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Uvalas and their relationship to sinkholes (dolines) in an evaporite karst setting

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Enclosed topographic depressions are characteristic of karst landscapes on Earth. The scale and morphological characteristics of such depressions are variable, but the most common depression type is a sinkhole (doline). Certain karst depressions that are much larger than sinkholes and that display gentler slopes and more complex three-dimensional shapes are known as uvalas. A single uvala typically contains numerous sinkholes within it. The developmental relationship between sinkholes and uvalas has been subject of debate, however, mainly because long developmental timescales impede direct observation in classical limestone karst, where such features are most commonly reported.

Here, we describe the development of five uvalas and numerous associated sinkholes in an evaporite karst setting on the eastern shore of the hypersaline Dead Sea. This karst landscape evolved rapidly over a 25-year period from 1992 to 2017 in response to the anthropogenically-driven decline in the Dead Sea level. Our remote sensing data and field observations show that both the sinkholes and the uvala-like depressions formed through subsidence in a very close spatio-temporal relationship. While many sinkholes developed initially in clusters, the uvalas developed around such clusters as larger-scale and gentler depressions that are structurally distinct both in space and time.

In agreement with inferences for examples in limestone karst settings, the uvalas in this evaporite karst setting do not form by a simple coalescence of sinkholes. Instead, these evaporite-karst uvalas form through subsidence (sagging), interpreted here as in response to distributed subsurface dissolution and physical erosion within a mechanically unstable subsurface volume (e.g. a groundwater conduit network). Sinkholes, on the other hand, are interpreted as discrete subsidence responses within that volume to smaller-scale zones of highly localised material removal (e.g. individual groundwater conduits). Our observations and interpretations are consistent with numerical modelling of subsidence produced by the development of multiple void spaces at progressively deepening levels. Morphometrically, our results also agree well in several respects with a recent re-evaluation of uvalas in some classical limestone karst areas.

Consequently, this study helps to clarify the nature, occurrence and genesis of uvalas in karst systems generally.