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Accurate localization of mining induced events in the Ruhr district, Germany

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Mining induced seismicity is observed worldwide in all types of mines. In the Ruhr district, Western Germany, seismicity is induced by coal mining. About 1330 events with a local magnitude between 0.7 and 2.4 occurred in 2006. Excavated areas are not refilled and the produced caves lead to stress redistribution in the surroundings. The accumulation of stress in certain layers is released in sudden failure of these rocks and thus can be detected as a seismic event. Mining induced seismicity in the Ruhr district has continuously been observed for the last 25 years. Spatial and temporal correlation between seismicity and mining activity is well proved, e. g. single events can be assigned to specific longwalls and less events occur at the weekends and on holidays when mining stops. Thus, seismic events are a direct answer to stresses induced by the advance of mining. Although there are some ideas about the influence of previously mined areas and specific siltstone layers on the occurrence of induced events the generating mechanisms are not understood in detail. Previous analyses have shown that even neighbouring longwalls can behave very differently, e. g. distinct magnitude-frequency relations were found.

In this study we analyze the seismicity of a certain longwall in Hamm-Herringen. In addition to seismological investigations rock samples from this longwall are analyzed by engineering geologists. Accurate localizations of the hypocentres which can be provided by a local network allow to assign the events to specific layers so that rock properties of seismic and aseismic layers can be compared. In laboratory experiments two different kinds of failure were observed: some samples of dense siltstone showed explosive failure whereas others failed more slowly in different steps.

For this study a local seismological network directly above the longwall was installed between June 2006 and July 2007. Coal with a total volume of about 850 m x 300 m x 2 m was excavated at a depth of 1100 m between August 2006 and April 2007. The entire period of excavation was monitored. The network consists of 9 short period and 7 broad band stations at the surface. Broad band stations were installed for the observation of near-field effects, e. g. static offsets, as the stations are in short distances from the sources. Additionally, 6 subsurface stations complete the net. In each case two stations were installed above each other, up to 84 m above and down to 90 m below the longwall.

Data of surface stations were recorded continuously with a sampling rate of 200 Hz. An amount of 400 GB data was collected. Events were triggered with a STA/LTA-filter (STA:0.1 s, LTA: 20s, STA/LTA: 4.9). If at least 5 stations triggered within 0.3 s triggers were associated to an induced seismic event. Within one month about 900 events occurred in Hamm. Subsurface stations provide triggered data which were sampled with 500 Hz.

In December 2006 a gas outburst occurred in the longwall under investigation. As the hypocentre coordinates are known by the miners this event allows to calibrate the velocity model. For the localization we use the onsets of P-waves and a homogeneous model with $v_P = 3870 m/s$. The localization error is about 30 m. Maps of epicentres show that events proceed together with the longwall face. Differences are observed in the hypocentral depths. In August 2006 events occur around the mining depth whereas most of the events in December 2006 are 60 m to 100 m above the longwall. Localization accuracy can be improved when using subsurface stations. The accuracy of relative localizations then is about 10 m. As the position of the gas outburst is known we can also determine the absolute depths of events and the relative position with respect to the longwall.