Rockbursts in South African mines: risks, research, remedies and regulation

Professor Raymond Durrheim; Mr Kevin Riemer

Abstract

Gold was discovered near present-day Johannesburg in 1886. Mining-induced seismicity and its hazardous manifestation, rockbursting, were first encountered in the early 1900s when extensive stopes reached depths of several hundred meters. Gold-bearing conglomerates were found buried beneath younger strata in the East Rand district in 1914, the Far West Rand and Klerksdorp districts in 1937, the Orange Free State in 1946, and the Kinross district in 1955. The dipping conglomerate “reefs” were found to persist to depths of several kilometres. Rockbursts became one of the most serious and least understood problems facing deep mining operations, claiming the lives of thousands of mine workers. Despite many technical advances, rockbursts continued to pose a significant risk. The largest mining-related seismic event recorded in South Africa occurred in the Klerksdorp district on 9 March 2005. The M_L=5.3 main shock and aftershocks shook the nearby town of Stilfontein, causing serious damage to several buildings and minor injuries to 58 people. No. 5 Shaft at DRDGold’s Northwest Operations suffered severe damage, two mineworkers lost their lives, and 3200 mine workers were evacuated under difficult circumstances.

The Ophirton Earth Tremors Committee was appointed in 1908 to investigate the cause of the tremors and to determine what could be done to mitigate their effects. The Ophirton Committee recommended that support pillars be replaced by waste packs and that seismographs should be installed. The seismograms provided compelling evidence that the tremors were driven by the mining activity. As the industry expanded and mining proceeded to greater depths, other committees were appointed in 1915, 1924, 1964 and most recently in 2005 following the Stilfontein event to address essentially the same questions.

Research was carried out in an ad hoc way until Chamber of Mines Research Organization (COMRO) was established in 1964. Since then, research addressing the risks of deep hard rock mining has mostly been conducted under the auspices of the COMRO (until its closure in 1993), CSIR, the Mine Health and Safety Council, and several public-private research programs.

Research work to mitigate the rockburst risk has focused on three main areas: (i) development of macro-layouts (e.g. sequential grid) and regional support (e.g. backfilling) to control the release of seismic energy through the geometry and sequence of mining; (ii) development of support units and systems (e.g. rapid-yielding hydraulic props, pre-stressed elongates) to limit rockburst damage; and (iii) mine seismology, which seeks to develop techniques to continually assess the seismic hazard and control seismic activity (e.g. through the rate of mining).

Implementation of these technologies, together with improvements in training, work organization and regulation, have reduced fatality rates and made it possible to mine successfully at depths approaching 4 kilometres, the greatest mining depths anywhere in the world by far. Current research aims to reduce the risk further by implementing mining methods that reduce the exposure of mine workers.