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Investigating untypical seismicity distribution in Upper Silesia hard coal mine – insight into natural, human-induced and coseismic stress changes.

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The Upper Silesia Coal Basin (USCB) in southern Poland is the place of intense seismicity accompanying coal mining. The exploitation of three longwall panels in one of USCB coal mines held between 2005 and 2010 was accompanied by seismicity characterized by very unusual time-space distribution. The earthquakes did not follow the depth of mining but exhibited changing depths from great below to close to mined seam. What is more, most of the strongest seismic events with ML>2.2 recorded during exploitation of these longwall panels occurred when exploitation had approached the axis of Bytom syncline, local tectonic structure intersecting several mines in Upper Silesia. Strong event's hypocenters were thus at close epicentral distance to both Bytom syncline axis and active mining front but at the great depth below mined seam. Such rather unusual seismicity pattern provided the unique opportunity to study the possible coupling of natural, human-induced and coseismic stresses in longwall coal mining environment. In present study we focused on distribution of seismicity of one of the longwall panels and in particular on the strongest event which occurred during its exploitation, ML3.7 event. The full moment tensor solution of the event showed that it occurred as almost vertical reverse faulting on a northeast-striking plane consistent with approximate strike of Bytom syncline. To evaluate inducing factor of ongoing and past exploitation we performed geomechanical modelling of its influence on strain and stress in the rock mass at the target depth of ML3.7 event. The estimated mining stress changes exhibited changing vertical stress regime which might have promoted failure on preexisting, almost vertical planes of weakness. Also, the amplitude of vertical displacement along the profile at the earthquake's depth was of similar order as the estimated slip on the fault. The earthquakes' rate variation in time showed no increase in activity right after the occurrence of ML3.7 event. This could be due to its slow rupture inferred from P-S-wave spectra corner frequency ratio. However, the Coulomb stress change analysis showed that the magnitude of stress changes due to coseismic slip of ML3.7 event at the hypocentral depth is of the same order as stress changes caused by mining. Thus, the distribution of seismicity at this level could have been driven by both exploitation and coseismic stresses. Moreover, the seismicity which occurred within first few weeks after ML3.7 event, followed positive stress changes. The obtained results let us prove that the ML3.7 event was the tectonic earthquake triggered by ongoing exploitation and that the distribution of following seismicity was affected by coupled natural, exploitation-induced and coseismic stresses.