Review comments on *Azimuth-, angle-, frequency-dependent seismic velocities of cracked rocks due to squirt flow*

In this work, the authors use numerical methods to study the azimuth, angle and frequency dependent seismic velocities for cracked rocks due to squirt flow. The authors do a rigorous 3D numerical study using a simple geometry and set up two different experiments – connected and disconnected cracks. The authors show that the seismic velocities are dependent on azimuth, angle and frequency only for connected cracks case. The authors also compare the results of the disconnected crack with the high frequency results of the connected cracks case. Apart from Thomsen's parameter that is primarily used for anisotropic studies in geophysics, the authors also formulate and use scalar parameter called anisotropy index parameter to describe the anisotropy dependence for squirt flow.

This is a nice piece of numerical study for a simple geometry that gives new insights into anisotropy that arises due to squirt flow. The study is missing benchmarking of the numerical results with some simple analytical solutions or to some laboratory data. Benchmarking will help the readers have more confidence on the numerical results. I believe that the authors could make some comments on the practical uses of this in some details apart from the introduction section of the paper where they mention a generic statement on it. Also, I think that the value of the work can be increased by application of the work on a real digital rock sample apart from the geometry that has been considered. The authors can also think about presenting the figures for the results section in a better/simpler way (if possible). These figures are the crux of the paper and will be the most important thing for the readers to gain as a take-home message.

I have mentioned my specific comments on the paper in the following section.

General comments:

Was any software (eg. COMSOL) used for the simulations?

Can there be a way to apply this work for a real 3D digital rock sample?

Can the results be benchmarked with some standard analytical solution or measurements from the laboratory?

Specific comments:

Comments on Introduction section:

1st line is a good motivation for the study but leaves the reader with the question why or how cracked rocks play a crucial role. Some references or a line to elaborate it would be effective. One might argue that the next one mentions hydraulic properties are affected by cracks is the justification, however, I still think it deserves some clarity.

Line 24 – Mesoscopic scale definition preferred before this line.

Missing reference to Mavko and Nur (1975) classic paper that introduced “squirt flow”!

Line 51 – Das et al. (2019) Numerical simulation of coupled fluid-solid interaction at the pore scale: A digital rock-physics technology is the full paper in Geophysics and is a better reference than the conference abstract.

Comments on Numerical methodology section:

Line 79 – Definition of *u*?

In the finite element numerical solver are you solving for displacement or velocity for the fluid phase (equation 3)? How is the coupling done in terms of displacement at the boundary between the two phases? It might be useful to mention a few lines here instead of just references.

Line 86 – Why are the inertial terms neglected? What would be the limitations that might arise due to this approximation? Any discussion on how this can be included?

Line 88 – Why is the PARDISO solver used? The reader might wander what are the advantages of using this versus any other solver.

Line 89 – What is direct relaxation test? Reference/ one line description can be useful.

Line 96 – Is the harmonic displacement a function of time? Are you solving the equations in time domain or frequency domain? How does combining equations 2 and 3 work if the equations are solved in time domain vs frequency domain?

Line 100 – What are mixed direct tests?

Comments on Numerical model:

Line 108 Any specific reason for having an aspect ratio of 0.01?

Line 109 Any specific reason for using glycerol?

Line 110 In Table 1, how is the Bulk Modulus (K) of the fluids used in equation 3?

Line 111 Can there be some quantitative ways of describing fine and coarser mesh – size of the elements (maximum and minimum size, average size of the mesh element) including the details mentioned in the caption of Figure 2. Also, along the z axis of the mesh, parts of it has 3 elements as per the snapshot in Figure 2. Is this sufficient number of elements from numerical point of view? Is there any way to justify that the numerical solution is stable with the number of elements used?

Line 113 What type of system configuration was used for making the simulations? It seems like 0.95TB of RAM would require very specific type of machine to run. How much time did it take to run each of the simulation?

Line 126-127 Does the difference between the stiffness of the two disconnected cracks also depend on the boundary conditions applied to the system? In other words, will the stiffness be always different irrespective of the boundary condition applied?

Comments on Results section:

Line 147 Unclear what is meant by the cracks can be described by only two compliances as per equation 6?

I am also confused that in Line 142 it is mentioned that there is a significant difference due to vertical crack separation. However, in Line 148, it is mentioned that only connected cracks case is considered? Can this be explained better?

Line 165 – What are the values of frequencies used for LF, Fc and HF?

Line 173 – It is unclear what is meant by the elastic limit in this case? Can this be compared to any standard elastic limits that are mentioned in literature?

Figure 4 might be improved from a reader's perspective.

Line 180 – Even in figure 4a, the Real part of the c22 and c33 component coincides. Is there a specific reason for pointing out separately the attenuation and dispersion components are same due to symmetry of the model?

Line 183 – It might be useful to explain what negative attenuation means in physical sense. Is there a reason for the negative attenuation behavior?

Line 194 – It might be useful to mention how the seismic velocities are calculated as a function of phase?

Figure 6 – Is there a reason for the discrepancy between V_SV between the disconnected crack model and the high frequency result at a phase angle of 0, 90 and 180 degrees?

Comments related to Discussions:

Line 311 – What are the model parameters that the conclusion will depend upon? The authors mention about the need of sensitivity analysis of the model parameters. It would be useful to give a qualitative idea about the possible model parameters that the results will depend on.