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Comment

# ***Interactive comment on “Small sinkhole-like features in alluvial plains: the example of Paganico (Lucca Plain, Italy)” by M. Dell’Aringa et al.***

**Anonymous Referee #2**

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The authors present an interesting case study and present at least two mechanisms for the formation of “micro-sinkholes”. However, the authors do not seem to come to a single, solid conclusion. Whereas, a little uncertainty is necessary to move the science forward, the authors need to adopt the most-likely scenario for sinkhole formation and then provide uncertainty. As it is written, the authors are so uncertain as to why the sinkholes are forming (equal weight seems to be given to alternatives) that they seem to be confused. Several things from their study are clear: 1) Pumping of the sand and gravel aquifer has created a drawdown near the city and groundwater is being drained from the entire column of the overlying strata (both sandy silt and silty clay

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layers) resulting in the formation of sinkholes. Consequently, the macropores of the materials overlying the aquifer must be connected in some way. Could it be that the sandy silt layer does not contain a perched water table, but contains THE water table? 2) Sinkholes only form in the sandy silt layer and not in the silty clay layer. This, and the distribution of micro-sinkholes in the vicinity of the city wells, suggests that the silty clay layer may have little to do with sinkhole formation other than providing pathways for drainage of groundwater into the underlying sand and gravel aquifer near the well field. In fact, Figure 15 indicates that all strata are hydraulically connected, although it is not clear what data was used to prepare this model. 3) The horizontal tunnels look very much like animal burrows. This possibility needs to be addressed. 4) Based on the conclusions, sinkholes have little to do with damage to buildings and, I assume, infrastructure. This does not come across to the reader in the Abstract.

Whereas, the flow of water between the overlying sandy silt and the sand and gravel across an aquitard could contribute to lowering of the overlying perched water table, lowering of the perched water table in the sandy silt seems to be controlling the formation of microsinkholes near the canals. This suggests that the movement of groundwater and sediment through horizontal tunnels may be controlling the formation of microsinkholes near the canals. Did the authors note the direction of the horizontal conduits and/or look for discharge points of these horizontal tunnels along the drainage canal? If present, does the discharge water (spring water) along the canal carry large sediment loads? Did the authors look for fine sediment consistent with the character of the overlying strata that might be periodically found in wells that intersect the sand and gravel aquifer? The drawdown near the well field and the steep hydraulic gradient toward the drainage ditch are similar conditions conducive to the formation of conduits and sinkholes. The authors need to treat them as one triggering mechanism.

There is a significant language problem throughout the manuscript and some of the terminology is odd in this paper (e.g., superficial waters and water table, temporary aquifer, sinks, vertical tunnels, aquitard water table, aquifer roof). Many are no doubt

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due to translation from Italian to English, and the manuscript needs to be revised by a technical editor prior to publication. Unfortunately, the manuscript comes across as though the authors are not familiar with standard terms of hydrogeology.

Figures: The soil cracks (macropores) in Figure 5 are widest at the top and narrow with depth. The distribution of micro-sinkholes seems to be controlled, to a large extent, by the roadways and railway lines of the Paganico area (Figure 13). Whereas, this distribution might be partially explained by changes in the stratigraphy (p. 3421, lines 26-30), this situation seems rather odd and might suggest a biological component (e.g., a burrowing animal) whose migration patterns might be altered by the local infrastructure. Sub-horizontal tunnels look a lot like animal burrows (Figures 7, 10 and 11). Did anyone look for evidence of animal activity?

Minor comments: The concept of a “temporary aquifer” (p. 3414, lines 25-28) should be changed to a “perched aquifer”. Further, the “silty-clayey horizon” should not be referred to as “impermeable” because it is clearly not impermeable; it is fractured.

Panno et al. 1994, not 2003. P. 3425, line 6.

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