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Routine Estimation of Source Parameters of Mining-Related Earthquakes
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Mining in the Witwatersrand region of South Africa has led to induced seismicity. Seismicity is concentrated in several clusters associated with current mining production and flooding in abandoned mining voids. Starting in 2010, a surface network consisting of over 60 strong ground motion seismograph stations was installed in three clusters. Automatic earthquake location software from Home Seismometer Corp. based on an automatic location algorithm developed by Dr. Horiuchi was used to locate the large number of aftershocks quickly and accurately. Software for the estimation of seismic source spectral parameters was developed. The software is robust and most of the processing is performed automatically in a batch mode. A catalogue of a few thousand earthquakes was created and the spectral parameters of the events were estimated. Systematic shifts in the range of the spectral parameters for the three clusters were observed. Fluid-induced seismic events have a much smaller static stress drop (0.02- 5MPa) compared to areas where active mining is present (0.1-40MPa). The scalar seismic moment varied from 10^{10} to 10^{14} Nm for the fluid-induced seismicity cluster and for active mining it varied from 10^{10} to 10^{15} Nm. The relationships between static stress drop and scalar seismic moment undoubtedly show that the stress drop increases with seismic moment. Nevertheless, the scattering of the static or apparent stress drop around a fixed seismic moment spans roughly 1.5 -2.0 orders of magnitude.

An unexpectedly large earthquake of magnitude M_L 5.5 (M_w 5.3) was recorded in a district where active mining is currently taking place. Spectral analysis was performed in the frequency range 0.2 - 80Hz. An assumed quality factor of Q=400 was used. This value is used by underground mining networks. Kappa was set to 0.005. Analyzed waveforms were restricted to those recorded at small distances (2-20km) to reduce the effect of a possible error associated with the correction for path effects. The distribution of aftershocks located in the first 24 hours indicates the length of rupture zone to be roughly 6 km; however, spectral analysis of the entire S-wave group shows a maximum source size of approximately 2 km (S-wave corner frequency 1-1.3Hz). Visual inspection of the waveform clearly shows three sub-events. The first one is small followed by two stronger sub-events with similar pulse durations. The two strong sub-events occur about 0.5 sec apart. Analysis of the main event and aftershocks showed that the main event had a static stress drop of 35-45MPa, while the biggest aftershocks recorded in the first 10 days have static stress drops of 25-30MPa, and the largest aftershocks recorded in the next 10 days have static stress drops in the range 7-10MPa. The aftershocks with the largest static stress drops are distributed across the entire 6 km rupture zone. The relationship between stress drop and scalar seismic moment for all the aftershocks showed that the stress drop increases with seismic moment. The static stress drop varies in the range from 0.1 to 40MPa and scalar seismic moment varies from 10^{10} to 10^{14} Nm. The main event appears as a strong outlier with large scalar seismic moments of 2.6×10^{16} - 10^{17}Nm on the three components.

キーワード: spectral source parameters, induced seismicity, routine processing, static stress drop
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