Lines 301-302*** and ***Lines 316-317***. Moreover, the ***figure captions of Figs. 1, 2, 4, 5, 6, 7, 9, and 11*** were updated.

(6) After all the data exposed, it is difficult to understand the conclusion 3.

Response: We agree and have revised the respective point in the ***conclusions section*** accordingly, highlighted in red (***Lines 389-391***) as this issue was also raised by reviewer #1.

****** Recommended literature: ******

Please consider the following classic literature dealing with fracture roughness and hydraulic aperture:

Response: Thank you for the valuable suggestions regarding additional literature. The references colored in blue below were added to the revised manuscript.

- Y. W. Tsang, "Usage of "equivalent apertures" for rock fractures as derived from hydraulic and tracer tests," Water Resources Research, vol. 28, no. 5, pp. 1451–1455, 1992.

- G. M. Lomize, Flow in Fractured Rocks, Gosenergoizdat, Moscow, 1951.

- C. Louis, "A study of ground water flow in jointed rock and its influence on the stability of rock masses," in Rock Mechanics Research Report, Imperial College, London, 1969, Rock Mechanics Research Report 10.

- E. F. de Quadros, Determinação das características do fluxo de água em fraturas derochas, Department of Civil Construction Engineering, Polytechnic School, University of Sao Paulo, 1982.

- S. R. Brown, "Simple mathematical model of a rough fracture," Journal of Geophysical Research: Solid Earth, vol. 100, no. B4, pp. 5941–5952, 1995.

- S. R. Ogilvie, E. Isakov, and P. W. Glover, "Fluid flow through rough fractures in rocks. II: a new matching model for rough rock fractures," Earth and Planetary Science Letters, vol. 241, no. 3-4, pp. 454–465, 2006.

- E. Isakov, S. R. Ogilvie, C. W. Taylor, and P. W. Glover, "Fluid flow through rough fractures in rocks I: high resolution aperture determinations," Earth and Planetary Science Letters, vol. 191, no. 3-4, pp. 267–282, 2001.

- S. R. Ogilvie, E. Isakov, C. W. Taylor, and P. W. J. Glover, "Characterization of rough walled fractures in crystalline rocks," Geological Society, London, Special Publications, vol. 214, no. 1, pp. 125–141, 2003.

Please also add some literature about roughness assessment using SfM photogrammetry and hydraulic aperture estimation using computer fluid dynamics (i.e. Zambrano et al., 2019). The following literature should be considered in paragraph 55:

Response: The suggested references were added to the revised manuscript in ***Line 57***.

- Zambrano, M., Pitts, A. D., Salama, A., Volatili, T., Giorgioni, M., & Tondi, E. (2019). Analysis of Fracture Roughness Control on Permeability Using SfM and Fluid Flow Simulations: Implications for Carbonate Reservoir Characterization. Geofluids.

- Corradetti, A., McCaffrey, K., De Paola, N., & Tavani, S. (2017). Evaluating roughness scaling properties of natural active fault surfaces by means of multi-view photogrammetry. Tectonophysics, 717, 599-606.

Check the classic of Barton et al. (1985) that relate mechanical aperture, hydraulic aperture, and joint roughness coefficient.

Response: The suggested reference was added to the revised manuscript in ***Lines 30-31*** and ***Line 34***.

- Barton, N., Bandis, S., & Bakhtar, K. (1985, June). Strength, deformation and conductivity coupling of rock joints. In International journal of rock mechanics and mining sciences & geomechanics abstracts (Vol. 22, No. 3, pp. 121-140). Pergamon.

Please check carefully the following article related to the use of the miniperm device.

Response: As mentioned in our response to comment (3), the work by Filomena et al. (2014) is now included and discussed in the manuscript in ***Lines 250-259***.

- Filomena, C. M., Hornung, J., & Stollhofen, H. (2014). Assessing accuracy of gas driven permeability measurements: a comparative study of diverse Hassler-cell and probe permeameter devices. Solid Earth, 5(1), 1.