Apparent stress and rupture speed of small earthquakes in a South African gold mine

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Nine tri-axial borehole accelerometers were installed within 200 m along a 2,650-m-deep haulage tunnel in the Mponeng gold mine in South Africa. We analyzed the high sample rate recordings (15 kHz) to determine source parameters of small earthquakes in the mine. We analyzed radiated seismic energies and static stress drops of 28 earthquakes (M=0.0-1.4) that occurred within 200 m of the stations to investigate their apparent stresses. Apparent stresses of the 28 events were from 0.05 to 1 MPa (Figure 1) and static stress drops were 0.71 to 29 MPa. These values are similar to those for larger earthquakes. To study the source processes, we also carried out multiple time-window waveform inversions for the five largest events (M=0.8-1.4) among the 28 earthquakes. From the inversion results, we could determine the fault planes for all five events and estimate the range of rupture speed. We can conclude that rupture speeds were faster than 2.5 km/s (65 % of the shear wave velocity). The radiation efficiency is written as a function of the rupture speed and becomes greater with increasing rupture speed. This study indicates that radiation efficiencies of small earthquakes in the South African gold mine are almost equal to those of larger natural earthquakes. We found that the source parameters (apparent stress, rupture speed, radiation efficiency, and static stress drop) did not largely differ from values for larger earthquakes. This suggests that the dynamic rupture processes of these small events were similar to those of the larger earthquakes.

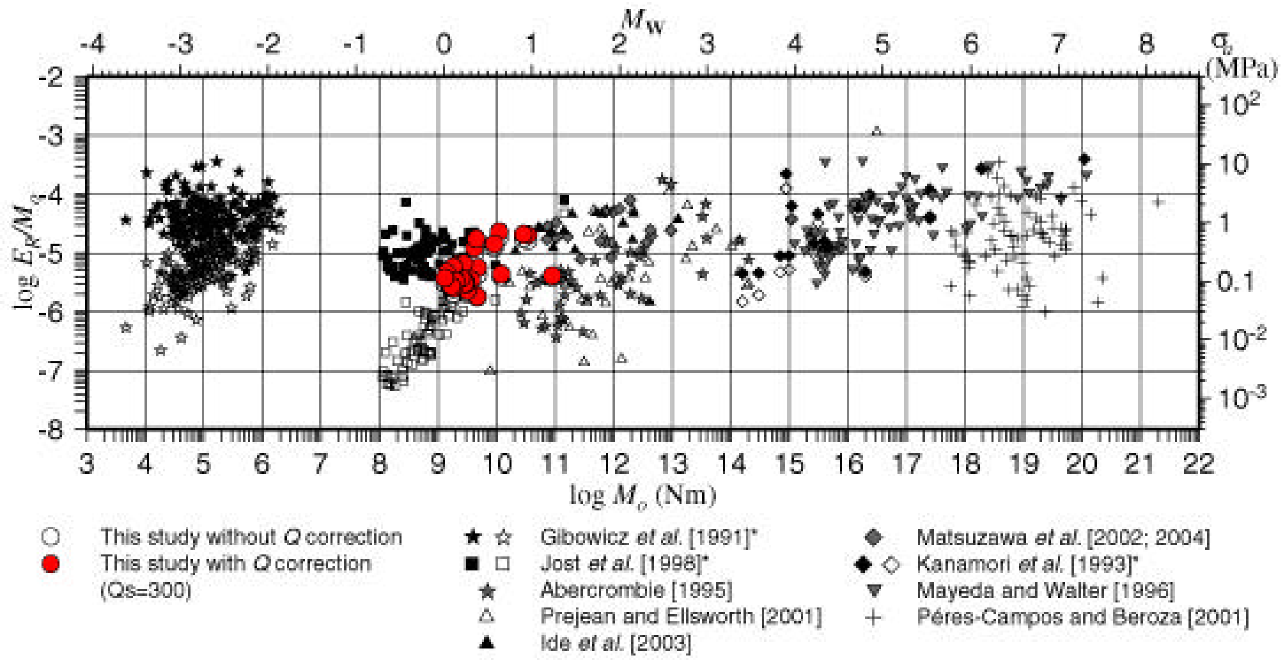

Figure 1.: Ratio of radiated energy to seismic moment plotted as a function of seismic moment. Red and open circles indicate radiated seismic energies with and without *Q* correction for the 28 events analyzed in this study. Red circles are almost superposed on the open symbols because for the very close hypocentral distances *Q* corrections do not significantly change the estimates of radiated energies if *Q* values are several hundreds. For *Gibowicz et al.* [1991], *Kanamori et al.* [1993], and *Jost et al.* [1998], open symbols are their original results, and solid symbols are results corrected by *Ide and Beroza* [2001].