Durham University
Department of Earth Sciences

Profs Ken McCaffrey, David Selby, Bob Holdsworth
https://www.durham.ac.uk/staff/k-j-w-mccaffrey/

Reactivation and mineralisation associated with the Lake District Boundary Fault

1. Background

The Lake District Boundary Fault (LDBF) defines the western edge of the Lake District massif and separates it from the East Irish Sea basin. The LDBF is a prominent expression of an extensive NNW-SSE-striking fault system that developed across northern England that display complex, variable histories of faulting and reactivation. The geometrical and temporal complexity of the LDFZ emerged during extensive drilling and onshore/offshore seismic acquisition during UK NIREX Ltd investigations for potential repository sites in the 1990s. In summary, parts of the LDBF may have originated as Early Paleozoic intra-arc rift faults. Reactivation occurred during Siluro-Devonian transtension before Permo-Triassic rifting formed the East Irish Sea basin margin with intervening episodes of Acadian, Variscan and Cenozoic inversion variously invoked. The Mesozoic activity and extensive hematite mineralisation is well documented for the LDBF with step-overs between fault segments and open fissures acting as foci for mineralisation in carbonate host rocks (Fig. 1).

Motivation for this study is provided by renewed interest in the LDBF because it largely defines the west coast of Cumbria which has significant current and potentially future infrastructure sites (e.g. Sellafield and potential GDF sites) and any possibility of fault-related hazard needs to be fully assessed. More broadly the East Irish Sea basin is being considered for fluid repository projects and a better understanding of the NNW-SSE faults that are the major structural elements in the basin is desirable.

2. Aims and methods

This project will combine an integrated onshore/offshore structural data collection with a geochronology study of fault and mineralisation products to produce a new understanding of the LDBF, its reactivation and mineralisation history.
The study aims and methods are:
1) To (re)assess the structural history of the LDBF through detailed fieldwork onshore and geophysical and marine datasets offshore. This will enable structural model building and paleostress analysis. Fieldwork will also be critical to evaluate the extent and nature of the hematite and other mineralization and enable the collection of key samples for follow-up studies.
2) Re-evaluation of the LDBF and related structures in light of recent Durham work highlighting the role of fissure systems in carbonate host rocks from sub-unconformity basement terrains and their importance for fluid storage and transmissivity.

Figure 1: Hematite/calcite mineralisation at Hodbarrow Point formed in step-over in the Haverigg Fault – a strand of the LDBF. Note obliquely plunging slickensides. Notebook for scale.

3. Scientific benefits

1. New detailed field description and characterisation of the LDFZ and related structures exposed onshore with constraints from offshore drilling and publically available geophysical datasets.
2. Demonstrate that state-of-the-art methodologies are required to understand fault and mineralisation histories and a new assessment of evidence for potential fissuring processes.

4. Training

- Industry-relevant research experience – with good opportunities for onshore/offshore structural interpretation and modelling.
- Constraining genetic histories of fault and fissure evolution and associated mineralisation.

Reading

Akhurst, M.C., Barnes, R.P., Chadwick, R.A., Millward, D., Norton, M.G., Maddock, R.H., Kimbell, G.S. and Milodowski, A.E., 1998. Structural evolution of the Lake District boundary fault zone in west Cumbria, UK. Proceedings of the Yorkshire Geological Society, 52(2), pp.139-158.
Needham, T.I.M. and Morgan, R., 1997. The East Irish Sea and adjacent basins: new faults or old?. Journal of the Geological Society, 154(1), pp.145-150.
Soper, N.J. and Woodcock, N.H., 2003. The lost Lower Old Red Sandstone of England and Wales: a record of post-Iapetan flexure or Early Devonian transtension?. Geological Magazine, 140(6), pp.627-647.
Tamas, A., Holdsworth, R.E., Tamas, D.M., Dempsey, E.D., Hardman, K., Bird, A., Roberts, N.M.W., Lee, J., Underhill, J.R., McCarthy, D. and McCaffrey, K.J.W., 2023. Older than you think: using U–Pb calcite geochronology to better constrain basin-bounding fault reactivation, Inner Moray Firth Basin, western North Sea. Journal of the Geological Society, 180(5), pp.jgs2022-166.
McCaffrey, K.J.W., Holdsworth, R.E., Pless, J., Franklin, B.S.G., & Hardman, K. 2020. Basement reservoir plumbing: fracture aperture, length and topology analysis of the Lewisian Complex, NW Scotland. Journal of the Geological Society, 177, 1281-1293