

Digital twinning for post-mining environmental transitions

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Project Highlights:

- Underground and overground landscapes are digitally replicated, to virtually test alternative post-mining uses.
- Scalability and robustness of approaches are queried for diverse types of extraction and geographic situations.
- Decision-making for post-mining socioenvironmental resilience is built into the mining life cycle, for policy, industrial and community stakeholders.

Overview:

Mining is a cornerstone industry that utilises natural capital. Downsizing or cessation of mining occurs when ore deposits become subeconomic or exhausted. The loss of a cornerstone industry, combined with limited economic diversification and negative environmental legacies, are key challenges for resilience in post-mining communities. The PhD project mission is to build sustainability on the natural capital and infrastructure foundations left behind by declining extractive industries.

The research has strategic importance because escalating resource consumption will drive a greater number of mine sites into transition, for reopening of legacy sites, care and maintenance of marginally economic mines, or closure of mines in exhausted ore bodies. Existing strategies for decision-making about reuse of mined landscapes are not adequate. This project builds the UK-based knowledge economy for responsible mining life cycles.

The ultimate goal of the project is a decision-making strategy to support mine transition, from the outset of the industrial planning stage and through mine development. Identification of opportunities for economic diversification (and thereby community resilience) must be sensitive to the physical landscape and environmental protections, to minimize industrial pressure on ecosystems. The approaches must be robust enough to apply to multiple geological and geographic contexts because there is an ever-wider range of ore deposits being exploited. The primary case studies are overland (S Wales) and underland (Isle of Portland) mine spaces that are ready for reutilisation.

A digital twin is a virtual replica that will be created for each of the two primary case study landscapes. The virtual replicas will be used to model possible reuse scenario and test alternative futures without costly mistakes and socioenvironmental missteps. Input data will be required on the alternative future landscape uses and how they are selected. The project will therefore consist of a three-step approach: (1) understand how mine sites can be reused; (2) test the suitability of

alternative futures using the digital twin models for the main case studies; (3) determine how twinning tools and policy can steer decision-making towards optimized positive outcomes. Scalability will be interrogated using wider comparisons, e.g. with SW England and the Peak District).



a. Cessation of Albion Stone mining activity in underground space



b. Overground industrial space is at a premium for economic development



c. 34% of land is designated as Priority Habitats

Figure 1: Underground and overground spaces are available for reuse on the Isle of Portland: the Neighbourhood Plan designates areas for habitat protection, mineral safeguarding and managed change (this includes Quarries and Open Space).

Alt Text: Figure 1 shows photographs of the underground mine, and overground mine and environment on the Isle of Portland, UK.

Methodology:

This work will be supported by Deep Digital Cornwall (DDC) lab facility at Camborne School of Mines (CSM). The student will:

1. **Desk-survey** and **consult** on the ways that old mine/quarry/tip sites are internationally remixed for: resources, environmental restoration, tourism or cultural heritage projects, alternative and innovative manufacturing and research industries,
2. **Field-survey** using remote sensing and laser scanning, for data to replicate the primary UK post-extractive underground and overground landscape case studies,
3. **Digitally twin** the landscapes using the DDC lab and test how they can be reconfigured for alternative uses,
4. **Analyse** the sustainability potential for the alternative options using appropriate criteria and local consultation, to optimize solutions,
5. **Develop** the technical approach as an optimization tool kit that is adaptable to multiple scenario, and
6. **Determine** how the approach can be used to create impact by transforming decision-making for management of industrial extraction and post-extractive resilience.

Possible Timeline

Year 1: Field visits for familiarisation and consultation. First surveying campaign with Isle of Portland and south Wales mine contexts and training in use of DDC. Comprehensive review and analysis of diversity of mine reuse options, how the reuse unfolds, over what timeframes and under the guidance of which stakeholders. Manuscript topic drafting: Analysis of decision-making practices for reuse of extractive landscapes.

Year 2: Second surveying campaign and processing of data for visualisation. Reconfiguring digital twins for alternative future uses to examine how they can be optimised for best fit to socioenvironmental context. Manuscript topic: Digital twins as a tool for visualisation of alternative land reuse after the cessation of mining.

Year 3: Consultation for revision of digital twin models and to understand how to centre community needs and ambitions in underground/overground environmental planning. An exploration of policy and regulatory structures that will enable/enforce implementation of best practice for mine remediation, which does not sterilise mined landscapes as a resource. Manuscript topic: Policy for community-driven landscape planning in post-mining landscapes. Manuscript submission(s) and Thesis preparation.

Training and skills:

TARGET researchers will participate in a minimum of 40 days training over the 3.5 years of study composed of:

- an annual one-week workshop dedicated to their year group, and tailored to that cohort's needs in terms of skills development – *for the first three years of their study*;
- an annual all-TARGET workshop with cross-year interactions, advanced training and opportunities to specialise in particular areas – *all years of study*;
- a number of one-day workshops;
- additional online events and in-person workshops attached to relevant conferences.

National competency for training in mining-oriented solutions is dominantly located in the Camborne School of Mines (CSM) in the Department of Earth and Environmental Sciences at the University of Exeter. Expertise in the wider Department includes futures thinking for socio-environmental sustainability, co-located with the mining expertise. The project is therefore based in the University of Exeter.

No one candidate can be expected to have all the competencies required for this project. Training in laser scanning and digital twinning will be provided in CSM, where the Deep Digital Cornwall facility is located. PhD students at the Camborne School of Mines can access BSc and MSc modules on environmental mine management and resource politics for further interdisciplinary training.

Accessibility statement:

The project can be full or part time. Some mobility is required for UK site surveys, but there is a shortlist of available sites with variable accessibility requirements so that field activities can be tailored to personal circumstances. There is no formal requirement for international travel.

Partners and collaboration (including CASE):

Island Community Action will support the project on the Isle of Portland, which is the underground technical mine case study.

The Mine Remediation Authority will support the project in south Wales, the location over the overground technical mine case study.

Requirements: Applicants are not expected to have all the competencies for this project and can consider applying from different interdisciplinary backgrounds. They should ideally have a BSc Hons degree in geology, geography, computer sciences or environmental studies, with an interest in surveying or sustainability.

Further reading:

Santiago Santos C, Garcia Praça Leite M, Mota de Lima H (2025) Integrated mine closure planning adherence Index: a new approach for evaluating mine closure plans. Resources Policy [10.1016/j.resourpol.2025.105604](https://doi.org/10.1016/j.resourpol.2025.105604)

Whitbread-Abrutat P and Lowe R (2024) 102 Things to do with a Hole in the Ground. Eden Project, 264 pages.

Further details:

Please visit <https://target.le.ac.uk/> for additional details on how to apply. Correspondence about the project can be directed to Kate Moore: k.moore@exeter.ac.uk; <https://experts.exeter.ac.uk/21180-kathryn-moore>