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Resue firing and dilution control in narrow vein mining

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Abstract

Mining of narrow vein/ore bodies invariably depending on the mining method selected involves the extraction of both ore and waste rock. The level to which mining of waste rock can be minimised depends on numerous factors, but particularly the thickness and dip of the deposit. Resue mining is a method of mining that allows split face firing within stopes to allow waste and ore to be mined separately allowing dilution to be minimised. This paper examines the technique of Resue firing and its applicability to the mining of narrow vein deposits. Particular emphasis is placed on the conditions in which Resue mining presents a suitable option for mining of narrow veins.

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Introduction

Narrow vein mining is a challenging mining process. Mining using narrow vein mining methods in the modern industry is highly equipment orientated but still offers the same challenges as the old miners faced, one of these that is a critical parameter is dilution control (Dominy et al, 1998). In order to access narrow vein deposits in order to extract the mineral it is generally required to make the drives of larger dimensions than the vein being mined. In some cases this can be achieved using specifically designed narrow profile mining equipment, for example at Waterval in South Africa (Atlas Copco, 2006). In many cases where standard equipment is utilised the effects of dilution can be considerable and have an impact on the economics of the mining operation. Particular problems associated with excessive dilution in narrow vein operations include:

1. Difficulty in maintaining a consistent head grade to mineral processing operations
2. Increased transport costs associated with transporting highly diluted run of mine ore from the mine
3. Geotechnical difficulties
4. Difficulty in applying modern mining equipment, leading to enhanced labour costs
5. Low production rates

The above list is by no means exhaustive but indicates that for profitable production a high degree of engineering skill, good communication between all professions at the mine site and good planning are essential.

This paper discusses the method of reseue mining, in particular simultaneous firing reseue methods to narrow vein mining.

Reseue mining

Reseue mining methods can be broadly defined as ‘a method of stoping in narrow vein deposits whereby the wall rock on one side of the vein is blasted first and then the ore’ (Wickens, 2007).

From this definition two types of reseue mining can result. In most systems either the ore or waste rock are blasted first, mucking is then undertaken, then the remainder of the material is blasted and mucked. This is a two stage process and as such greatly increases the mining cycle time and therefore the cost of the operation. Other problems also are possible with this method such as the potential for safety problems and geotechnical problems particularly in seismically active mining operations.

The second type of reseue operation is where all the rock is blasted in one firing. In this case either the ore or waste are blasted during the initial stages of the firing and thrown further down the drive, then the remainder of the drive is fired with less throw. Thus ore and waste are separated and can be mucked out separately utilising modern mining equipment and ensuring workers
always work under fully supported ground. This method can be termed a simultaneous method of resue firing, or a method of firing which fires out the face in two distinct periods but within a single blast.

**Simultaneous resue firing**

The method of simultaneous resue firing is best described with reference to an example. Consider the situation as illustrated in figure 1, with a drive in a narrow vein mining operation where there is a vein running diagonally across the drive, at this point it should be noted that the orientation of the vein is not of relevance. In a typical mining situation this drive would be fired as a single continuous blast resulting in mixing of both the waste and ore which would need to be mucked out as a single product, so resulting in dilution.

In the method of simultaneous resue firing the drive would be blasted as shown in figure 2. Figure 2a shows the drive prior to firing. In this case the blast holes within the ore zone are fired as per a normal drive blasting operation using long period detonators allowing the material from the cut and each sequential set of holes to be fragmented and ejected a distance down the drive, prior to the next set of holes being fired as illustrated in figure 2b. Once the ore has been blasted the remaining waste is blasted using millisecond delays to provide minimal throw but to fragment the ore and leave it at and/or close to the freshly blasted face, as illustrated in figure 2c. Use of perimeter control blasting at this latter stage also ensures minimal damage to the surrounding rock mass enhancing the stability of the freshly created drive.

As can be seen from figure 2 a blast sequenced in such a way would result in a two separate zones of fragmented material, ore thrown further down the drive and waste close to the blasted face. Thus the two materials could be mucked separately with ore being transported to surface for subsequent treatment and waste transported to be used as waste fill underground as required. This minimises haulage costs to surface. In reality it is unlikely that the results of such blasting would result in two distinct zones of material, there will be a zone where ore and waste are mixed together, this would require a decision to be made regarding the destination of this mixed and diluted material. It should be noted that if this material were to form part of the ore stream the amount of dilution would lower than in the tradition blasting method.

**Practical Application of the method**

As part of a final year student project (Place, 2007) the method of simultaneous resue firing was to be trialled at Tom’s Gully mine in the Northern Territory in early 2007. The aim of the study was to trial the method to reduce dilution from the underground mining operation. A number of firing options using a variety of long period and millisecond delay periods were outlined and being prepared to be implemented. Unfortunately due to a significant rainy season the underground operation flooded and the method could not be tested. In the proposed study the waste was to be blasted first and after a period of 2 seconds the ore was to be blasted, the reverse to the situation illustrated in figure 2. A particular issue at this mine was the
competence of the waste rock hosting the veins of gold mineralisation and a key parameter of the investigation was to determine the amount of waste to leave in place to support the ore during the 2 second waiting period between the sections of the blast for the method to work effectively.

It is hoped the method can be trialled at another mine in the near future.

**Suitable conditions for simultaneous resue firing**

From the preceding discussion it can be seen that simultaneous resue firing offers a potential method of mining narrow vein deposits by for example a cut and fill mining method. It also offers the potential to apply standard mechanised mining equipment and to reduce dilution of the ore stream coming from the stopes. The question arises under what conditions this mining method could be potentially selected. It should be noted that this mining method should only be selected if it provides a more economic method of mining for a given geometry and set of actual mining conditions.

Some of the conditions favouring selection of this method are listed below:

1. Well constrained vein type deposit with good definition of both the hanging and footwall contacts
2. All dips of vein can be mined
3. Suitable for mining variable width veins
4. Good viable differentiation between ore and waste materials would be preferred
5. Geotechnically similar and dissimilar ore and waste can be mined. Where geotechnical competency is dissimilar account must be taken of the need to leave supporting waste for the ore during the rest period between the long period and millisecond detonators if the ore is fired second

**Conclusion**

Simultaneous resue firing offers the potential to reduce dilution in narrow vein mining operations as historically standard resue firing has. It also allows standard mechanised mining equipment to be utilised without the need for personnel to work under unsupported rock. The method is to date untested and will require further refining on a site by site basis before becoming an accepted narrow vein mining method. It is highly suited to curtail and fill mechanised mining in narrow veins but could also be used-in-room and pillar operations.

**References**


Figure 1: Example drive cross-section

Figure 2: Firing of drive