
*Ogasawara, H
ogasawar@se.ritsumei.ac.jp, Faculty of Science and Engineering, Ritsumeikan University, 1-1-1 Noji Higashi, Kusatsu 525-8577 Japan

Iio, Y
iio@dpri.kyoto-u.ac.jp, Research Center for Earthquake Prediction, Disaster Prevention Research Institute, Kyoto University, Gokasho, Uji, 611-0011 Japan

The Research Group for Semi-controlled Earthquake-generation Experiments in South African Deep Gold mines

After briefly reviewing our previous experimental phases in 1994-2001, we introduce our new project (2002-2006) to monitor the entire life span of an earthquake on fault or dyke at the gold mines in South Africa where an $M > 3$ event is expected.

For investigation of an earthquake preparation-process, it is time wasting to wait for a great natural earthquake. So, near-source monitoring of small earthquakes that occur much more frequently is crucial to have as many lessons as possible within several years. South African deep gold mine is one of the best experimental fields in the world. Mining takes place at depths of 2000-3000 m in South Africa, thereby inducing events with $M$ equal to or larger than 3 in the close vicinity of stopes, with the largest events so far recorded being $M > 5$. As a result, seismogenic processes can be monitored at very short distances with sensors installed ahead of time in seismogenic areas. Nicolaysen referred to this process as a semi-controlled earthquake-generation experiment, which cannot be done with natural earthquakes monitored from the Earth's surface. In the 1970s-1980s, pioneering work (e.g. McGarr, Green, Spottiswoode and many South African people) yielded abundant, fundamentally important results in this area. In more recent times, wide-band and wide-dynamic-range monitoring (e.g. ISS International Ltd.) has enabled us to study additional details of the seismogenic process. Therefore, we have attempted to monitor the entire life span of an earthquake within a hypocentral distance of a few hundred meters. Since 1994, in co-operation with ISS International Ltd. and Witwatersrand University, we have monitored four experimental fields in South African mines: near a strong dike 1700-m deep in a mine, a homogeneous area 2700-m deep without existing faults or dikes in another mine (see details in Ogasawara et al. RaSim5 Proc. 2001 or Seismogenic Process Monitoring, Balkema, 2002). From 2000 we began to continuously monitor normal and shear strains on a fault with 25-Hz and 24-bit sampling, where an $M$~3 event is expected (see posters for the details). We use Ishii strainmeter that can be installed in a several-cm-diameter hole, accommodate as large strain as $10^{-4}$ and detect as subtle strain change as the earth tide. However, only a single strainmeter was available at the second and third experimental field. So, from 2002-2006, we are going to deploy an array covering the entire seismogenic fault of an $M$~3 event. The array consists of four Ishii strainmeters and tri-axial accelerometers, being recorded with a wide-band, wide-dynamic recording system of ISS International Ltd.

** Members on South African side of our research group: Alexander Mendecki, Artur Cichowicz, Gerrie van Aswegen, Tony Wald and many other personnel of ISS International Ltd. On Japanese side: the group consists of national universities (Tokyo, Kyoto, Nagoya and Tohoku), national institutes (AIST / Geological Survey) and Ritsumeikan University.
In the next phase of our experiment we also plan to carry out:
In-situ stress measurements with overcoring (Ishii & Yamauchi), inelastic strain relaxation (Satoh & Kawakata), Kiser effect (Kato) methods prior to installing the Ishii strainmeters,
An attempt of wide-band high-resolution monitoring of fault slip (Nakao & Kato), and Rock sample collection on the seismogenic fault before and after the events to investigate melting and parameters of constitutive friction law (Ohtsuki and Kato).
In-situ observation of the seismogenic fault before and after the event.

The candidate experiment site for a strainmeter array is the Pretrius fault at 104L/44 or 104L/46 crosscut tunnels. The candidate site for in-situ stress measurement with multiple methods is near a dyke at 99L at the Tautona mine. These can never be done with surface monitoring for natural earthquakes. The outcome of our experiments will contribute to understand the seismogenic process, in particular, scaling problem, earthquake perdition and mining safety.

Acknowledgements: The projects is funded by Grant-in-aid of Ministry of Education and Science, Japan, Earthquake research Institute, the university of Tokyo and Ritsumeikan University. We thank Mponeng and Bambanani mines for permission of our current experiments