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Recovery of ruptures from seismogenic zones at Cooke 4 mine (ICDP scientific drilling project in the South-African gold mines)

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This work is part of the ICDP project titled "Drilling into Seismogenic zones of M2.0 - M5.5 earthquakes in South African gold mines (DSeis)". The target source zones are located 1 - 4 km below the surface in four deep mines. The project is partially completed, as overviewed by Ogasawara et al. (EGU2018-3624). Here we present the results of efforts to recover ruptured rock from seismogenic zones several tens of meters in extent, which formed ahead of thin tabular stopes in a highly-stressed remnant of the shaft pillar at 1 km depth at Cooke 4 mine, South Africa. These drilling targets were determined based on microseismic monitoring (acoustic emissions, AE) of micro-fracturing down to Mw -5 by Masao Nakatani and his colleagues. Naoi et al. (2014, 2015abcd) have documented the spatio-temporal evolution of the ruptures, from their nucleation elucidated by the monitoring, to their seismological characteristics. A subset of the seismic sources were self-similar to micro- or small-earthquakes and comparable to typical tectonic seismicity. Another subset of the seismic activity was strongly localized along planar fracture interfaces and had considerably higher b-values, which may reflect the topography of the microscopically two-dimensional fracture interface and warrants further inspection.
In order to study the physical processes behind the forming of fracture interfaces, we mapped some of the rupture surfaces exposed in the stope and recovered intact samples of the ruptured surfaces with the help of low viscosity epoxy. These samples are also to be compared with the samples recovered by drilling into the same rocks, to ensure that the recovered cores preserve the fine micro-structural deformation.
A 45m BQ drilling with a triple-tube core-barrel successfully recovered both host rock and ruptures from the rupture zones with only a little drilling damage or core loss. The cores and samples will allow us to address questions about the formation of planar fractures and their highly localized seismic behavior, questions which are closely related to shear localization and fault dynamics in the upper and middle crust which cannot be addressed by surface studies of active and exhumed faults. We will present our mapping and preliminary results of microfracture analysis, and compare borehole vs. stope expression of mining induced faulting.