Strain transients before and after earthquakes smaller than 2 monitored with Ishii's strain meter at distances within 200 m

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In South African deep gold mines 2 - 3 km deep, earthquakes smaller than M=5 are induced in proximate front of excavation. So, we can a priori install instruments to monitor seismogenic process (e.g. Iio 1995). So far, we have had three experimental fields in three deep gold mines in South Africa. With tri-axial accelerometers, Ishii's multi-component strain meters and broad-band, wide-dynamic-range data acquisition system by ISS International Ltd. we had monitored rock mass response associated with mining (e.g. Ogasawara et al. 2001 RaSim5, 2002 Seismogenic Process Monitoring, Balkema). In the third field, in 1999 we drill a hole in parallel to the strike of a fault from a crosscut tunnel across the fault ~2400 m deep in Bambanani mine (Harmony mine after November 2001), Welkom, South Africa (Ishii et al. 2000 JSS Fall meeting). On the fault M~3 events are expected, associated with mining. To monitor strain buildup larger than 10^(-4), strain transient as subtle as 10^(-8) and dynamic response of remote triggering faster than several Hz on the seismogenic fault, we installed a multi-component Ishii's borehole strain meter in the hole. The strain meter with the recording system accommodates normal and shear strains on seismogenic faults larger than 10^(-4) continuously with a 24-bit, 25-Hz resolution. In addition, unclipped 120-dB seismic data of these mines are available to discuss stress change.

After intermission by underground fire, strain and seismic data recording started from 2001. So far, more than 50 CD-ROM were sent to us, in which more than 27,000 seismic events were recorded within 400 m x 400 m area centered on the strain meter.

Strain data are chopped into 2-minutes files, being sent to the surface central workstation. Data traffic jams during blasting hours, increasing missing rate of strain data. However, more than 90 % of the period from March to September 2001, the missing rate of strain data was less than 3 %. Before and after Bambanani mine is sold, the missing rate increased because of theft of cables in addition of frequent power shortage. After January 2001, however, it is getting better.

The secular strain change exceeded 3 x 10^(-5) during a 7-month period from March 2001 in the largest component. Associated with some events within 200 m from the strain meter, clear co-seismic strain steps with post-seismic drifts were observed. The largest co-seismic step observed so far was by the event of M=0 at 20 m distance. By the event, post-seismic drift of ~10^(-5)/month followed co-seismic strain step as large as 10^(-5). In multiple components, oscillation of about 10 Hz were observed for ~1 s prior to co-seismic strain step. Coherent strain transients with a period of ~10 s and an amplitude of less than 10^(-8) seem to precede the co-seismic step in all components. Now, we are carefully checking frequency characteristics and directivity of the strain meter and clock accuracy.

Mining within several ten m from the strain meter begin from January and last until March 2002. Prominent seismicity closest to the strain meter will be induced and recorded in the near future.

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