

JAGUARS-project: Observation of seismic events with frequencies $f > 25\text{kHz}$ at Mponeng deep gold mine, South Africa

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The “Japanese-German Underground Acoustic Emission and Microseismicity Research in South Africa” (JAGUARS)-project measures seismic events with frequencies $0.7\text{ kHz} < f < 200\text{ kHz}$ in Mponeng gold mine, Carletonville/Republic of South Africa. The seismic network combining 1 triaxial accelerometer (sensitivity: 50Hz to 25kHz) and 8 Acoustic Emission (AE)-sensors (sensitivity 1kHz-200kHz) monitors a highly-stressed rock volume of approx. 300 m x 300 m x 300 m at a depth of 3540 m. From June 2007 to June 2008 nearly 500,000 events were successfully recorded including more than 57,000 events with frequency content $f > 25\text{ kHz}$. All seismic events display clear P- and S-wave onsets.

Several distinct seismic patterns including background seismicity, post-blasting activity, and seismicity recorded during work hours could be identified in the resulting catalogue, demonstrating that high-frequency events play a role in all seismic processes inside the mine.

Additionally an aftershock sequence following a $M_w=1.9$ event that occurred 30m from the network was recorded. Approx. 25,000 aftershocks are recorded which delineate the rupture plane and were found to follow Omori’s law.

Analysis of the network’s detection limits shows that high-frequency waves ($f > 25\text{ kHz}$) were able to travel as far as 100 m. The influence of local geology, engineered structures and exploitation is visible.

Magnitudes were calculated studying both records from the accelerometer and AE-sensors. The magnitude-frequency characteristics display a Gutenberg-Richter relationship. The magnitude of completeness was estimated as small as $M_c=-4.4$ in the centre of network’s sensitivity. In general it is found that the magnitude of completeness displays strong spatial variations in agreement with the network’s detection capabilities.

The spatial distribution of the magnitude of completeness is confirmed when analysing the probabilistic magnitude of completeness.

JAGUARS-project is demonstrating that seismicity with sources in centimetre scale is existing and can be recorded in underground environments e.g. deep mines. The high-frequency activity is found to follow common laws of seismology and is therefore a new approach to close the gap between seismology and laboratory fracture experiments.