The manuscript by Shavelzon et al. aims to establish a novel connection between chemical weathering, transport self-organization, and non-equilibrium thermodynamics by using a particle-tracking reactive transport model in 2D porous media with varying heterogeneity. This topic would likely be of interest to researchers seeking better frameworks to describe the formation of preferential pathways in the subsurface driven by water-rock interactions. However, the current version of the manuscript is difficult to read and interpret, due to excessive technical density, insufficient narrative structure, and limited discussion of the model assumptions and broader scientific implications. I think major revisions are needed before the manuscript can be considered for publication.

1. Excessive length, technical complexity and abstract terminology. The paper dives into lengthy derivations and modeling details early on (especially Sections 2-3), but without sufficient explanations for why this framework matters or what the reader should expect to learn. This makes it difficult to parse how the pieces fit together—especially for readers unfamiliar with entropy generation in porous media. A conceptual figure or roadmap either at the end of the Introduction or at the beginning of the Methods would help guide the readers.

2. Unclear assumptions in reactive transport setup and their implications for the conclusions. The authors employ a simplified reactive system consisting of only two solute species (H^+ and H_2CO_3) and a single dissolution–precipitation reaction involving calcite. Important geochemical complexities, such as full aqueous speciation (e.g., bicarbonate, carbonate), are omitted. I think it is necessary to clarify the rationale for these assumptions and discuss their implications for the applicability of results to real-world weathering environments.

3. Conclusions are too technically narrow. It would better for the authors to frame their findings in the broader implications for real-world geochemical systems, such as rock weathering in karst systems or channelization in CO_2-enhanced weathering. Discussing such applications would help connect the modeling results to field-scale processes and enhance the overall significance of the study.

Minor comments:

- Abstract, Line 2: "that" -> "which"; add "the" before "emergence"
- Introduction, Line 17: It is not appropriate to refer to chemical weathering as a geophysical phenomenon. Consider revising to “geochemical process”
- Line 663: typo "expend Figure 8biture for the network"