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Interactive comment on "Bilinear pressure diffusion and termination of bilinear flow in a vertically fractured well injecting at constant pressure" *by* Patricio-Ignacio Pérez D. et al.

Patricio-Ignacio Pérez D. et al.

ortiz.adrian@gmail.com

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Dear Editor:

In the first place we want to sincerely thank Anonymous Referee #1 for the detailed and extensive revision of the manuscript and for all his suggestions. They have helped us to substantially improve the manuscript and we have implemented to a large extent all the suggestions may by him.

According to the reflection criterion considered in this work, the termination of bilinear flow occurs at the time at which a first variation of pressure is evident in the fracture

tip. When lower isobars than the isobar under study have already reached the fracture tip, these isobars are partly reflected from the fracture tip toward the well, due to the hydraulic conductivity contrast experienced at the interphase between the fracture tip and the matrix. This hydraulic conductivity structure causes the isobar reflection at the fracture tip back toward the well and the isobar transmission further into the matrix. Thus, the propagation velocity of all isobars decelerates when they leave the fracture tip and start to propagate through the matrix. The previous text was added at the beginning of the section 3.2.2 "Reflection criterion", in order to make the explanation of the criterion more understandable. From the industry point of view, the termination time of the bilinear flow is relevant since it can be used to estimate a minimum value of fracture length when the dimensionless fracture conductivity T_D≥3. Moreover, for lower values of T_D the termination time of the bilinear flow can be used to restrict the minimum fracture length. This information is important to characterize and model a fractured reservoir. Having reliable data on fracture dimensions is critically important for production optimization strategies. The introduction was modified including this clarification as well as the corresponding cites.

In relation to a more detailed description of the numerical model, additional information has been incorporated at the beginning of section 2.4 "Description of the model setup". This information includes the following "We ran the numerical simulations in the Subsurface Flow Module of COMSOL Multiphysics® software program. The space- and time-dependent balance equations, described in section 2.1, together with their initial and boundary conditions are numerically solved in the entire modeling domain employing the finite-element method (FEM) in a weak formulation. The discretization of the partial differential equations (PDEs) results in a large system of sparse linear algebraic equations, which are solved using the linear system solver MUMPS (MUltifrontal Massively Parallel Sparse direct Solver), implemented in the finite element simulation software COMSOL Multiphysics®. Utilizing the Galerkin approach, Lagrange quadratic shape functions have been selected to solve the discretized diffusion equations for the pressure process variable. For the time discretization, a Backward Differentiation Formula (BDF, implicit method) of variable order has been chosen.". We also incorporated two important remarks concerning studies of mesh- and boundary condition-independency of the solution in the modeling domain we are most interested in. The first one "That way, boundary condition-independency of the solution has been guaranteed for in the computational subdomain of most interest" (included in the manuscript in the corresponding place), and the second one at the end of section 2.4 "We performed mesh convergence studies refining the mesh, particularly, in the computational subdomain that contains steep hydraulic gradients, until the solution became mesh-independent."

Additionally, in order to show the evolution of isobars we incorporated to the manuscript Figure 3 (added also to this reply), which displays simulation results of pressure contours through the computational domain in a 2D cross section for the dimensionless fracture conductivities T_D=0.3 and T_D=6.3 for three different times. We chose these values of T_D because they represent two interesting and illustrative scenarios. Furthermore, we introduced the following text in section 3.1 "Propagation of isobars along the fracture and the matrix", just after the definition of P_N, "The isobars behave differently depending on the value of T_D. For cases with low T_D, it is distinguishable that after the termination of bilinear flow, the isobars reveal a tendency of progressing toward an elliptical or pseudo-radial flow while still propagating along the fracture (see, for example, T_D= 0.3 in Fig. 3 a, b, c). The lower the value of T_D, the more pronounced this tendency becomes. On the other hand, for high T_D the behavior of the isobars is similar to the formation linear flow beyond the fracture (see T_D= 6.3 in Fig. 3 d, e, f). Although the behavior of isobars after the termination of bilinear flow is also highly interesting, this aspect is not addressed in further detail in this work. It remains pending to be studied in a follow-up investigation.".

We expose in the supplement a list with some clarifications related to the manuscript (the most important ones are discussed above) as well as some minor corrections that the Anonymous Referee #1 suggested in the supplement. With the revisions

and corrections made we hope that all the questions raised by the Anonymous Referee #1 have been addressed. Sincerely, The authors (Patricio-Ignacio Pérez D., Adrián-Enrique Ortiz R., Ernesto Meneses Rioseco)

Please also note the supplement to this comment:
https://www.solid-earth-discuss.net/se-2019-170/se-2019-170-AC1-supplement.pdf

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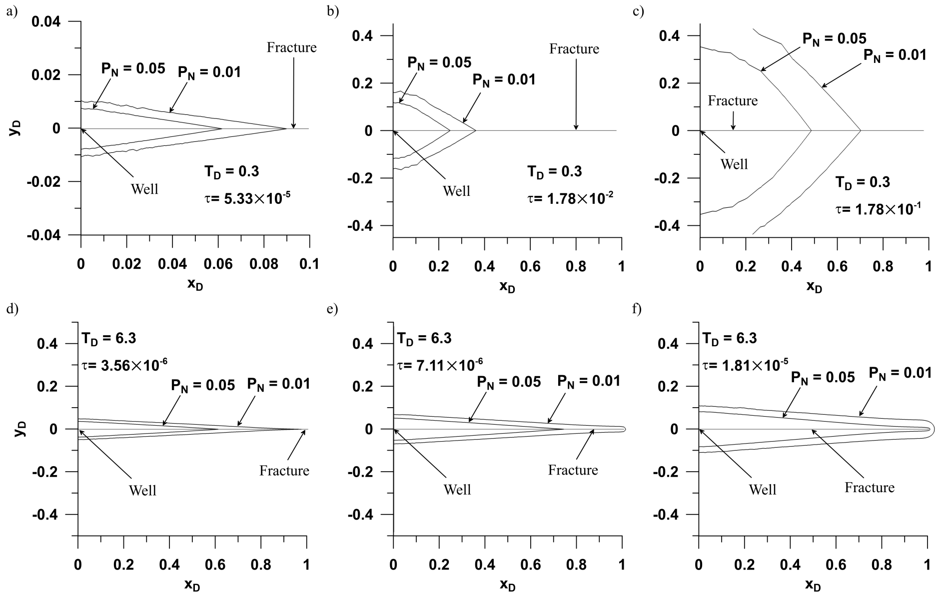

Fig. 1. Figure 3: Spatial evolution of isobars P_N=0.01 and P_N=0.05 over time through the modeling domain, for the dimensionless fracture conductivities T_D=0.3 (a, b, c) and T_D=6.3 (d, e, f).