

Comparison of stress modeling with in-situ strain monitoring at seismogenic area in South African gold mines

OGASAWARA, Hiroshi^{1*} ; KATSURA, Taishi² ; HOFMANN, Gerhard³ ; NAKATANI, Masao⁴ ; YABE, Yasuo⁵ ; ISHII, Hiroshi⁶ ; NAKAO, Shigeru⁷ ; OKUBO, Makoto⁶ ; ANTHONY, Ward⁸ ; JERRY, Wienand⁹ ; PATRICK, Lenegan⁹ ; KAWAKATA, Hironori¹ ; MURAKAMI, Osamu¹ ; UCHIURA, Taka¹

¹Ritsumeikan University, ²Hitachi Solutions, Ltd., ³Anglogold Ashanti Ltd., ⁴The university of Tokyo, ⁵Tohoku University, ⁶Tono Research Institute of Earthquake, ⁷Kagoshima University, ⁸Seismogen CC, ⁹Sibanye Gold Ltd.

Compared with continuous in-situ strain monitoring in other mines, we discussed the time evolution of stress in rock mass at a depth of 3.3km for a ~1.5-year period 90m beneath a dip pillar at Mponeng mine. The pillar contained a 30m-thick dyke which a ML2.1 seismic event obliquely bisected. We analyzed the recordings of two multi-component Ishii borehole strainmeters which had been already installed nine months prior to the ML2.1 event. One of the strainmeters was installed in the dyke (gabbros) and the other in the host rock (quartzite) near the dyke contact, both being within a few tens of meters from the ML2.1 rupture plane.

The magnitudes and directions of the principal strain changes were similar for both strainmeters in the period prior to the ML2.1 event. This suggested that the increase in stress in the dyke was significantly larger because the dyke was significantly stiffer than the host rock.

After the ML2.1 event, associated with the start of mining on the eastern side of the strainmeters, the pattern of deformation changed between the two strainmeters.

The above-mentioned characteristics of deformation were compared with numerically modelled deformation by an elastic boundary element method using Map3D Fault-Slip. The magnitude of the Map3D strain changes were, however, several times smaller than the observed strain changes both prior to and after the ML2.1 event. The rock mass just around a stope in deep tabular mining is fractured and behaves time-dependently and non-linearly. Whatever the inelastic deformation, the stress field in an elastic area can be reproduced within reason provided that the boundary condition (deformation, force or stress) is appropriately specified on the elastic-inelastic boundary. Because it is well known that time-dependent inelastic stope closure is much larger than instantaneous elastic stope closure, as a trial, we analyzed a response to an additional forced stope closure using Map3Di (Seismic Integrator version). It was then found that the forced additional stope closure better accounted for both the magnitude and the deformation pattern observed by in situ strain monitoring. We concluded that the effect of inelastic deformation around the stope was significantly larger than the elastic effect induced by the advance of mining faces, and the direct effect of the very close ML2.1 event was not so significant.

A great amount of better maintained data sets of strain are now being accumulated in four gold mines, which will allow us to discuss in further depth.

Keywords: SA gold mines, Seismogenic areas, In-situ strain continuous monitoring, Stress time evolution