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A geomechanical model of a sinkhole formation

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On December 2010 a sinkhole was suddenly formed close to the eastern flank of Ocna-Mures salt dome. Soon after the collapse the sinkhole was filled with brine forming a salt lake called Plus Lake. The total volume of sinkhole of about 100000 m3 remained constant since February 2011.
The Ocna Mures salt dome is situated on the western border of the Transylvanian basin (Romania) and has been exploited for a long time. The ceilings of some shallow mine chambers are now collapsed and filled with brine.
Along the eastern flank of the salt dome there is a disturbed zone due to diapirism. Its presence is suggested by the strong fragmentation of rock in the boreholes drilled along the salt-sterile contact, as it resulted from the low values of RQD index. The sinkhole is probably due to a pressure increase along the diapir flank. The causes of this sudden increase of pressure are not well known. Most probably it is due to the damage of the tubing of a flank borehole as mentioned in a technical report of the exploiting company. The injected fresh water expelled through the breaches of the damaged borehole and, due to the high pressure flushed up the crushed material of the disturbed zone.
In order to better understand the setting up of the Plus Lake joint research efforts were performed by teams from Bucharest and Basel Universities since 2013.
For the geomechanical approach a numerical model was performed using the Flac 7.0 code. In a first stage the creep behavior of salt was analyzed considering a Norton creep law. It resulted that after 100 years the salt reached equilibrium, the creep could be neglected and in a first approximation mechanical equilibrium could be analyzed considering only an elasto-plastic behavior of both the salt and the sterile. For both the salt and the surrounding sedimentary rocks the Mohr-Coulomb criterion was considered.
The properties of sterile rocks were estimated following the GSI system. Due to poor rock quality the strength parameters have very low values, with a cohesion within a range from 0.167 to 0.46 MPa and a friction angle in a range between 1.05 and 4.5 degrees.
As a result the global safety factor is strongly diminished, to values close to 1. In this case the rock mass exceeds the limit for equilibrium and will collapse. Also the maximum shear strain rate is concentrated in a narrow zone which delineates a disequilibrium prism, which according to the velocity vectors is sliding to the old mine chambers. Thus, after the collapse of the prism the rock mass will enter into the old mine chambers and the expelled brine will form the Plus Lake.