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Hydrology and Earth System Sciences
Discussions

Interactive comment on "Dissolution and precipitation of fractures in soluble rock" *by* Georg Kaufmann et al.

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Reply to interactive comment by *Anonymous Referee #2*

We would like to thank the Anonymous Referee #2 for his valuable comments and take the opportunity to discuss the points made.

Major comments

1. The introduction and literature review appear to be disconnected from the main focuses of this study. For example, the paragraph that starts with line 3 on page 2 elaborates on several modeling work, but it is unclear how this study is related to or different from those studies, except for the Kaufmann et al (2014) study. Moreover, while the literatures summarized in section 2.2 showed how fracture evolution is affected by different flow regimes and other factors, most of these factors are not addresses or

are simplified in this study. For example, a drop of hydraulic head of 10 m was used in the manuscript, but it was not compared with realistic cases, and it is unclear why this specific flow regime is chosen. Furthermore, these literatures focus on small scale processes, while this study investigates field scale phenomena. Can the authors comment on how these literatures are relevant (or irrelevant) to this study and the scaling issue?.

We will move the review of selected work on fracture evolution to the introduction, group them into laboratory studies and numerical studies, and summarise their main outcomes as a motivation for our work.

2. Some aspects of the model framework and parameterization need to be clarified.

a. Page 4 line 10: 'with a fracture roughness coefficient mimicking small-scale wall irregularities in the fracture', is this roughness coefficient used in the calculation of reaction rate or flow or both?

For flow, we will add this in the text.

b. Page 5 line 13: what is the threshold Re used in this study?

$\mathrm{Re}_c = 2200$ in our study, we will mention this explicitly.

c. Page 5: the friction factor for laminal flow was presented in eqn(3) but not used in eqn (1), was it used at all?

We condense the flow to a single non-linear equation, which has also been suggested by anonymous referee #1, then f_l is used explicitly.

d. Page 5: how is the wall roughness (w in eqn(3)) defined and determined in this study and what is the impact of this parameter?

We add the definition to table 3.

e. Page 6: eqn (5) is very different from the advection-diffusion-reaction equation, even if the diffusion term is excluded. Can the authors comment on this and clarify the underlying assumptions? For example i. Is steady-state assumed, although it appears not to be the case given the following results?

Simple mass balance determined by flow rate and flux rate, we will add a reference pointing to the derivation.

ii. Is CFL criterion assumed to be one?.
We discretise the spatial coordinates as variable concentration increments (see also reply to referee #1), thus obeying a convergence criterium.

f. Page 8/29 (table 1): i. Only one kinetic coefficient is reported for the calcite reaction, but three reaction pathways were listed in (6), can the authors comment on this discrepancy?
The analytical solution for c_{eq} derived by Dreybrodt uses the chemical reactions listed to approximate a closed-form solution for c_{eq}. All three surface reactions are therefore considered.

ii. For the gypsum reaction, the kinetic coefficients for the linear and non-linear rate laws are about one order of magnitude different according the reference cited, but the authors used the same kinetic coefficient, why and how the results may be affected?
We will add the relation for the non-linear rate constant k_2.

iii. The texts pointed out that different parameters are used in precipitation from dissolution, it should be clarified in table one.
We use the negative of the linear rate constant of each mineral species for precipitation, will be stated in the text.

g. Page 9 line 17: step 6 what is the time step?
Time stepping will be discussed in the text (see also referee #1).

h. Given the strong dependence of the evolution profile on kinetic rate laws, some sensitivity analysis or discussion of the uncertainties of the kinetic laws and coefficients should be provided.
There is a significant difference in evolution between the different soluble rock types considered, but the stated rate laws for each mineral species do only vary by around

one order of magnitude. Sensitivity analyses of the parameter values concerning the rate laws exist in the literature.

Minor comments

1. Page 2: how is section 2.1 fracture widening different from fracture dissolution discussed in section 2.2?
We will drop the sub-section titles, condense the processes section, and rearrange the literature review to the introduction. See also answer for referee #1.

2. There are a couple of typos. For example, Page 4 line 3 should be ?Jones and Detwiler (2016)?, and ?where? should be ?were?
Will be corrected.

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