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Discussions

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

Anonymous Referee #1

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This manuscript presents results from reactive transport simulations in single fractures idealized as long one-dimensional tubes. Two different fracture configurations were considered: shallow fracture that remained near the water table over its entire length, and a deep fracture that followed a parabolic path from near the surface to a depth of z_{max} and back to the surface. The study extends the results of Kaufmann et al. (2014) by simulating several mineralogies. In addition to limestone, the current study includes gypsum, anhydrite and gypsum-lined fractures in limestone. I have some general comments about the manuscript, an a number of detailed comments.

General comments

The motivation for the study outlined in the Introduction relies mostly on previous work of the authors and ignores the large amount of work over the last 15 years aimed

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Discussion paper

at better understanding permeability changes in fractured rock caused by fluid-mineral reactions. A sub-sample of other studies are cited in the Processes section, but each is briefly addressed independently with no effort to synthesize the results and findings of these previous studies to offer a compelling motivation for the current study. The statement that the previous studies focused on small-scale processes and the current study focuses on large-scale behavior is a bit of a generalization and not exactly true (e.g., Hanna and Rajaram, 1998; Chaudhuri et al., 2008; Szymczak and Ladd, 2011 each consider scaling issues associated with related reaction processes). This manuscript would be more compelling if it started with a more nuanced discussion of the motivation for the study in light of the significant number of related studies in the recent literature.

Some of the details of the model are not well justified or documented, which undermines the impact of the simulation results. For example, the decision to represent fractures as a single, one-dimensional tube is not supported by recent experimental, numerical, and theoretical results (see for example references cited in the previous paragraph), which show the importance of the two- or three-dimensional flow field within fractures on the development of preferential flow paths by dissolution. Here, you essentially assume that, at time zero, a preferential flow path exists across the entire domain and it then grows by dissolution. It may be reasonable to ignore the development stage of these preferential flow paths, but the onus is on you to explain why in the context of other papers that focus on this interesting process. See other modeling issues in my detailed comments below.

Detailed comments

p.4 lines 19-21: This example doesn't seem relevant. My understanding is that the uplift resulted from over-pressurized fluids, not from mineral precipitation.

p. 5 eq.1: Doesn't seem necessary to define Q_l and Q_t because your expression for Q_t is also valid for laminar flow when the friction factor is defined as 64/Re (e.g., eq. 3).

p. 8 lines 5-6: This needs more discussion. It is true that mass transport across the diameter will reduce value of the effective reaction-rate coefficient, the amount of reduction depends on the fluid velocity, diffusion coefficient, and reaction rate (e.g., Szymczak and Ladd, 2011). Furthermore, when the flow transitions to turbulence, mass transport is no longer limited by diffusion, but turbulent mixing.

p. 8 lines 10-13: This deserves a reference.

p. 9 lines 1-2: Why simplify to assume a hydrostatic pressure distribution when the model implicitly calculates the pressure loss along the flow conduit? Calculating the actual pressures seems trivially easy.

p. 9 lines 13-14: How is the flow rate in each fracture element calculated? Presumably this involves solving a system of linear / nonlinear equations depending on the flow rate. More information on the details of these calculations would be helpful.

p. 9 lines 15-16: This must also include eq. 5 for the mass flux between each cell?

p.9 lines 10-18: The scheme described here is first-order in both space and time and, thus, likely quite sensitive to Δt and Δx. Did you conduct a sensitivity analysis to ensure that Δt and Δx were adequately small to achieve convergence?

p. 10 line 7: What is a "classical fracture"?

p.10 line 27: Why increase the tube diameter for the deeper fracture? As noted by Kaufmann et al. (2014) and many others, fracture permeability is expected to decrease with depth. It would seem more physically relevant to include a tube with the same diameter at the surface and decreasing with depth than a larger fixed-diameter tube.

p. 12 line 25: Can you give an example when one might expect to have such a supersaturated influent solution?

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