Stress state in the source region of M2-3 earthquakes in South African deep gold mines

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As a part of the ICDP project "Drilling into seismogenic zones of M2.0 - M5.5 earthquake in South African gold mines (DSeis)”, we evaluate the stress states in the source regions of Mw2.2 earthquake in Mponeng mine (M-event) and of M3.5 earthquake in Savuka mine (S-event), both of which occurred in dykes at depths of 3.3-3.5 km. A scientific borehole was drilled across the fault of the M-event and two exploration boreholes were drilled across the fault zone of the S-event. States of borehole walls (borehole breakout, BB) and of core samples (core discing, CD) recovered from the boreholes suddenly changed across the fault or the fault zones, indicating a significant contrast between the stress states in the hanging-wall and the footwall of the source faults. Two stress measurement techniques (DRA and DCDA) were applied to the core samples recovered from the three boreholes. Differential stresses were found to be higher in the dyke compared with those in the host rock. Combining the stresses measured by these techniques with the occurrence criteria of BB and CD, the principal stress state in the source region of the M-event was estimated. The vertical stress was as high as ~180 MPa in the dyke in the hanging-wall of the fault, while it was ~100 MPa in the dyke in the footwall. This contrast between the vertical stresses in two sides of the fault can be attributed to the stress redistribution by an inhomogeneous slip on a non-planar fault, which is consistent with the pre-seismic stress distribution on the fault calculated by a numerical modeling of the stress perturbations due to nearby mining. The stress state in the source region of S-event significantly differed from the virgin stress state in this mine district. This should be due to the stress disturbance associated with nearby mining, as well as to the stress redistribution induced by the S-event. However, its spatial variation was too complicated to be explained by a simple model as in the case of the M-event.

Keywords: Mining induced earthquake, South African deep mine, Stress state in the source region, ICDP DSeis

