主题: Submission
发件人: JNGSE <eesserver@eesmail.elsevier.com>
日期: 2018/12/16 19:20
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Ms. Ref. No.: JNGSE-D-18-01722
Title: Numerical modeling of CO2 fracturing by the phase field approach
Journal of Natural Gas Science & Engineering

Dear Professor Yongxing Shen,

The reviewers have commented on your above paper. They indicated that it is not acceptable for publication in its present form.

I would appreciate if you could submit your revised paper by Jan 06, 2019.

However, if you feel that you can suitably address the reviewers' comments (included below), I invite you to revise and resubmit your manuscript.

Please carefully address the issues raised in the comments.

If you are submitting a revised manuscript, please also:

a) outline each change made (point by point) as raised in the reviewer comments

AND/OR

b) provide a suitable rebuttal to each reviewer comment not addressed

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I look forward to receiving your revised manuscript.

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Yours sincerely,

Wei Yan, Ph.D.
Executive Editor
Journal of Natural Gas Science & Engineering

Note: While submitting the revised manuscript, please double check the author names provided in the submission so that authorship related changes are made in the revision stage. If your manuscript is accepted, any authorship change will involve approval from co-authors and respective editor handling the submission and this may cause a significant delay in publishing your manuscript.

Reviewers' comments:

Reviewer #1: In overall, the manuscript is well written. I would recommend this manuscript for further consideration if the authors make the following revisions:
- The nomenclature should be consistent with SPE nomenclature, for example v should be used for velocity instead of q, l should be used for length instead of sigma.
- When CO_2 flow in the fracture and in rock, there are more than one phase because formation fluids also flow, hence the formulation should be for at least two phase.
- Please use a consistent color set for all figures, scale in some figures changes white to back while others change from blue to white.
- Please include a short paragraph to show how d and alpha_k (Eq. 9) are determined?
- Please use more close to reservoir condition for input data. The tensile strength in Tab. 1 is very high for the rock with that Young's modulus. The initial pressure is rather too low.
- Please include all necessary inputs for the simulation to allow other people to duplicate the job if needed.
- There is no data related to in-situ stresses. Although, they are not in the equation but they are the boundary condition.
- More numerical simulation or case studies may be needed and a comparison with other models may be useful to show the innovation of this model.
- We need more section to discuss the advantage of the model compared to other approaches.

Reviewer #2: This paper presents a very novel approach to model the CO2 fracturing process. I think this topic is very new and definitely worth digging into. The authors have presented enough details about the fundamentals of the solution, and overall I think this paper is very well laid out. I have following minor suggestions for further improvement:
1. One main concern is that this paper seems too mathematical. The layout of the manuscript could benefit from more description about the application of the methodology.
2. The validation is not very clear to me. The author presented three verifications, but are they trying to prove the validity of the proposed method? Honestly I didn't recognize the method that was used for validation. Is it a well established analytic solution, or results from well established simulation? I would strongly recommend re-write the validation part.
3. What is the limitation of the current method. It is not very clear to me that whether this method is application to traditional water based fracing or not. And if so, what is the advantage of the current approach?

Reviewer #3: The paper tries to use phase field method to model co2 fracturing. Some assumptions used in governing equations are not supported with the theory of poroelasticity. Hydraulic fracturing or CO2 fracturing involves strongly coupled processes. But the authors verify their model through non-coupled examples. The coupled behaviors about pressure and aperture evolutions are not demonstrated. This makes the correctness of the model in doubt.
I recommend resubmission of the paper after the model is correctly verified through asymptotic analytical solutions for hydraulic fracturing. Without correctly verifying the coupled model, I cannot recommend the acceptance of it.
The followings are a few comments:
1. The authors used a phase field depended permeability in their study. The permeability should be determined by the opening or close of fractures. Why could a damage variable be used to determine permeability? The phase field value is distributed over a range, however, a facture creates jump in pressure and displacement. Why could a continuous variable be use to represent discontinuous behaviors, especially for permeability?
2. Eq. 10 is not correct, which casts doubt on the whole sequentially coupled process. The treatment of porosity in Eq. 10 conflicts with the theory of poroelasticity. Change of porosity is not equal to the change of volumetric strain, not even in an approximate

manner.
3. Could the authors give the spatial and temporal discretization in appendix? Since the weak form is given already, spatial discretization is only one step away. I doubt the spatial discretization for a poroelastic medium could be derived from Eq. B1b or Eq. B2b. Though it is possible that the poroelastic model is ready for use in FEniCS package, the authors are suggested to provide the completely discretized formulations for the benefit of readers.
4. Fully coupled examples are needed to verify the model. Correctly verifying a tensile test and the pressurization of a fracture do not indicate the model can correctly simulate hydraulic fracturing or CO2 fracturing. The verification about pressurizing a bore hole is not a good example to show poroelastic responses. Actually, no typical poroelastic responses are shown in the example. Mandel's problem is suggested.
5. Please briefly explain the AT1 and AT2 model.
6. line 1-2 Page 1 Are you sure shale or mudstone is the most common sedimentary rock?

Reviewer #4: The authors have proposed a model for CO2 flow and fracturing in shale media. The manuscript has a good order, but needs revision to satisfy publication quality.
Gas flow in shale is one of the most challenging topics and has been widely investigated. The authors have used a relatively simple model for calculation of gas flow and permeability in shale media. A good model will capture important phenomena like Knudsen Diffusion and adsorption effect in shale rock media. Please modify this part of your model by providing a more holistic and detailed explanation. Please refer to series of papers by Javadpour et al. Also see: Seyyed A. Hosseini et al. "Novel Analytical Core-Sample Analysis Indicates Higher Gas Content in Shale-Gas Reservoirs" SPE Journal 2015.

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