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Mitigation of the rockburst risk in deep South African gold mines

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Earthquakes pose a significant risk to workers in deep and overstressed mines, such as South African gold mines. A 5-year collaborative project entitled OBSERVATIONAL STUDIES IN SOUTH AFRICAN MINES TO MITIGATE SEISMIC RISKS was launched in August 2010 to gain knowledge, develop and transfer technology, and build capacity. It was funded by the JST-JICA Science and Technology Research Partnership for Sustainable Development (SATREPS). Research sites were established at three deep gold mines: Cooke #4 Shaft, Hlanganani and Moab Khotsong. Boreholes were drilled to locate faults accurately that were considered capable of producing mining-induced seismic events. A variety of sensors were installed to monitor the quasi-static deformation of the rock mass, the accumulation of strain, tilt changes during the seismic event and post seismic creep phase and damage during the earthquake preparation phase, and changes in dynamic stress produced by the propagation of the rupture front. The Council for Geoscience (CGS) deployed 10 surface seismic stations in the Far West Rand district. SATREPS provided a Kinemetrics Antelope Seismic Processing System to handle the large volume of data being acquired by the networks and the Horiuchi algorithm to automatically pick P- and S-arrival times and locate events.

Rockbursts are seismic events that cause damage to underground workings. Strategies to mitigate the risk posed by rockbursts can be divided into three categories: prevention, protection and prediction. By prevention, we mean a reduction in the occurrence of damaging seismic events. This is achieved by optimizing the design and sequence of extraction. The SATREPS project has made a significant contribution to the mine design capability by adapting and transferring the Japanese Compact Conical Borehole Overcoring (CCBO) stress measurement technique. Stress measurements, together with observations of borehole breakouts and discing of borehole core and seismic source parameters, are used to calibrate numerical models of mining layouts and sequences.

By protection, we mean the creation of rockburst-resistant excavations. As part of the SATREPS project we have studied the state of the rockwall in stopes near the research sites, measured the response of the rockmass to mining, and studied the performance of support elements and systems. In a complementary project, CSIR is developing various technologies to enable the stability of the hangingwall to be mapped prior to the entry of miners. These include robust closure and ground motion meters, thermal and acoustic mapping of hangingwall stability, and a robotic platform to carry these devices.

By prediction, we mean the reliable and timely forecasting of rockbursts so that mine workers may take refuge. We have used the unprecedented volume of high quality data gathered at the SATREPS sites to search for forerunners of seismic events. While we have gained new insights into the development of mining-induced fractures and the nucleation of seismic events, and studied variations in seismic

parameters such as the b-value, we have not yet found a reliable precursory signal that can be used to raise an alarm.

Other lasting benefits of the SATREPS project include: (1) the enhancement of the National Seismograph Network, and (2) opportunities for several young South African researchers to visit Japanese institutes and gain experience in high-level research. The SATREPS project has been an extremely valuable contribution to researchers and practitioners working in deep South African mines, and we are grateful for the contributions of many dedicated Japanese scientists and the support of the Japanese government through JST and JICA.