Why the small-span small-pillar (sssp) concept for underground mining?

Introduction

By this time it is common knowledge that seismic events pose major risks for mineworkers, mines, and the public in the mining areas. The qualification and/or quantification of these risks to my mind are immaterial. The main objective should be to eliminate or control the causes of rockfalls and seismic events to the best of our ability. The mining fraternity should give more attention to removing or managing the causes of rockfalls and seismic events instead of mitigating the results.

Having worked on Crown Mines and East Rand Proprietary Mine, which was at that time (1952 to 1977) the deepest mine in the world, and being involved in rescue work underground after seismic events, I took a personal interest in this phenomenon.

After a considerable amount of research and following the development of the mines' efforts to address the problem of seismic events, I came to the conclusion as a production manager that *the major cause of seismic events was the excessive spans that were created during the stoping operations*. The challenge was to find a mining method (layout) that would enable the mines to keep spans between pillars to the minimum without jeopardizing profitability because of an unacceptable extraction ratio.

After the rock mechanics published their findings that a pillar in quartzite with a size to width ratio of 10:1 for a stoping width of 1 m should be indestructible, I put forward the idea of a pillar and stall method to the then Chamber of Mines Research Organisation.

The formation of a mine seismicity expert panel

This is a very commendable thought, provided it does not become another exercise in which a large amount of money is spent on the detail and intricacies of the different theories that are constantly being put forward for further investigation, which would be another of those nice-to-know exercises without presenting a real add-on value.

Why the small-span small-pillar concept?

The sssp method of mining comprises an array of small pillars left as support with the minimum span between pillars.

The cutting of pillars and stalls is looked upon as an unnecessary exercise, which will interfere with productivity and the extraction ratio of the orebody.

When this mining layout was compared with other known layouts for deep mines it proved to be the better layout, and in most cases where it has been accepted as practice in the platinum mines it has been found to be working well, with the added advantage of mechanized mining and fewer production delays due to 'backbreaks'.

To describe the progress of the SSSP concept I will set it out in chronological order, together with a brief summary of the findings and conclusions.

1993

Letter to the Government Mining Engineer dated 26 February 1993, written by F.S.A. de Frey. Reports on fatal accidents caused by seismic events on gold mines in the Carletonville area.

Conclusions:

The challenge is therefore to prevent seismic events or at least control the occurrence of seismic events by maintaining the state of equilibrium and stability in the mine at all times.

'If a board and pillar system can maintain the above stability, mining of the VCR and carbon leader at the same time should present no major problems.'

Letter from CSIR Mining Technology dated 4 May 1993.

'*I believe that your idea does warrant further attention and investigation, and that you should carry out the modeling yourself.*' [Signed] Duncan Adams.

Letter from J.A. Ryder dated 17 June 1993. Using BEPIL modelling.

'*4.1 The concept of using a dense array of strong squat pillars in mining at great depth has a number of extremely attractive features: minimal regional disturbance to the rockmass, with consequent low closure, ERR and field stress levels, and tolerable pillar foundation stress levels. Imponderables such as nature of hangingwall fracturing and incidence of damaging seismicity might best be evaluated on an actual field trial basis*'.

1995

Authors' reply to discussion on *Design of pillar systems in South Africa* by M.U. Ozbay, J.A. Ryder, and A.J. Jager. *Journal of the South African Institute of Mining and Metallurgy*, July/August 1995.

'*We agree wholeheartedly that further research, together with carefully planned field trials, is warranted in pursuit of this potentially highly rewarding concep*t.'

1997

Report from G.S. Esterhuizen, dated 20 June 1997. Using MINSIM-D stress analysis program.

Conclusions:

'It is concluded that bord and pillar layout at a depth of 3000 m will have minimal effects on the surrounding rock mass ... The proposed bord and pillar layout will result in extremely low levels of energy release rate, will have no destabilizing effects on geological structures, barring local instability. The layout will allow pre-development of tunnels at depths of 25 m 30 m below the reef. These tunnels will be safe from stresses induced by unmined geological structures on the reef plane.'

1998

A.R. Leach. Numerical evaluation of room and pillar mining methods in deep level mining. Completed as part of Deep-mine Task 3.2.1. CSIR Division of Mining Technology, Johannesburg, 31 December 1998.

Leach expressed doubts about the rock condition in close proximity to the sidewalls of the pillars. He concluded that it should not exceed the depth of 6 m in any normal longwall at depth.

1999

F.S.A. de Frey. Evaluation of bord and pillar as a mine design alternative for ultra-deep mines. Report on Deepmine task 3.2.1, March 1999. Submitted to F. Viera.

De Frey found that taking all the critical factors into consideration the only real problem would be the difficulty of ventilating mini-backstopes until the next holing for through ventilation is established. This was applicable only when the mining method was up-dip strike face stoping. Using overhand strike mining did not present a problem and is at present (2009) being successfully applied at the Amplats Waterval platinum mine.

2002

'Examine the criteria for establishing the small span small pillar concept as a safe mining method in deep mines'. SIMRAC GAP 828, January 2002

De Frey, Handley, and Webber expanded on the findings of the Deepmine project. So much time and effort was spent on proving that it was feasible to design a mine based on the sssp concept that the advantages of the *design from a seismic event* point of view did not get the necessary attention, and to my mind the real advantage was clouded by a lot of mining issues. In the end it was concluded that sssp compared very favourably on all the critical issues but that the main issue might be the possibility of pillar failures.

De Frey is of the opinion that this argument carries no weight if you compare all the other advantages from a seismic event point of view. It could only provide safer conditions from a seismic event or rockfall point of view.

2008

B.P. Watson *et al*. Merensky pillar strength formulae based on back-analysis of pillar failures at Impala Platinum. *Journal of the South African Institute of Mining and Metallurgy*, volume 108, August 2008.

The authors did an excellent job but to my mind are still only concentrating on the strength of the pillars and not giving the necessary attention to the effect of the spans between the pillars and their effect on the strength of the pillars.

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