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A study of VCR multi-reef remnant extraction in the Carletonville area

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ABSTRACT

Even after years of mining, a vast gold resource remains in the Carletonville area of the Witwatersrand basin. Mining in this area nevertheless predates 1934 and the accessible ore-reserves on the primary reefs are being depleted. Mining of secondary reefs and remnants has therefore become important in recent years. Of particular interest is multi-reef mining as it will become much more prevalent in this part of the gold mining industry. Very little rock engineering research on multi-reef mining scenarios at great depth is available in the literature. Owing to the lack of proper understanding and guidelines for remnant selection and extraction in a multi-reef environment, a study was conducted by the author of this dissertation. The key references of earlier work are discussed in the literature survey.

This study compared two displacement discontinuity boundary element codes, MINSIM and TEXAN, to simulate multi-reef environments. The preliminary analysis proved to be valuable and indicated that a small middling with a large overlap of mining is required to achieve a significant effect on ERR and average pillar stress on the remnant pillar. Care should be exercised with the so-called “45° rule” when destressing pillars and modelling is required in all cases. The study found that there is no significant difference between the results obtained from the two numerical modelling codes.

To better understand the process of understoping, a simplified geometry of a pillar being understoped was investigated. An analysis of the incremental stress evolution in the middling between two reef horizons, as the pillar was being incrementally understoped, revealed valuable information. A zone of very high major principal stress and low minor principal stress develops between the two reefs. This indicates a high risk of violent shear failure between the two reefs. The reason for successful historic extractions of actual multi-reef remnants was therefore explored in more detail.

As part of this analysis, an “extended” ERR concept introduced by Napier in 1991, was investigated. It was found that bedding planes and lithology played a crucial part in the stable dissipation of energy in these multi-reef remnant geometries. The study indicated that the stope convergence and the various energy components are affected by the presence, position and properties of a bedding plane. The energy solutions are very complex and sometimes counterintuitive. Care should be exercised when modelling specific cases. The modelling was nevertheless valuable to indicate that energy dissipated on weak layers, such as bedding planes, may reduce the risk of violent failure in a multi-reef mining scenario. This is an important novel contribution of this study.

As a further step, actual multi-reef remnants were selected and back analysed to verify the hypothesis of weak layers being useful to make multi-reef mining less hazardous. Aspects such as seismic history, numerical modelling and photographic records were studied. From the analysis it was found that multi-reef extraction was successful in cases where a weak rock type was present in the immediate stratigraphy or where pertinent bedding planes were found. This supported the hypothesis as presented above.

An important practical outcome of this study is that much greater emphasis needs to be placed on studying the rock mass surrounding multi-reef environments at depth to determine the risk of extraction in these conditions. This should be added to the list of remnant selection criteria.