Elvan dykes as sources, fluid pathways and traps of Sn, W, Cu and Li in SW England

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Project Highlights:

- Field-, core shed- and laboratory-based project on granite dyke magmatism and related mineralisation in SW England.
- Aims to constrain the timing and process relations between the emplacement of granite plutons, elvan dykes, mantle-derived lamprophyre dykes, upper crustal faulting and Sn, W, Cu and Li mineralisation.
- Will enhance exploration models for granite-related Sn, W, Cu and Li mineralisation in SW England, with potential applications worldwide, and develop student exploration skills and employability.

Overview:

The UK government's target of net zero greenhouse gas emissions by 2050 will require huge quantities of 'critical' raw materials including Sn, W and Li, plus Cu (non-critical), for green technology, e.g., batteries for electric vehicles. The Cornubian Batholith and associated world-class ore field has a long history of Sn, Cu and W extraction and hosts the largest Li resource in Europe. There is active exploration ± development for these metals (Cornish Lithium, Cornish Metals, Cornish Tin, Cornwall Resources, Imerys British Lithium) and in every area there are microgranite or porphyry dykes, known locally as 'elvans'.

The elvans have strike-lengths up to 10 km and widths up to *c.* 50 m, and have a spatial association with fault-controlled magmatic-hydrothermal lode mineralisation, which can be younger, older or synchronous. Whilst there has been little recent published research on the elvans (e.g., Antipin et al., 2002), there has been considerable new work on the Cornubian Batholith (e.g. Simons et al., 2017), processes affecting Li enrichment in micas (Putzolu et al., 2024), and the U-Pb cassiterite dating method (e.g. Tapster and Bright, 2020).

This project aims to answer the following key research questions:

1) When, and under what controls, were the elvan dykes emplaced, and in what context, relative to post-Variscan deformation, pluton/batholith construction, intrusion of mantle-derived (lamprophyre) dykes and pulses of Sn, W, Cu and Li mineralisation?

2) What was the role of elvan dykes in the production and transport of mineralising fluids? Did they exsolve mineralising fluids themselves, preferentially host fracture pathways for fluid transfer from greater depths and larger volumes of magma, and/or provide supersolidus

pathways for fluid percolative flow through crystal mush in the dykes, as hypothesised by Carter et al. (2021) in the formation of porphyry Cu deposits in Nevada?

3) What influence did the composition, structural context and age of the elvan dykes have on the nature (mineralogy, grade, distribution) of associated mineralisation? Can the resulting information be used to predict which elvan dykes and associated mineralisations will have the lowest cost and environmental impacts to mine, i.e. highest grades and lowest sulphide contents?

The student will be mainly based in the world-class ore-field and beautiful environment of SW England, on the Penryn Campus of Exeter University, supervised by experts in granite genesis and related mineralisation and structural geology. Geochronological studies will be carried out at BGS and fluid and melt inclusion analyses at UCL. This exciting, industry-facing project will provide the student with a range of transferable, geological and analytical skills towards a career in research or the mining industry.

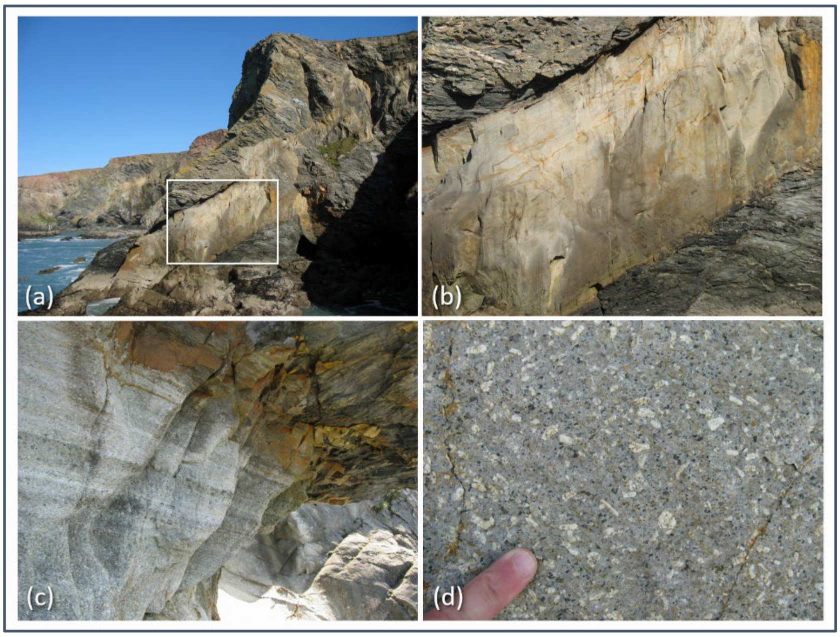

Figure 1: Field example of an elvan dyke, near Trevellas Porth, Cornwall (strike-length >5 km), dated at 283.21 ± 0.032 (2σ) Ma by CA-ID-TIMS U–Pb zircon (Tapster and Bright, 2020); (a) dyke hosted by NW-dipping extensional fault (cliff is 90 m high); (b) detail of area outlined in (a) showing flow-banded margins; (c) upper contact with Devonian slates showing flow-banding and quenched marginal facies; (d) close-up of quartz and feldspar phenocrysts in a fine-grained groundmass.

Methodology:

1) Existing data (locations, types, orientations and ages of granites, elvan dykes and lodes) will be compiled in a GIS project. The results will be used to select locations to assess the structural and timing relations of the dykes and lodes and to collect samples for a range of modern analytical techniques. The ages of magmatic rocks will be determined using high precision (state-of-the-art) U-Pb zircon geochronology, and of the mineralisation by cassiterite U-Pb dating, as developed by Tapster and Bright (2020).

2) Mineral chemical, textural and fluid and melt inclusion evidence (including from laser Raman spectroscopy and LA-ICP-MS) will be sought from the dykes for magma-fluid exsolution, fracture-controlled flow, and/or fluid percolation through crystal mush.
3) The results from 1 and 2 will be used to construct an exploration model for elvan-related mineralisation, that will include criteria for establishing which dykes are of higher grade and/or contain less sulphide.

Possible Timeline

Year 1: Familiarisation with relevant literature, data sources and sample archives (including that of Dr Charlie Moon); production and interpretation of an ArcGIS database and maps of locations, types, orientations and ages of the granites, elvan dykes and veins (both mineralised and unmineralised); selection of sites for field studies and sampling; introduction to CASE partners to discuss their perspectives on elvans, and possibilities for logging and sampling; preparation of a first draft literature chapter; field studies and sample collection; textural and mineral-chemical analyses of initial collected and archive sample (EPMA and LA-ICP-MS at UoE); re-evaluation of training needs.

Year 2: Sample selection for geochronological and fluid and melt inclusion studies, and gathering of initial data; infill sampling and fieldwork; further laboratory-based textural and mineral-chemical analyses geochronological and fluid and melt inclusion studies; consideration of career options and training needs. Presentation of preliminary results at a UK research meeting (probably MDSG)

Year 3: Completion of laboratory studies and synthesis and interpretation of all data; presentation of the results at an international meeting; preparation of a manuscript on the textural and mineral-chemical data; preparation of a manuscript on the mechanisms and timing of dyke emplacement and associated mineralisation, and links to deformation, the evolution of the Cornubian Batholith and mantle-derived (lamprophyre) magmas; drafting of results chapter of the thesis; consideration of career options.

Year 4: Final six months to finish interpreting the data and to draft the thesis; finalisation of manuscripts for submission to international journals, liaison with industry and consideration of career options.

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.

The student will regularly complete a supervision agreement, training needs assessment and generic online courses, and receive face-to-face lab inductions and specific training for the experiments they will undertake. They will be part of a thriving and inclusive research community within CSM, currently totalling 26 students, and can participate in MSc Exploration and Mining Geology modules, the CSM seminar series, presentations from potential mining industry employers, and join the CSM SEG Student Chapter. The Penryn Campus of UoE has excellent IT, library and support services, lively social spaces and offers a wide range of sporting opportunities.

Partners and collaboration (including CASE):

Robin Shail, Jens Andersen and Sam Broom-Fendley (UoE) will ensure that the student works in a vibrant and inclusive research environment, and co-ordinate fieldwork, visits to CASE partners, sample collection and analyses at UoE. Dan Condon (BGS) will supervise U-Pb cassiterite and high precision U-Pb zircon age determinations, and Katie McFall (UCL) the fluid and melt inclusion studies. CASE Industrial partners (Cornish Lithium, Cornish Metals, Cornish Tin, Cornwall Resources) will provide access to core for logging and sampling and, together with Dr Charlie Moon (Independent Consultant), will provide context to elvans in their exploration areas.

Further reading:

Antipin, V.S., Halls, C., Mitichkin, M.A., Scott, P. and Kuznetsov, A.N. 2002. Elvans of Cornwall (England) and Southern Siberia as Subvolcanic Counterparts of Subalkalic Rare Metal Granites. *Russian Geology and Geophysics*, 43, pp. 847–857,

Carter, L. C., Williamson, B. J., Tapster, S. R., Costa, C., Grime, G. W. and Rollinson, G. K. 2021. Crystal mush dykes as conduits for mineralising fluids in the Yerington porphyry copper district, Nevada. *Communications Earth & Environment*. https://doi.org/10.1038/s43247-021-00128-4.

Putzolu, F., Seltmann, R., Dolgopolova, A., Armstrong, R.N., Shail, R.K., Spratt, J., Buret, Y., Broderick, C. and Brownscombe, W., 2024. Influence of magmatic and magmatic-hydrothermal processes on the lithium endowment of micas in the Cornubian Batholith (SW England). *Mineralium Deposita*, pp.1-22.

Simons, B.J., Andersen, J., Shail, R.K. and Jenner, F.E. 2017. Fractionation of Li, Be, Ga, Nb, Ta, In, Sn, Sb, W and Bi in the peraluminous Early Permian Variscan granites of the Cornubian Batholith: precursor processes to magmatic-hydrothermal mineralisation, *Lithos*, 278-281, pp. 491-512.

Tapster, S. and Bright, J.W. 2020. High-precision ID-TIMS cassiterite U–Pb systematics using a low-contamination hydrothermal decomposition: implications for LA-ICP-MS and ore deposit geochronology. *Geochronology*, 2, pp.425-441.

Further details:

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Please visit https://target.le.ac.uk/ for additional details on how to apply.