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Initial report on drilling into seismogenic zones of M2.0 – M5.5 earthquakes from deep South African gold mines (DSeis)

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The International Continental Scientific Drilling Program (ICDP) approved our proposal (Ogasawara et al., EGU 2016) to drill into and around seismogenic zones where critically stressed faults initiated ruptures at depth. The drilling targets include four ruptures equivalent to M2.0, 2.8, 3.5, and 5.5 that dynamically and quasi-statically evolved in 2.9 Ga hard rock in the Witwatersrand basin, South Africa. Major advantages of our drilling locations are the large quantity and high-quality of existing data from dense seismic arrays both on surface and near-field underground in three deep South African gold mines. Additionally, the great depths (1.0 to 3.3 km from surface) to collar holes reduce drilling costs significantly and enable a larger number of holes to be drilled. Flexibility in drilling direction will also allow us to minimize damage in borehole or drilled cores. With the ICDP funds, we will conduct full-core drilling of 16 holes with drilling ranges from 50 to 750 m to recover both materials and fractures in and around the seismogenic zones, followed by core and borehole logging. Additional in-hole monitoring at close proximity will be supported by co-mingled funds and will follow the ICDP drilling.

Expected magnitudes of maximum shear stress are several tens of MPa. We have established an overcoring procedure to measure 3D-stress state for adverse underground working conditions so as not to interfere with mining operations. This procedure was optimized based on the Compact Conic-ended Borehole Overcoring (CCBO) technique (ISRM suggested; Sugawara and Obara, 1999). Funato and Ito (2016 IJRMMS) developed a diametrical core deformation analysis (DCDA) method to measure differential stress using only drilled core by assuming diametrical change with roll angles caused by elastic in-axisymmetrical expansion during drilling. A gold mine has already drilled a hole to intersect the hypocenter of a 2016 M3.5 earthquake and carried out the CCBO stress measurement in other holes at the M3.5 seismogenic zone. As we successfully conducted DCDA with the above-mentioned drilled core, we look forward to shedding light on spatial variations of stress in the seismogenic zones following our ICDP DSeis drilling.

A M5.5 earthquake which took place near Orkney, South Africa on 5 August 2014, offers a special opportunity to compare seismically inverted spatio-temporal evolution of both the main rupture and the aftershock activity with the information directly probed by the ICDP DSeis project. Moyer et al. (2016 Seismol. Res. Lett. submitted) calls for comparing seismic source models as part of a workshop proposed to the Southern California Earthquake Center for Fall 2017. In addition, the upper edge of the M5.5 rupture is located hundreds of meters below the mining horizon, sufficiently away from anthropogenic activity. This allows geomicrobiologists to investigate deep microbiological activity fueled by H2 from seismic rupture to address questions about Earth's early life.

Drilling machines are being rigged underground soon to kick off our ICDP DSeis drilling in early 2017.