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Seismic risk mitigation in deep level South African mines by state of the art underground monitoring - Joint South African and Japanese study

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Two underground sites in a deep level gold mine in South Africa were instrumented by the Council for Scientific and Industrial Research (CSIR) with tilt meters and seismic monitors. One of the sites was also instrumented by JApanese-German Underground Acoustic emission Research in South Africa (JAGUARS) with a small network, approximately 40m span, of eight Acoustic Emission (AE) sensors.

The rate of tilt, defined as quasi-static deformations, and the seismic ground motion, defined as dynamic deformations, were analysed in order to understand the rock mass behavior around deep level mining. In addition the high frequency AE events recorded at hypocentral distances of about 50m located at 3300m below the surface were analysed.

A good correspondence between the dynamic and quasi-static deformations was found. The rate of coseismic and aseismic tilt, as well as seismicity recorded by the mine seismic network, are approximately constant until the daily blasting time, which takes place from about 19:30 until shortly before 21:00. During the blasting time and the subsequent seismic events the coseismic and aseismic tilt shows a rapid increase.Much of the quasi-static deformation, however, occurs independently of the seismic events and was described as ‘slow’ or aseismic events.

During the monitoring period a seismic event with MW 2.2 occurred in the vicinity of the instrumented site. This event was recorded by both the CSIR integrated monitoring system and JAGUARS acoustic emotion network. The tilt changes associated with this event showed a well pronounced after-tilt. The aftershock activities were also well recorded by the acoustic emission and the mine seismic networks. More than 21,000 AE aftershocks were located in the first 150 hours after the main event. Using the distribution of the AE events the position of the fault in the source area was successfully delineated. The distribution of the AE events following the main shock was related to after tilt in order to quantify post slip behavior of the source.

An attempt to associate the different type of deformations with the various fracture regions and geological structures around the stopes was carried out. A model, was introduced in which the coseismic deformations are associated with the stress regime outside the stope fracture envelope and very often located on existing geological structures, while the aseismic deformations are associated with mobilization of fractures and stress relaxation within the fracture envelope.

Further research to verify this model is strongly recommended. This involves long term underground monitoring using a wide variety of instruments such as tilt, closure and strain meters, a highly sensitive AE fracture monitoring system, as well as strong ground motion monitors. A large amount of numerical modeling is also required.