Geophysical Research Abstracts
Vol. 20, EGU2018-10377-2, 2018
EGU General Assembly 2018

Core and borehole logging and stress measurements of a 817 m long borehole drilled from 2.9 km depth toward the Moab Khotsong 2014 M5.5 aftershock zone (ICDP DSeis project in South Africa)

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A M5.5 earthquake took place below a 2–3 km depth mining horizon at the Moab Khotsong / Great Noligwa gold mines near Orkney, South Africa, in August 2014. The in-mine seismic network with 46 underground seismic stations clearly delineated a nearly vertically dipping planar aftershock zone striking NNW-SSE, with the upper edge several hundreds of meters below the mining horizon. At the 95 level, about 2.9 km from surface, we could find a drilling site where drilling does not interfere with mining production. NQ-size drilling and coring were carried out with a rig normally used for routine in-mine exploration drilling at Moab Khotsong. As it is a rare opportunity to be able to drill into a seismogenic zone, ICDP approved the project "Drilling into Seismogenic zones of M2.0–M5.5 earthquakes in South African gold mines (DSeis)" in August 2016 (https://www.icdp-online.org/projects/world/africa/orkney-s-africa/details/ or Ogasawara et al. EGU2018-3624).

The geological structure below the mining horizon was unknown and the faulting mechanism of the M5.5 earthquake (left-lateral faulting) was different from typical mining induced earthquakes (normal faulting). Thus, we first aimed to delineate the lithology and the geological structure of the M5.5 seismogenic zone. The direction of drilling was carefully planned in order to minimize drilling-induced damage to the core and borehole. The direction of the maximum principal stress was expected to be vertical on the mining horizon and horizontal near the M5.5 fault. We started drilling the first borehole with a plunge of about 41° to intersect the fault obliquely.

We collared the first NQ borehole at 2.9 km depth below ground surface in June 2017 and completed 817 m drilling in September 2017. We did not intersect the fault because the drilling was deflected more than we expected. However, we could drill at least several tens of meters below the depth of the upper edge of the nearly vertical M5.5 aftershock zone. Throughout the drilling >99% of core was recovered. Geophysical borehole logging (3-arm caliper, natural gamma, vp/vs, density, optical and acoustic televiewer) and core logging were conducted. These will be presented at the EGU 2018 meeting.

In addition, we measured stress using the Diametrical Core Deformation Analysis method (DCDA; Funato and Ito, 2017, Int. J. Rock Mech. Min. Sci.). In order to measure variations of core widths, LED light is projected on a drilled core specimen and the core shadow size at different roll angles is detected. These data can be converted to differential stress on a plane normal to the core axis. DCDA is based upon the assumption that anisotropic stress relief results in an anisotropic expansion during drilling. The stress inferred from DCDA is consistent with the stress field of left-lateral faulting.

As at 22 December 2017, the length of the second NQ borehole from 2.9 km depth is about 300 m and should intersect the fault in the first quarter of 2018. Outcomes from the second hole will also be reported at the meeting.