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Assessment of Past, Present and Future Stability Conditions in the Kłodawa Salt Dome Based on 3D Numerical Modeling

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Abstract

Located in central Poland, the Kłodawa salt dome is 26 km long [16.16 miles] and about 2 km [1.24 miles] wide. The dome is characterised by complex geological structure. Zechstein salt formation (late Permian) consists of rock salt, potassium-magnesium salts and barren rocks. Exploitation of the dome started in 1954 and has been carrying out till these days. The structure and geometry of mine workings is complicated as a result of room exploitation system. All these factors in connection with necessity to consider the exploitation progress made the assessment of rock mass stability very challenging.
The 3D numerical model of Kłodawa salt mine included 7 mining fields and 14 mining levels (about 2000 mine workings) at the depth from 322 to 698 meters below sea level [from 1056.43 to 2290.03 ft.b.s.l.]. The dimensions of the model were 4200 m x 4700 m x 1200 m [2.61 mi x 2.92 mi x 0.75 mi] what was simulated by 33 million elements. Numerical modelling was carried out in FLAC 3D and included period from the beginning of exploitation to the end of 2015 as well as the prediction of further exploitation (till 2052). Consequently, rock mass stability during 60 years of exploitation and its predictions for the next 37 years were determined. This almost 100–years duration was divided into 5-years periods in which the exploitation progress was projected chronologically. Moreover, for every 5-years period the numerical model was calculated firstly as elastic-plastic mode and secondly as visco-plastic mode (with use of power-law and Coulomb-Mohr models). Assessment of stability conditions was based on convergence measurements and laboratory tests. The strength/stress ratio in the vicinity of exploited mine workings on different levels and for different periods of time were determined.
The 3D numerical model was built taking into account the current knowledge about the salt dome geological structure and mechanical parameters of rocks mass. Application of changes concerning e.g. mechanical parameters, geometry of mine workings is possible. Consequently, periodic update of the model is advisable especially in a view to changes in exploitation progress or mine management plans.

Key words: rock salt, Kłodawa salt dome, rock mechanics, 3D numerical model