

The Semi-controlled Earthquake-generation Experiments in South African deep gold mines (2004-2005)

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The talk digests the 2004-5 activity of the Research Group for the Semi-controlled Earthquake-generation Experiments in South African deep gold mines (SeeSA). Since 1995 the research group has deployed a pilot and five experimental sites, attempting to monitor the entire life span of an earthquake within a seismic-fault length at depths of 2-3 km in South African gold mines. The experiment purposes to bridge the scale gap between natural large earthquakes and laboratory rock experiments.

Takeuchi et al. 2003 (IUGG, AGU) and 2004 (JSS) have already reported the world first, complete records of about $1E-4$ strain release with a resolution of 24 bit and 25 Hz that can be recorded only within a seismic-fault length. They were recorded associated with two $M \sim 2$ earthquakes at distances less than 100 m at a depth of about 2.4 km at the Bambanani gold mine, Welkom, South Africa. In 2004, we further investigated several hundreds of smaller strain steps (from $1E-9$ to $1E-5$) for the Bambanani strain recordings, but found that the $M2$ event in February 2003 was the only case preceded by a sequence of foreshocks with significant strain changes, and no quasi-static acceleration of strain was seen for all recordings beyond their noise levels until 0.1 s before the onset of P-waves. During the period the earth tide was clearly recorded, suggesting the Ishii strainmeter worked well. We compare the theoretical steps with the observed steps confirming the Ishii strainmeter worked well except the closest events (hypocentral distances less than 100 m with the location error of several tens of meters). We are attempting better hypocentral location with a cross-correlation phase picking and the Double-Difference method, being reported in the talk.

The problem of the Bambanani experimental site was the single strainmeter not accompanied by a close seismic station; a several meter distance seismic station was not operational because of the fall of ground by the seismic events. So, more redundant monitoring array also with a fault-heat-generation monitoring was deployed at 104/44 Mponeng gold mine. Several tens of MPa has been loaded and $M1.8$ is the closest, largest event to date, as detailed in other presentation in this meeting (Nakatani et al. and Morishita et al.).

The ICDP/NSF cooperation project started at the 120L Tau Tona mine (a 3.6 km depth; the world deepest mining area). The Tau Tona mine excavates the gold reef several hundreds of meters beneath the gold reef that the Mponeng mine is currently mining. In both mine areas with a width of several kilometers, the Pretorius fault zone with a thickness of several tens of meters runs through, vertically offsetting the gold reefs by several tens of meters. Our existing experimental site is located on the fault zone at a 2.9-km depth at the Mponeng mine and the ICDP/NSF cooperation site also on the fault zone at a 3.6-km depth at the Tau Tona mine. In addition to the monitoring similar to SeeSA, two long holes (more or less 100 m) are drilled through the fault zones logging cores in detail and installing sensitive creep meters. We also install the Ishii strain meters at the site. As scheduling is the most crucial because mining is much faster than drilling, we play an important role based upon our experience of SeeSA.