Japan Geoscience Union Meeting 2015
(May 24th - 28th at Makuhari, Chiba, Japan)

SSS30-P08 Room:Convention Hall Time:May 25 18:15-19:30

Reproduction of M˜2 earthquakes by elastic Boundary Element modelling and constraint of Mohr-Coulomb failure criterion

UCHIURA, Taka[1*] ; HOFMANN, Gerhard[2] ; WIGGINS, Mitch[3] ; STONE, Wouter[3] ; NDABA, Pinkie[3] ; PLOTZ, Janelle[3] ; LENEGAN, Patrick[3] ; YILMAZ, Halil[4] ; ZVARIVADZA, Tawanda[4] ; MNGADI, Siyanda[4] ; CARPEDE, Andrew[4] ; DURRHEIM, Raymond[5] ; MILEV, Alexv[6] ; OGASAWARA, Hiroshi[7] ; YABE, Yasuo[8] ; KATO, Harumi[9]

[1]Ritsumeikan University, [2]Anglogold Ashanti, [3]Sibanye Gold, [4]Witwatersrand University, [5]CSIR / Witwatersrand University / SATREPS, [6]CSIR, [7]Ritsumeikan University / SATREPS, [8]Tohoku University / SATREPS, [9]3D Geoscience, Inc.

Several M˜2 earthquakes have taken place at a mine, close to one of the sites of the JST-JICA SATREPS project. At this site, three Ishii borehole strainmeters were installed, continuously monitoring at a sampling frequency of 100Hz since December 2011 and achieving better data return than previous projects. Although an AE network was not planned at this site, CSIR installed four 14Hz geophones with spatial intervals less than 100m to improve hypocenter location accuracy of the in-mine seismic network (station intervals >˜500m yielding a few ten of meters of errors in epicenter locations and much larger errors in z-location). The initial stress assumption was well calibrated at the adjacent mine (˜3 km to the west; Hofmann et al., 2013) and in-situ stress measurements ˜1km to the south in a mine are available. Uniaxial laboratory tests were conducted to measure elastic and strength properties of selected core collected from the nine holes with a total length of about 340 m for the instrumentation,.

This study attempted to numerically simulate four M˜2 earthquakes (one and the next occurred in December 2013 and January 2014 respectively and the remaining two in August 2014) that occurred in a range of distances from 180m to 351 m from the site by using an elastic Boundary Element stress modelling software, Map3D. In Map3D stress modelling, non-linear elasto-plastic fault ride is reproduced with its magnitude and extent controlled by the peak and residual strength, when estimated stress reaches specified peak strength.

Hofmann et al. (2012) successfully reproduced plausible source size and mechanism of an Mw2.2 event which had occurred at a dyke at Mponeng mine in December 2007. They took into account the aftershock planer cluster Yabe et al. (2009) delineated by the JAGUARS AE network (Nakatani et al., 2008). Hofmann et al. found that the aftershock plane coincided with that plane with largest Excess Shear Stress (i.e. shear stress exceeding shear strength; ESS). It could therefore be suggested that we could define slip planes with some confidence if we find planes with maximum ESS.

In this study, progressive tabular mining about 1m thick was modelled on a mine-wide scale by Displacement Discontinuity planes that represented the monthly advance of mining faces from December 2012 to August 2014. We used the initial stress state determined by Hofmann et al. (2013) and calibrated with several in-situ stress measurements in adjacent mines several km to the west of a mine. We also confirmed the assumed initial stress could reproduce stress states capable of producing breakout or core-discing that was actually observed in nine instrumental holes at our site. In the stress states just prior to the occurrence of the four M˜2 events, we grid-searched (in 10 degree increments of dip) for the plane with maximum ESS that contained the located hypocenter and had a strike parallel to the edge of the closest thin tabular stope. We found that for three of the four M˜2 event, composite plots of shear stress versus normal stress on assumed fault planes were relatively well limited by a single Mohr-Coulomb strength criterion line, but the strength suggested was significantly larger than those suggested by Hofmann et al. (2012), while the strength suggested for the remaining event were similar to that estimated by Hofmann et al. (2012). We have to discuss potential reasons, e.g., alteration of stress field by some geological structures or difference between intact rock and existing plane of weakness. The progress in the discussion, including analyses of the monitored strain change, will be reported in 2015 JpGU meeting.

Keywords: Mohr-Coulomb failure criterion, Deep South African mines, Elastic Boundary Element modelling, Stress in seismogenic zone