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Ground subsidence and fault reactivation during in-situ coal conversion assessed by numerical simulations

Mansour Hedayatzadeh[1], Vasilis Sarhosis[1], Torsten Gorka[2], Mária Hámor-Vidó[3], and István Kalmár[4]

[1]School of Civil Engineering, University of Leeds, LS2 9JT, Leeds, UK (manhed83@gmail.com)
[2]DMT GmbH & Co. KG, Am TÜV 1, 45307 Essen, Germany
[3]Department of Geology and Meteorology, University of Pécs, Ifjúság u. 6, 7624 Pécs, Hungary
[4]Calamites Ltd., Daraboshaz 3, Nagymanyok 7355, Hungary

One unconventional coal extraction method is in-situ coal conversion. In this process, the coal is gasified in an underground reactor. A crucial issue that should be considered in this approach is the assessment of short and long-term environmental hazards and risks to human health and the environment resulting from potential surface subsidence and fault activation in the presence of complex geological conditions. This research aimed to assess potential environmental impacts associated with a commercial-scale application of in-situ coal conversion in a high coal production area in the Maza-Varalja region in Hungary. The Maza-Varalja region is an environmentally protected forested area. In this research, the numerical modeling of surface subsidence and fault activation was implemented using the finite-volume numerical modeling software FLAC3D. A predictive three-dimensional geomechanical model has been developed using site-specific geological data. The material model is Mohr-Coulomb elastic-plastic. Zero thickness interfaces were employed to address the fault behavior with friction and cohesive characteristics. The in-situ stress was determined by geostatic loading and a horizontal stress factor. The boundary conditions were zero-displacement and positioned sufficiently far from the coal seams to not artificially influence the stress field. The initialized zone stresses were considered using the density of the zones above them and gravity. The horizontal to vertical stresses ratio was determined to be one. A series of sensitivity studies were conducted to address the importance of geologic parameters that have an impact on surface subsidence, fault activation, and pollutant migration to the surface. In order to achieve this, seven variables, including the unit weight, Young's modulus, Poisson's ratio, friction angle, cohesion, fault friction, and excavation sequence, were considered. Sixty-six simulations were undertaken and analyzed. The simulation results demonstrate that surface subsidence is affected by the average Young's modulus of the geological strata and the fault activation to the friction angle of the faults. Also, shallower seams are more likely to produce surface subsidence, while as excavation depth increases, surface subsidence decreases. The model's results have been used to develop an Environmental Hazard and Risk Management toolkit (Tranter et al., 2022) for planning and decision-making processes during in-situ coal conversion to ensure that environmental risks and mitigation actions are clearly quantified and outcomes forecasted.