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# Multi-hazard analysis of abandoned coal-mines

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## Abstract.

Nowadays, most coal mines in Europe are already closed or are in a state of liquidation. However, the problem concerning the abandoned coal mines and their influence on the environment is still a central objective of the mining industry and coal regions in transition. After the end of the exploitation, numerous disturbances can occur. Mines operators, local authorities and decision makers face multi-hazard and multi-risks related to mine closure. Land and especially planning for a proper old mining site rehabilitation require better tools to apprehend the multiplicity of hazards and constraints.

The objective to improve risk assessment by creating a new methodology to treat a global and multi-hazard related to abandoned coalmines instead of each hazard separately and study the interaction between the hazards related to post-mining areas.

The mining hazards concern: ground movement, hydrologic hazards, self-heating, soil and water pollution. One hazard can trigger another one. Different tools such as a global matrix, fault tree, etc. for identifying the hazard interaction. The hazard interaction matrix was built, figure 1 shows a tentative view of interactions that phenomena in the columns (source phenomenon) may have with phenomena in the rows (target phenomenon). Figure 1 also shows indicative interactions between source phenomena and target phenomena according to 4 levels of interactions: No known case of interaction between phenomena (white colour), Low (yellow), Medium (green) and High (red). The final adopted interactions are based on the feedback and the deep discussion between experts. This approach will help the mining actors to improve and design the mitigation measures facing the multi-hazard impact and consequences.

	Subsidence	Localised collapse	Generalized collapse	Crevice	Settlement	Slope movement	Rock falls	Hydrological disturbances	Pollution	Gas emissions	Ionizing Radiation emissions	Induced seismicity	Combustion
Subsidence	Grey	Yellow	Red	Yellow	Yellow	Yellow		Red	Yellow	Yellow	Yellow		Yellow
Localised collapse		Grey		Yellow	Green	Green		Green	Yellow	Yellow	Yellow		Yellow
Generalized collapse	Green	Green	Grey	Red	Green	Green		Yellow	Yellow	Yellow	Yellow		Yellow
Crevice		Yellow		Grey		Yellow	Yellow	Red	Yellow	Yellow	Yellow		Yellow
Settlement	Yellow				Grey			Red					
Slope movement						Grey	Yellow	Yellow	Yellow	Yellow	Yellow		Green
Rock falls							Grey						
Hydrological disturbances								Grey	Yellow	Yellow	Yellow		
Pollution		Yellow	Yellow						Grey				
Gas emissions										Grey	Yellow		
Ionizing Radiation emissions											Grey		
Induced seismicity		Yellow	Yellow	Yellow	Yellow	Yellow	Yellow	Yellow	Yellow	Yellow	Yellow	Grey	
Combustion		Yellow			Red	Green		Red	Red	Red	Yellow		Grey

Figure 1. Interaction matrix of different hazard related to mine closure