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Sinkhole risk management process within thermal collieries : A practical approach thereof

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ABSTRACT

Previously undermined areas pose a significant challenge to mining by opencast due to the risk of sinkhole occurrence. In order to optimise reserve utilisation as well as safeguard personnel and equipment there was need to develop a "Sinkhole Prediction Model" to assist in the prediction of areas prone to sinkhole formation. The aim of this research therefore was to develop a "Sinkhole prediction tool" with a view to pre-identifying areas of potential sinkhole hazard to inform better controls to assist in mining these areas safely. This was done utilising the current Hill (1996) caving height method culminating in the development of a hazard index model dividing the mining zones into high and low hazard. These areas were colour coded Red (High hazard) and Green (Low Hazard).

The "Sinkhole Prediction Model" evolved to include over hundred sinkhole incidences that were statistically analysed to firm up on the robustness of the Prediction Model capabilities. The Hill (1996) caving height formula was discounted after the statistical analysis indicated that a good prediction model lies in the interrogation of site specific data.

The outcome of the work conducted in this research report indicated a 97% correlation between the refined "Sinkhole Prediction Model" and the actual sinkhole occurrence at the Anglo American case study area (Mine X). Various refinements inclusive of lithological assessments, blast and drilling reconciliations as well as the implementation of the roughening up quality audits led to the implementation of a robust sinkhole management process that has managed to consistently assist in safeguarding equipment and personnel thus allowing for coal extraction optimisation in areas that could have been written off due to the sinkhole hazard. This risk can only be eliminated by mining the areas with the sinkhole risk.

Currently the method is being impacted by significant roughening up cost incurred in a drive to make the areas safe to allow for coal extraction. The roughening up process on average costs R3.5 million per sinkhole and is a function of the number of sinkholes found, which translates to an equivalent cost of R7 / sales tonne. The current sinkhole prediction model being employed in deficient in that it cannot pinpoint the actual location of the void in the area previously undermined by bord and pillar and this is a great limitation of this report. Various geophysical techniques were pursued to assist in the precise identification of the actual sinkhole spatially. This process was aimed to reduce the roughening up cost (entire block stabilisation) as opposed to targeted sinkhole excavation and stabilisation. This process proved futile as the void identification systems are highly incapable of identifying the voids /

sinkholes spatially (x, y and z coordinates) to assist targeted sinkhole treatment as a result of the following:

- System inability to penetrate areas comprised of highly conductive strata such as clays.
- Inability to distinguish between the underground voids and geological anomalies such as dykes.
- Not suitable for penetrating wet strata.
- Impacted by noise interference from mining machinery.

The major result of this research is the establishment of a site specific "Sinkhole Prediction Model" that can generate hazard plans in real time thus informing the management on areas associated with a potential sinkhole hazard. The hazard plans can be generated timely and decisions made to facilitate safe coal extraction in areas of high sinkhole hazard.

This has culminated in a robust sinkhole management process within the group that has managed to eliminate the risk of personnel and equipment exposure at Mine X. The roughening up process is accepted as the primary sinkhole mitigation or rehabilitation process with the need to work towards reducing the roughening up costs through development of the tool capable of precisely identifying the voids routinely to facilitate targeted rehabilitation. Significant research is required in this area as the mining environment is comprised of strata that currently cannot support the use of real time void identification to facilitate targeted void identification and rehabilitation. There is also merit in the future to formulate the database capable of assisting in the prediction of sinkholes in the Witbank coalfield as well as assist in robust management of mining boundaries across the different mining houses. The system implemented at Mine X is currently being deployed to other operations in the group where modification will be made to match the site specific conditions.

Future research into understanding the sinkhole occurrence dynamics is quite crucial if targeted rehabilitation is to be achieved for cost reduction and mining sustainability. A combination of the understanding of the sinkhole occurrence driving mechanisms in conjunction with use of modelling packages such as ELFEN (a hybrid Modelling) tool will go a long way in enhancing the development of precise sinkhole prediction point in space.