Tracing the sources of deep and legacy metals in Cornish waters: lithium, strontium and neodymium isotope applications for mine-water remediation and geothermal resource assessment

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Project Highlights:

- Use new Sr and Nd isotope capability to fingerprint mine-water contamination in the Carnon River, one of the UK's classic legacy mining catchments
- Link water quality, sediments and ochres with Li-Sr-Cl tracers to distinguish adits, tailings, treatment-plant inputs, diffuse sources and possible deep lithium-bearing waters
- Work with Cornwall-based water, groundwater and geothermal partners to turn isotope geochemistry into practical evidence for remediation, monitoring and low-carbon subsurface resources

Overview:

Abandoned metal mines continue to affect rivers long after closure, but management is often limited by a common problem: where is the contamination source coming from? The Carnon River is an ideal natural laboratory because it receives inputs from historic mine workings, tailings, adits, springs, treated mine water and possible deeper groundwater components before discharging towards Restronguet Creek and the Fal estuary.

Previous Exeter SPF-funded work (Figure 1) shows that County Adit and Hicks Mill are major acid mine drainage inputs, while a small circumneutral orange spring is an extreme arsenic source. The same dataset also shows that Clemmows Stream and the Wheal Jane mine water treatment plant form a distinct chloride, lithium and strontium concentration endmember, demonstrating that conservative tracers can separate hydrological inputs even where toxic metals have been removed by treatment.

This PhD will develop Sr and Nd isotope fingerprints for the Carnon system with Li concentrations as a tracer of deep or treatment-plant-influenced waters. Sr isotopes will trace dissolved water-rock interaction, mine-water mixing and treated-water influence. Nd isotopes will predominantly target particulates, ochres, sediments and source materials, helping distinguish granite-derived, metasedimentary, tailings and mine-waste contributions. Together these tools will test whether dissolved metals, arsenic-bearing ochres, lithium-rich waters and contaminated sediments share common sources, or are supplied by different catchment components.

The project is designed to interest both water-quality partners and geothermal/critical-mineral partners: it addresses practical contaminant apportionment and remediation, while also testing how deep Cornish waters acquire lithium, salinity and radiogenic Sr signatures during granite-hosted water-rock interaction.

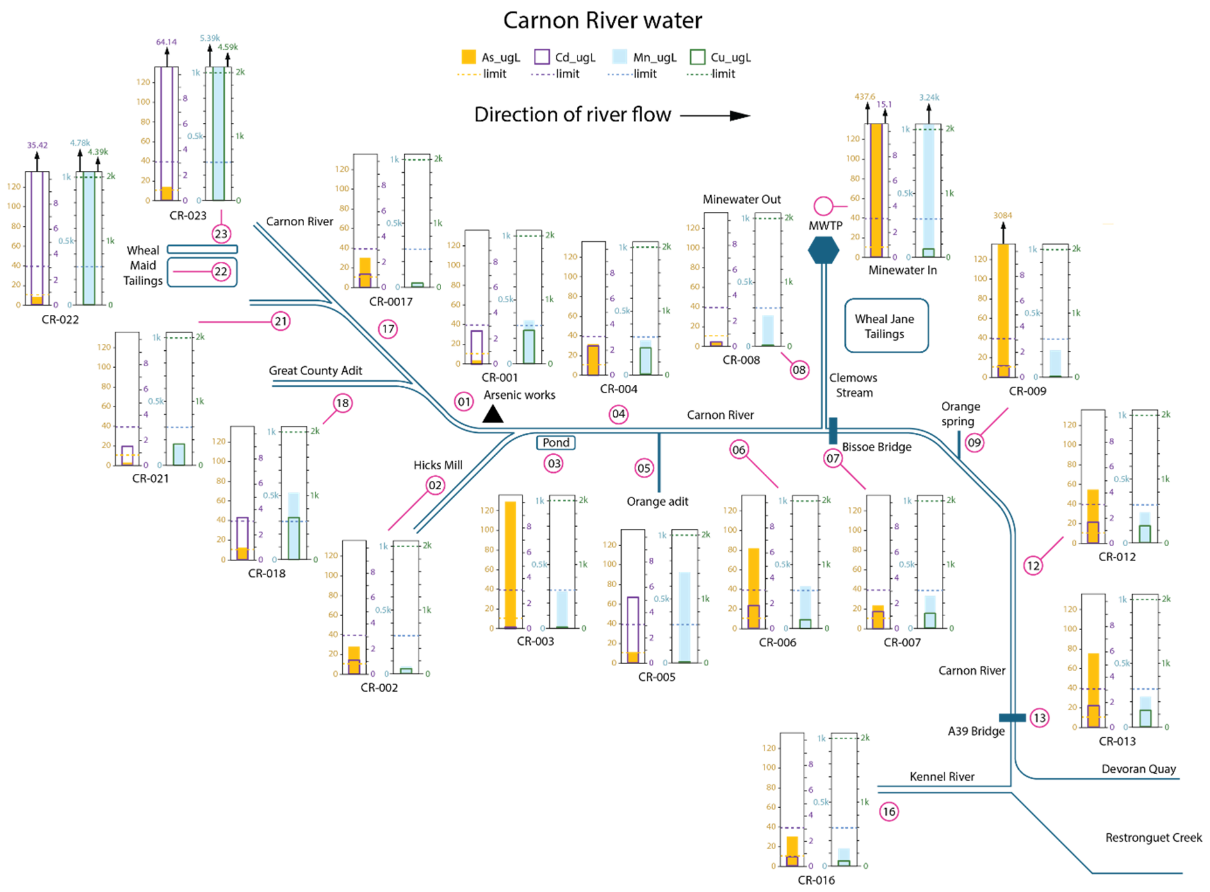

Figure 1: Preliminary Carnon River source results showing acid mine drainage inputs, treated Wheal Jane/Clemmows Stream water, an orange arsenic spring and downstream water-quality impacts.

Methodology:

The student will undertake seasonal field campaigns along the Carnon River, tributaries, adits, springs, mine-waste sites and treatment-influenced reaches, with targeted sampling around Wheal Jane/Clemmows Stream. Samples will include filtered/unfiltered waters, particulates, ochres, riverbank sediments, soils and source materials. Analyses will include pH, conductivity, alkalinity, major ions, Li-Sr-Cl relationships, ICP-OES/ICP-MS metals, PHREEQC modelling, pXRF screening and MC-ICP-MS isotope work. Core isotope methods will be 87Sr/86Sr in waters and solids, and Nd isotopes in sediments, ochres, particulates and selected waters where feasible. Mixing models will link isotope fingerprints to As, Cu, Zn, Cd, Mn, Fe and Li behaviour.

Possible Timeline

Year 1: Review literature; finalise sampling design with CASE partners; first field campaigns including Carnon/Wheal Jane targets; major/trace element and Li-Sr-Cl screening; develop Sr clean-lab chemistry and pilot 87Sr/86Sr analyses.

Year 2: Expanded seasonal sampling; Nd method development for sediments, ochres and particulates; isotope analysis of key endmembers; PHREEQC and mixing-model development; first conference presentation/paper.

Year 3: Integrated source-apportionment model; targeted follow-up sampling; comparison of dissolved, particulate and deep-water pathways; applied guidance note for partners; thesis chapters and publications.

Training and skills:

The student will gain training in environmental field sampling, mine-water and groundwater geochemistry, clean-lab isotope chemistry, MC-ICP-MS, ICP-OES/ICP-MS, pXRF, PHREEQC, source-apportionment modelling, risk communication and applied catchment/resource management. They will also receive TARGET cohort training, transferable-skills development and opportunities to present to academic, water-sector and geothermal/resource audiences.

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.

Partners and collaboration (including CASE):

GEL will advise on deep Cornish waters, geothermal/lithium relevance and possible samples/site context. Premier Water Solutions will advise on practical water-management, monitoring and remediation needs. Cornwall Groundwater Partnership will provide groundwater stakeholder context and knowledge-exchange routes. Partner input will focus on project-shaping, meetings and support, site visits, relevat samples and applied interpretation.

GEL

PWS & INSTALLATIONS
Premier Water Solutions 10 Ltd

CORNWALL GROUNDWATER PARTNERSHIP

Further reading:

- Jennings, E. et al. (2025) Spatial and temporal (annual and decadal) trends of metal(loid) concentrations and loads in an acid mine drainage-affected river. *Science of the Total Environment*, 964, 178496, https://www.sciencedirect.com/science/article/pii/S0048969725001305
- Pirrie, D. et al. (2003) The spatial distribution and source of arsenic, copper, tin and zinc within the surface sediments of the Fal Estuary, Cornwall, UK. *Sedimentology*, 50, 3, 579–595, https://onlinelibrary.wiley.com/doi/full/10.1046/j.1365-3091.2003.00566.x
- Sanjuan, B. et al. (2022) Lithium-rich geothermal brines in Europe: An up-date about geochemical characteristics and implications for potential Li resources. *Geothermics*, 101, 102385, https://www.sciencedirect.com/science/article/pii/S0375650522000372
- Whitehead, P.G. et al. (2005) Chemical behaviour of the Wheal Jane bioremediation system. *Science of the Total Environment*, 338, 41–51, https://www.sciencedirect.com/science/article/pii/S0048969704006229

Further details:

Please visit https://target.le.ac.uk/ for additional details on how to apply. Contact Sev Kender (s.kender@exeter.ac.uk) for project enquiries.