A 3 km deep on-fault thermometer array to measure Earthquake Heating in a South African gold mine: Stability of temperature data.

Masao Nakatani[1]; tsuneo yamauchi[2]; Hiroshi Ogasawara[3]; Tony Ward[4]; Takamori Ito[5]; Jun'ichi Takeuchi[6]; Naoyuki Shimoda[3]; W Zibi[4]; Fracois du Plessis[7]; Hanno Hoogenboezem[7]; Patric Lenegan[7]; Peter Mountfort[7]; Janusz Danilowicz[7]; Kouhei Nagata[8]; Ken Morishita[9]; Osamu Kuwano[10]; Kenshiro Otsuki[11]; Hironori Kawakata[12]; Aitaro Kato[13]; Shigeru Nakao[14]; Rob McGill[15]; Yoshihisa Iio[16]; Sumitomo Norihiko International Research Group for Semi-controlled Earthquake Generation Experiment at South African Gold Mine[17]

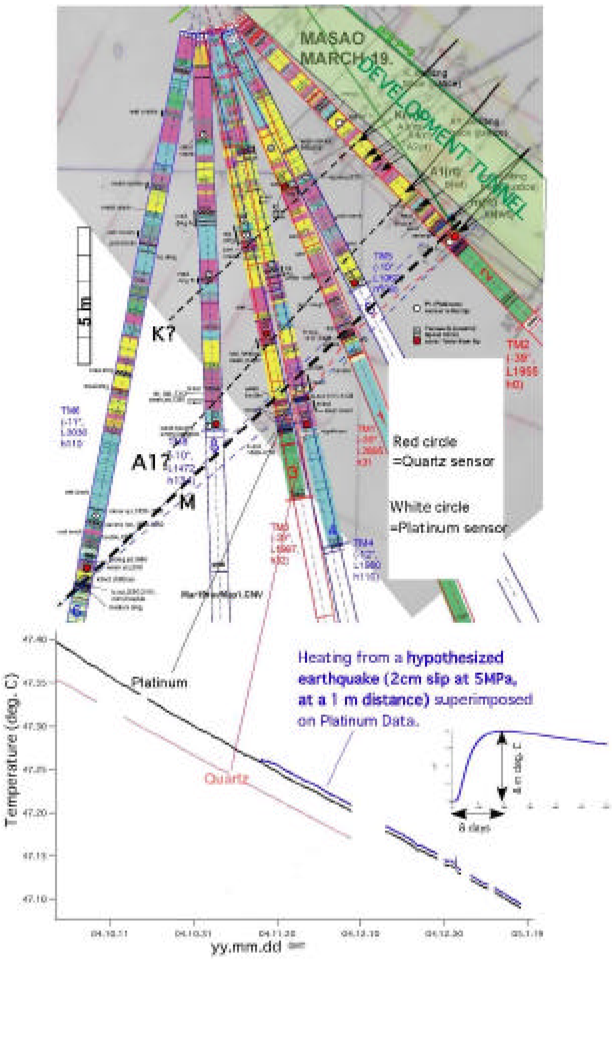
[1] ERI; [2] RCSVDM; [3] RitsumeiUniv.; [4] Seismogen; [5] OYO SI; [6] RitsumeiUniv.

; [7] ISS International; [8] Earth and Planetary Sci.,Tokyo Univ.; [9] Physical Science, Ritsumeikan Univ; [10] ERI, Univ. of Tokyo; [11] Earth Sci., Tohoku Univ.; [12] DRS, DPRI, Kyoto Univ.; [13] ERI, Univ. Tokyo; [14] Kagoshima Univ.; [15] Mponeng mine; [16] DPRI; [17] -

We have installed many temperature sensors in the seven boreholes drilled to a major geologic fault that intersects the ongoing mining at a depth of 3 km (See map). We have installed two platinum resistance sensors and one quartz thermometer in each borehole. The exact location of each sensor was planed so that likely future slip planes are covered redundantly. As reported at this meeting last year, borehole camera observation and examination of the logged cores suggest existence of a discrete weak plane ("M" on the map) at this locality, at the edge of a 20 m thick fault zone of well lithified fine matrix cataclasite, with clasts of the host rocks (quartzite and basalt) of variable sizes in it. Five of the quartz sensors and six of the platinum sensors are located within ~1 meter from this plane. The other sensors were distributed at shallower depths of the boreholes, with an intention to cover the two well-foliated 10 cm thick layers ("K" and "A1") recognized at the development tunnel. All these three features are sub-parallel and have a nearly vertical dip. After positioning the sensors, the boreholes were filled with concrete to avoid disturbance.

Temperature is sampled every one minute. Data from quartz sensors are stored at the on-site data logger and also telemetered to the surface through the mine's seismic monitoring system. Data from platinum sensors are also telemetered (no on-site recorder at the moment). Power and communication lines for the two systems are made as separate as possible for fail-safe because temperature observation must be kept after an earthquake to measure frictional heating from it, whereas considerable damage is likely because this observation is situated right at the fault. At 1 m from fault, it takes ~8 days for the local temperature to reach the peak (see inset of the lower panel): Power of the system is backed up with batteries, targeting at such duration. All the data are e-mailed hourly to Japan.

A typical example of the temperature data is shown in the lower panel. At the time of writing, no earthquake has occurred yet in the area covered with our thermometer network, so this is a background temperature trend. Generally, temperature decreases quasi-linearly, presumably due to the cooling from the development tunnel. We do not find aftereffects of drilling/installtion/grounting in this 3 months period starting five months after their completion. The platinum data fluctuate more than the nearby quartz sensor, but still seems to be usable. To demonstrate the resolution, we show a dummy data where a heating signal expected from an earthquake at a 1 m distance is superimposed on the observed data with the platinum sensor. A very weak fault (5MPa, 1/10 of the value expected from the laboratory friction measurements) and a 2 cm slip were assumed. We conclude that this size of signal (8 m deg. C, see inset), is about at the detection limit with platinum sensor, and safely detactable with quartz sensor.


MASAO
MARCH 19.
DEVELOPMENT TUNNEL
5 m
K?
A1?
M
Red circle
=Quartz sensor
White circle
=Platinum sensor
Heating from a hypothesized earthquake (2cm slip at 5MPa, at a 1 m distance) superimposed on Platinum Data.
Platinum
Quartz
Temperature (deg. C)
47.40
47.35
47.30
47.25
47.20
47.15
47.10
04.10.11
04.10.31
04.11.20
04.12.10
04.12.30
05.1.19
yy.mm.dd
8 days