The Semi-controlled Earthquake-generation Experiments in South African deep gold mines (SeeSA; 2006-2007)

Hiroshi Ogasawara[1]; Masao Nakatani[2]; Yoshihisa Iio[3]; Yasuo Yabe[4]; Sumitomo Norihiko International Research Group for Semi-controlled Earthquake Generation Experiment at South African Gold Mine[5]

[1] RitsumeiUniv.; [2] ERI; [3] DPRI, Kyoto Univ.; [4] RCPEV,Tohoku Univ.; [5] -

We digest our activity in 2006-7, including newly found slow steps (˜2e-6) with clearer forerunners.

We monitor the entire life spans of a few years for M3 earthquakes (E/Q) or smaller within a fault-length [e.g. Iio'95, Ogasawara et al.'02]. This allows us to consider the gap between the scales in labs and natural great E/Qs. So far, the velocity and complexity in rupture, stress drop and apparent stress were confirmed to be similar between M=1-2 mine tremors and natural larger E/Q [Yamada et al.'05,'07JGR]. Since 1999, in addition to an event-trigger E/Q monitoring, we started the strain monitoring with an improved resolution (25Hz, 24bit).

At the Bambanani (BAM) mine, Welkom, Ishii et al. ['00JSS] installed an Ishii strainmeter only 10m from a potential M3 E/Q source fault. On the fault prominent seismicity occurred (Mw_{max}=2.9) causing about 2000 strain steps, some being followed by post-seismic drifts [Yamamoto et al.'05JSS; Naoi et al.'06aGRL]. A small number of E/Qs was preceded by foreshocks, which were followed by their post-seismic drifts until the onset of the mainshock. However, a smoothly accelerated change, as seen in lab or numerical experiments, was not seen. Neither seen for an E/Q with a ˜1e-4 strainstep without a foreshock, nor for hundreds of smaller E/Qs [Takeuchi'05 Master thesis; Ogasawara et al.'05a RaSim6]. Naoi et al. ['06aGRL] found 20% of the steps of 1e-7 or larger was significantly slower than those associated by catalogued mine E/Qs. They referred to these as LDR events (Little Dynamic Responses following the steps). A smaller number of LDR events were much slower ('slow steps'), a little number of which were preceded by clear forerunners. Most LDR events followed the largest strainsteps (˜1e-4) by the largest E/Qs, when Yamamoto et al. ['06JSS] found 'repeating E/Qs' frequently took place within the source and aftershock areas for the E/Qs. Naoi et al. ['06bSSJ] successfully constrain that some slips occurred on the fault 20-30m from the strainmeters. The LDR events follwoint the 2003 M2 are smaller than Mw=1.5 [Naoi'07 Master thesis], being considerably smaller than those for slow events observed along Japanese ocean trenches. However, a single strainmeter didn't allow us to do it further.

At MPO, to address the problem, two Ishii strainmeters were installed with a ˜14m interval at 10-20m distances from a fault fracture zone at a 2.9km depth [Ogasawara et al.'05b RaSim6]. At the mine, large strain steps were also newly found associated with E/Q (M=2-3) within 200-300m from the strainmeters, with comparable magnitudes in strain step to those found at BAM. However, again, no detectable forerunners preceded the E/Q steps, nor did smaller E/Q steps [Morishita et al.'06 JEPS, Yasutake et al.'06JSS]. Nevertheless, Yasutake et al. ['06JSS; this meeting poster] proved the recording, finding slow steps, which were again not associated with catalogued E/Qs in the mine. One of these was as large as 2e-6 strain, more than ten times larger than those observed at BAM. This allowed us to clearly see the forerunner and a sequence of smaller steps at the final stage of the slow event. The reliability of these two strainmeters seems to be good because the correlations in responses for the earth tide [Morishita et al.'06 AGU; Morishita'07 Master Thesis], remote blasting, and remote E/Qs are quite well. For some slow events, the two strainmeter shows different responses. Their distances and moments constrained were, nearer than 20-30m from the strainmeters and Mw ˜-1, respectively [Yasutake et al. this meeting].

We also report the status of new projects. One is at MPO (3.5km deep), extending the monitoring window to cover AE to directly bridge the lab- and mine- scales [Nakatani et al.'06JEPS]. Another is at the flooded mines, where we can access to the boundary of the flooded compartments to study the effect of pore water [Ogasawara et al.'06JSS].

About 70 people are working for the projects.