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Flooding Induced Seismicity in the Ruhr Area – a geomechanics numerical modelling approach

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The Ruhr region is characterized by centuries of coal mining at depths reaching more than 1000 meters. After the closure of the last mines, their controlled flooding started. The Floodrisk project investigates ground uplift, stress changes due to pore pressure changes and the reactivation potential of faults to explain induced seismicity. We focused on monitoring the eastern Ruhr area and are investigating in detail the relationship between mine water rise, tectonic stress and induced seismicity in the Haus Aden drainage area.

In the region of the former "Bergwerk Ost", which had the highest seismicity in the Ruhr area during active mining, the RUB has installed a network of up to 30 short-period seismic stations. Continuous monitoring of seismicity and mine water levels is available for this region from the active mining phase through the post-mining phase to flooding. The temporal evolution of the mine water level after the pumps were shut down in mid-2019 shows a strong correlation with the temporal evolution of the observed microseismicity. Over 2200 induced events have been located since the beginning of flooding, showing spatial clustering. A comparison of the mine galleries, which today serve as the main underground waterways, with the localizations of the events shows that most of the events occur about 300 m below the main pillars located between the longwall panels.

This study provides a compilation of the regional stress state in the eastern Ruhr area based on the mine measurements, which were re-evaluated to derive the regional stress component and compared with stress orientations from independent sources (information on stresses in deep boreholes and earthquake focal mechanisms). The spatial distribution of stress orientations in the Ruhr region shows a rather homogeneous stress pattern with only very few locations where stress orientations differ significantly from the average.

Based on the geometry of the pillars, shafts and longwall panels, a generic numerical FE-model was developed using the compiled stress data for model calibration. The results indicate increased vertical stresses within and below the pillars as a result of stress arching. The horizontal stress changes are minor, thus differential stress increases in the vicinity of the event localizations.