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Investigation into the magnitude and direction of ground stresses in the coalfields and their impact on safety and productivity

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Abstract

In situ stress is an important input for design in rock mechanics. It is often used as the boundary condition in numerical modeling. In coal mines, and particularly South African coal mines, stress has been granted very little attention. As a result, mine layouts have been designed with little consideration of stress. However instances of stress related falls of ground which lead to injuries, fatalities and production losses are reported.

The present study, through site visits and direct roof observations, has assisted in quantifying the impact of stress in the Witbank and Highveld coalfields. It was found that some mines experience severe stress-related problems. A hazard map was created based on observations and results of in situ stress measurements carried out in the Witbank and Highveld coalfields. This hazard map is intended to be used for estimating the potential of stress related problem in absence of accurate stress measurements.

A NNW-SSE direction of major horizontal compressive stresses was found to be consistent across the two coalfields, although a change to a NE-SW direction was also observed in the north-eastern part of the Witbank (Arnot Colliery). This change in stress direction was confirmed by both in situ stress measurements and underground mapping. While this change in direction has been attributed to local effects such as the presence of surrounding opencast mines or major structures (faults and dyke), this study has shown that the propagation southward of the east African rift can also be the cause.

Numerical modelling was carried out to demonstrate how ground stress is generated by geological processes such as erosion and sedimentation. Results of this analysis were found to correlate well with the in situ stress measurements. Therefore, it was concluded that the actual stress regime across the Witbank and the Highveld coalfields is the result of a complex process of erosion and sedimentation. Numerical modelling and observation have also confirmed that the k-ratio (horizontal stress) increases with the depth of weathering and that isopach maps of weathering can be used in prediction of stress related problem.

Various mitigating techniques are being used in the Witbank and Highveld coalfields to combat deleterious effects of horizontal stress. As part of this study, the reduction of the cutout distance, and the undercutting technique have been modeled in detail using a finite

element software package (Phase2). It was found that these mitigating techniques are more efficient for lower k-ratios than higher k-ratios. Therefore, they are expected to work better when mild stress problems are experienced rather than severe ones.