Title of Project : Multidisciplinary monitoring of preparation and generation of earthquakes at M2 sources in South African gold mines

Hiroshi Ogasawara
(Ritsumeikan University, School of Science and Engineering, Professor)

Research Area : Mathematical and physical sciences

Keyword : Earthquake phenomena, Crustal movement, Seismic motion

【Purpose and Background of the Research】

How should we extrapolate rupture mechanics derived from tiny laboratory specimens to large natural earthquakes rupturing several tens of kms? Up-close examination of intermediate-scale earthquakes is one of the best ways to answer this question. Our earlier observations deployed at 2-3.5 km depths in South African gold mines revealed some aspects of preparation and generation processes of earthquakes up to 100-m scale, with a resolution unattainable by conventional observations from surface. The present project will elucidate further details by deployment of denser array of various sensors.

【Research Methods】

Proposed site is at about 2.8 km depth in the Moab Khotsong gold mine near Klerksdorp, South Africa. The site has a large fault, which will be unclamped by the planned mining. Mining and induced seismicity will peak in 2010 and 2011. At least a few earthquakes of Magnitude 2 to 3 (i.e. rupture over hundred to several hundred meters) are expected in a few years. We will start observation by then and keep the observation till the end of active period. Due to the complex geology of the fault zone, earthquakes here are expected to be nucleated and generated with clear forerunners.

The site has several parallel horizontal tunnels separated from each other by ~100 m in both vertical and horizontal directions. The tunnels intersect our target fault, so a 3-D array can be realized by relatively short drillings.

The project will monitor the following items (1) Quasi-static rock mass deformation (DC to ~50 Hz). Especially sought are slow strain steps with clear forerunners and quasi-static deformation during foreshock sequence. (2) Dynamic stress change (~50 Hz to ~50 kHz,) at the rupture fronts of a 100-m scale earthquake. (3) Microfracturing down to a several-cms size, which may delineate the nucleation and rupture plane of a 100-m scale earthquake.

The project will be carried out by international academia-industry-government cooperation, including researchers from Ritsumeikan, Tokyo, Tohoku, Kyoto and Kagoshima universities, AIST, TRIES on Japanese side, AnglogoldAshanti Ltd., ISS International Ltd. and others on South African side.

【Expected Research Achievements and Scientific Significance】

An earthquake generation scenario, where quasi-static nucleation precedes dynamic rupture, is widely accepted, but it is however justified only in lab. The present project can be the first test of this scenario on actual geological structures.

Also, the present project can achieve enough resolution to first unravel the nested structure of dynamic and quasi-static processes occurring on inhomogeneities at all scales, which are thought to control the preparation, evolution and termination of rupture.

The sensitive, broad-band, and wide dynamic-range observation by a 3-D array surrounding the 100-m scale source of future earthquake offers a unique solution to these long standing problems in earthquake physics.

【Publications Relevant to the Project】

Ogasawara et al., Semi-controlled earthquake-generation experiments in deep gold mines, South Africa, - monitoring at closest proximity to elucidate seismogenic process, Zisin2, 2009, in press (in Japanese with English abstract).

Naoi, M., et al., Small slow-strain steps and their forerunners observed in gold mine in South Africa, Geophys. Res. Lett., 33, L12304, doi: 10.1029/2006GL026507, 2006.

【Term of Project】 FY2009-2013

【Budget Allocation】 148,400 Thousand Yen

【Homepage Address and Other Contact Information】

http://www.ritsumei.ac.jp/se/~ogasawar/SA/SeeSA_home.htm