Numerical modelling of surface subsidence associated with block cave mining using a finite element/discrete element approach

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Recent years have seen a major increase of interest in the block cave mining method which is characterized by extraction of a massive volume of rock usually accompanied by the formation of a significant surface depression above and in the vicinity of the mining operation. The ability to predict surface subsidence associated with block caving mining is important for mine planning, operational hazard assessment and evaluation of environmental and socio-economic impacts. Owing to problems of scale and lack of access, the fundamental understanding of the complex rock mass response leading to subsidence development is limited as are current subsidence prediction capabilities.

Through the use of an integrated FEM/DEM-DFN modelling technique this thesis presents a new approach to simulation of block caving induced surface subsidence allowing physically realistic simulation of surface subsidence development from caving initiation to final subsidence deformation. As part of the current research, a fundamental issue in modelling, the selection of representative equivalent continuum rock mass modelling parameters, is investigated and a procedure for calibration of modelling parameters devised. Utilizing a series of conceptual numerical experiments our fundamental understanding of the mechanisms and the role of the factors controlling block caving subsidence development is investigated. Valuable insights gained from this work are summarized in a preliminary subsidence classification and an influence assessment matrix of the governing factors. These are intended as an aid to engineering judgment for decision makers at the pre-feasibility and mine design stages.

This study also addresses one of the most challenging problems in mining rock engineering - the interaction between block cave mining and a large overlying open pit, focusing on caving induced step-path failure initialization. Using a novel approach to modelling data analysis a clear link between caving propagation, step-path failure development within the slope, and the resultant surface subsidence is established. In addition, FEM/DEM-DFN modelling is applied to the preliminary analysis of the block caving triggered slope failure at Palabora open pit.

This research represents a valuable contribution to block caving geomechanics and is a major step forward in the understanding of complex block caving subsidence phenomena, paving the way to more reliable assessment of caving induced subsidence deformations.