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Subsidence and collapse sinkholes in soluble rock: a numerical perspective

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Soluble rocks such as limestone, gypsum, anhydrite, and salt are prone to subsidence and the sudden creation of collapse sinkholes. The reason for this behaviour stems from the solubility of the rock: Water percolating through fissures and bedding partings can remove material from the rock walls and thus increase the permeability of the host rock by orders of magnitudes. This process occurs on time scales of 1,000-100,000 years, resulting in enlarged fractures, voids and cavities, which then carry flow efficiently through the rock.

The enlargement of sub-surface voids to the meter-size within such short times creates mechanical conditions prone to collapse. The collapse initiates at depth, but then propagates to the surface.

By means of numerical modelling, we discuss the long-term evolution of secondary porosity in gypsum rocks, resulting in zones of sub-surface voids, which then become mechanically unstable and collapse. We study two real-world case scenarios, in which we can relate field observations to our numerical model: (i) A dam-site scenario, where flow around the dam caused widespread dissolution of gypsum and subsequent subsidence of the dam and a nearby highway. (ii) A natural collapse sinkhole forming as a result of freshwater inflow into a shallow anhydrite formation with rapid evolution of voids in the sub-surface.