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The measurement of stress drops for -3<M<0 earthquakes recorded within 200 meters from the sources with 48 kHz sampling

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It is known that stress drops range from 0.1MPa to a few tens of MPa for M = 0 to 7 independently of an earthquake size. For micro-earthquakes (M = 0.6 to 3.0), Stork and Ito (2004) showed this with 800m-borehole data with sufficient frequency band. Yamada et al. (2007) estimated the stress drop for earthquakes (M = 0.0 to 1.3) at the Mponeng gold mine (about 2650 meters below the surface). As a result, the stress drops range from 3.2MPa to 88 MPa, being relatively high. However, for much smaller earthquakes (M= -3.6 to -1.9), Gibowicz et al. (1991) showed that a stress drop goes down, but the instrumental response was flat only up to 5 kHz. The corner frequencies seemed not be properly evaluated. So, in this study, using the accelerometers with a response flat up to 25kHz with a sampling frequency of 48 kHz and recording distances < 200m, we measure the stress drop value for M = -3 to 0. The previous studies at the same mine include Richardson and Jordan (2002), who analyzed mainly 2 kHz-sampling data with geophones which have a flat response up to a few hundred of Hz only. Although Ogasawara et al. (2002) and Yamada et al. (2007) analyzed the data recorded with a 15 kHz-sampling accelerometers which have a flat response up to a few kHz. So, the frequency range we analyzed is sufficiently higher and suitable for the measurement of stress drops for M<0 earthquakes.
In South Africa, gold mines where induced earthquakes occur in the vicinity of mining faces due to stress concentration are suitable field for near-source observations because planned mining enables us to anticipate where, when and how large earthquakes would occur. Therefore, we can install seismometers before an earthquake takes place. Therefore, we can get the near source record which it is difficult to get on the surface surveillance. At a depth of 3300 meters below the surface (109L) in the Mponeng gold mine in South Africa, a dyke (about 20m thick) is normal to a thin tabular reef that dips 20 to 25 degrees to southeast If the dyke is left unmined in these areas, stress would center on there. Then earthquakes are induced. Therefore, seven accelerometers that have a flat response up to 25 kHz have been installed 10 to 30 meters apart each other in a hard rock ground along the border of the dyke and host rock (the border between east and west) to get closest to anticipate hypocenters. In order to cover in 3D M2 scenario earthquakes, we drilled holes with lengths from 20 to 90 meters from a tunnel and installed the accelerometers. Four of them are three component accelerometers; the others are single component accelerometers. During a 17-day period from 2008/10/14 to 2008/10/30, 20975 events were recorded. We preliminarily estimated the stress drop for 40 earthquakes recorded at a 48 kHz sampling and within 200 meters from the hypocenters. From the S wave displacement spectra, fitted with Boatwright model (Boatwright et al.,1978), we read flat levels and corner frequencies, evaluating the stress drop.
The corner frequencies range from 0.5 kHz to 8 kHz. In the result, the stress drops measured for M = -3 to 0 range from 1MPa to a few tens of MPa. This result is consistent with those measured for natural earthquakes (M = 0 to 7).

Keywords: Stress drop, High frequency sampling, Size dependency, South Africa, Micro earthquake, Near field observation