

Interactive comment on “Distinct Element geomechanical modelling of the formation of sinkhole cluster within large-scale karstic depressions” by Djamil Al-Halbouni et al.

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This manuscript proposes a parametric study of numerical simulations reproducing the formation of sinkholes in different types of settings in Karsts, and the discussion/comparison of the simulation results with real sinkhole fields observed in the Dead Sea region, depending on the formation modes and ground properties.

The article is well written, illustrative, the simulations are convincing, the discussion is interesting, and its conclusions are well supported by the material provided. The phenomenon is interesting for the readership of this journal, and I support its publication.

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Discussion paper



I have a few small questions/suggestions :

1. In the codes used, what is the dynamics of particles, i.e. the interaction laws adopted ? What is the influence of the viscosity during the shocks on the patterns observed ? What is the influence of the inertia during the impacts ? Is the code overdamped ? Are the mechanical waves playing any role in the code dynamics ? Are the results dependent on the dissipation modes chosen (viscosity) ? Of the size of the particles ? How ?

2. Please precise the subrosion scenarios in more details – the first reading seems to show that particles are all removed at once, but subrosion rates are mentioned later on. Please provide a clearer / more detailed description. In general, there is an impact of removing particles in a single layer, or in several ones, as shown by the paper. This shows that the way of dissolving the particles matters. Hence, some details could matter : What are the physical mechanisms controlling this subrosion rate ? Is it constant ? Is it homogeneous ? What if particles are removed progressively, as in a chemical dissolution process, with an expression linking kinetics and concentration in some species (and possibly, stress) ? (See e.g. : Koehn, D., Renard, F., Toussaint, R., & Passchier, C. W. (2007). Growth of stylolite teeth patterns depending on normal stress and finite compaction. *Earth and Planetary Science Letters*, 257(3-4), 582-595. Szymczak, P., & Ladd, A. J. C. (2004). Microscopic simulations of fracture dissolution. *Geophysical research letters*, 31(23). Toussaint, R., Aharonov, E., Koehn, D., Gratier, J. P., Ebner, M., Baud, P., ... & Renard, F. (2018). Stylolites: A review. *Journal of Structural Geology*.)

3. Is it possible to relate such dissolution kinetics to the motion of the waterbed, and the simulation of concentration fields associated to it ? What is the concentration profiles leading to the differential erosion rate ? Is there any influence of damage due to precipitation during drying, as e.g. in : Noiriél, C., Renard, F., Doan, M. L., & Gratier, J. P. (2010). Intense fracturing and fracture sealing induced by mineral growth in porous rocks. *Chemical Geology*, 269(3-4), 197-209. ?

4. P15, line 2 : " It must be noted that porosities over 0.5 have not been translated into apparent elastic moduli, the latter is assumed to be zero then. ": It would be better to use a different color there, since in reality even unconsolidated granular media, under gravity, will have a non zero velocity. The velocity is not modeled, and the velocity is low, but it is certainly not zero. Please precise it in the figure to remove the ambiguity.

Some few typos follow :

P11, line 10 : " This produces deeper and sinkholes in the later stages of the model evolution. " : no " and "

P13, line 10 : "These aspect are better understood " : aspects

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