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## Future underground spatial utilization – The role of geological criteria in the repurposing process of former coal mines

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The end of coal mining activities in Germany has resulted in vast underground spaces becoming potentially available for alternative purposes. The reuse of underground space may therefore provide answers to a growing interest in terms of economic and environmental considerations. Underground spaces can play an important role in future renewable energy scenarios (e.g. electricity and heat storage) and they can be considered as sites for waste disposal and other goods.

One example in these scenarios is the use of abandoned coal mines as sites for future subsurface hydropower plants (UPSP). However, risks associated with underground cavity projects and hydropower plants are well known (Colas et al., 2023), and these may be the reason that there are only a few examples of reusing abandoned coal mines as UPSP. In any repurposing process for former coal mines, geological criteria necessary for a quantitative assessment of the usability of abandoned coal mines need to be established. We use in this study the former coal mine Prosper-Haniel, Ruhr Area, Germany, as a lab test case. The Prosper-Haniel mine covers an area of approx. 165 km<sup>2</sup>, has a maximum depth of 1,159 m at 7 different levels of coal production and can be accessed by a total of five sinking shafts and one inclined shaft. Although the mine has been closed since 2018, feasibility studies have been carried out to investigate the potential reuse of the mine as a heat storage reservoir (Geo-MTES, 2018) and as a lower reservoir for a UPSP (Niemann et al., 2018).

We present an outline of geological and hydrogeological considerations essential for the repurposing of the abandoned coal mine Prosper-Haniel. The approach integrates stratigraphy data, fault sets, mine geometry, geological properties, and three-dimensional geological modelling. The envisaged repurposing applications encompass the utilization of Prosper-Haniel as a lower reservoir for UPSPs, a reservoir for heat storage, a geothermal production site, and as an underground space for storage purposes including waste disposal. The multi-disciplinary and integrated approach presented aims to contribute to a nuanced understanding of the potential repurposing opportunities associated with underground coal mines.

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