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Strain changes observed with two Ishii strainmeters within only 20 m from an M2.1 fault located with AEs (2)

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In an extent of about 90 m at a depth about 3.5 km in the Mponeng mine of deep South African gold mine, we installed a 4-component Ishii strainmeter (hereafter Sd), a 3-component Ishii strainmeter (Sh), and eight AE sensors [Nakatani et al. 2007]. Tiltmeters are installed by CSIR [Milev et al. 2009 IASPEI]. These instruments target seismicity in and around Pink & Green dyke (hereafter PG) associated with ongoing tabular mining around the extent. In PG, an M2.1 earthquake took place on 27 December 2007. The M2.1 hypocentral fault was beautifully delineated with ˜20,000 AEs [e.g., Yabe et al. 2008 ASC; Naoi et al. 2008 AGU], showing Sd were located within 20m from the fault and Sh very close to mode II and II edges of the fault. Katsura et al. (2008 ASC) first analyzed strain data of Sh and Sd from 2007/Mar to 2008/Sep. They reported that the strain changes were on the order of 10^{-4}, before, at and after the M2.1. They also preliminarily reported some characteristics of the strain changes. However, they didn't report in further detail or discuss what deformation at the M2.1 fault or tabular cavity can account for the observed strain changes.

This study thought first delta CFF on the M2.1 fault before the M2.1. Because Sd and Sh show about the same strain change rates, assuming about the same strain change in PG, the delta CFF change can be assumed. Because normal strain direction of M2.1 fault in this period was remarkably extend, it is found that tend to occur event in proportion to time.

Next, in order to investigate what deformation can account for the observed strain changes, we used a crustal deformation analysis software MICAP-G [Naito & Yoshikawa. 1999] to simulate crustal deformation.
In order to consider coseismic strain change, we assumed a single rectangular fault with uniform slip that almost coincided with the M2.1 fault delineated by AEs [Yabe et al. (2008); Naoi et al. (2008 AGU); 80m L x 60m W; a dip angle of ˜65 deg.]. However, the co-seismic strain changes were not well explained by the single fault slip. So, we assumed several fault segments, consisting of a main segment [˜60m L x 40m W; a dip angle of 65 deg.] and smaller peripheral segments at Mode II and III edges of the M2.1 fault. Then we could have a much better agreement with the strain change estimated from observed strain changes.
The strain change over a 10-month period before the M2.1 could be explained by the closures of tabular stopes with a typical rate for gold mines at a similar depth.
As to postseismic period, over an 8-month period, the observed strain changes were not fully accounted for only by either stope closures or afterslips on the M2.1 fault. The advance of mining face or the extension of the M2.1 fault may results in the shifts of stress concentration areas, which may account for the observed strain change. At the meeting, we will report about those effects in detail.

We also report about new additional data obtained after September 2008, in which we can see a significant change in strain rate in October 2008. Sh-Ch.1 and Sd-Ch.1 (// sigma 1) had been extending after the M2.1 until June-September 2008 with a rate of 1 x 10^{-4} (strain/month). They died out around June-October and again started to contract. Whereas, Sh-Ch.3 and Sd-Ch.3 still continue to contract at a rate of ˜3 x 10^{-5} (strain/month) after the M2.1. At the meeting, we would report the interpretation of the change.