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Static and dynamic scaling relations from cm- to m- scale: A case study from in-situ geomechanical laboratory at Mponeng deep gold mine, South Africa

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We investigate the static and dynamic scaling relations of pico- and nanoseismic events ($M_W > -4.1$) recorded with a high-sensitivity seismic network at Mponeng deep gold mine, South Africa. Our aim is to link the laboratory experiments on rock samples to seismic events recorded in-situ and provide new insights into the ongoing discussion whether the self-similarity is preserved for extremely small seismic events. The in-situ JAGUARS (JApanese-German acoUstic emission Research in South Africa) laboratory is located at a depth of 3543 m, close to the on-going exploitation. Together with the local geological feature, the Pink Green dyke, the investigated area is highly stressed and seismically active. The JAGUARS network, composed of 3C accelerometer and 8 acoustic emission (AE) sensors covers the limited volume of rocks of approx. $300 \times 300 \times 300$ m and it is capable to record the seismicity in a high frequency range (50 Hz–170 kHz, $M_W - 5.0$ to $M_W 0$). During the project, the acquisition system recorded more than $500,000$ events. In this study, the waveform data of two datasets are analyzed: (1) aftershock sequence of a $M_W > 1.9$ event that occurred 30 m from our network and (2) post-blasting activity located at the exploitation level. Two different approaches are used to calculate the source parameters: an absolute source inversion method and a spectral ratio method. The calculated values of M_W ranged from -0.8 down to -4.1 with source sizes from 1.3 m to 8 cm. We do not observe a dependency of the static stress drop and apparent stress on seismic moment, but definitely a self-similar behavior of earthquake rupture process in the analyzed magnitude range. We find indications for slow rupture velocities and high stress offshoot of analyzed seismicity, the signature that the rupture process is friction-dominated for extremely small seismic events.