Roinn Cumarsáide, Gníomhaithe ar son na hAeráide & Comhshaoil
Department of Communications, Climate Action & Environment

Geological Survey
Suirbhéireacht Gheolaíochta
Ireland | Éireann

Research Programme
- Short Call 2020, Final Report -

Lead Applicant Name	Dave Blaney
Host Organisation name	BRG Ltd.
Project Title	Energy Critical Element Characterisation of Irish Mineral Deposits
Contract Number	2020-sc

This report covers the period 1st December 2020 to project end date 11th May 2022

2. (a) Project information:

Final project report (*max 2500 words, excluding figures and headings*):

Executive summary (lay abstract, approx. 250 words):

The Irish Midlands Orefield is recognised as a world class province for large, carbonate hosted, massive sulphide Zn / Pb deposits. Irish deposits tend to be of higher grade (than MVT), are dominated by sphalerite, galena and pyrite and form from relatively high temperature hydrothermal fluids (>180oC). Copper, silver, arsenic and nickel enrichments are prevalent close to feeder structures in the hotter localities of these deposits.

The Energy Critical Element (ECE) trace element characteristics of Irish deposits have not been thoroughly assessed and are accordingly, poorly understood. This is due in part to the relatively recent interest and growing industrial requirement for these elements versus the long history of mining in Ireland. It is also partly due to historical difficulty in the analysis and subsequent mineral processing for these elements.

The presence of significant quantities of Energy Critical Elements within Irish mineral deposits would be beneficial for a range of stakeholders, including:

- The mining companies exploiting the resource, providing additional exploitable commodity elements,
- The exploration companies who will have a more valuable and desirable target which has evolved in tandem with the requirements of modern society and aids global environmental strategies to reduce the carbon based economy,
- The Irish State, with the benefit of more investment in exploration and increased revenue in the form of royalties from a more valuable mine concentrate with respect to smelter credits,
- The EU with a secure and "local" source of Energy Critical Elements located within its borders and support of the "Green" agenda with the environmental drive to a reduced carbon dependency.

This study entailed the acquisition and geochemical analysis of 248 geological samples of Irish base metal style mineralisation. The analysis has identified whole rock concentrations of Energy Critical Elements of up to 59.2ppm gallium (Ga), 127ppm germanium (Ge) and 5.5ppm indium (In).
The highest gallium concentration is contained within a sample from the Keel deposit. Significantly elevated Ga concentrations were also identified in the Abbeytown, Carrickittle, Mallow, Oola and Pallas Green deposits.
The highest germanium concentration is in a sample from the Abbeytown deposit, with elevated concentrations recorded at the Kildare-McGregor, Pallas Green (Strahane West) and Kildare FC3 deposits where Ge values range from 32 to 59ppm.
The highest indium concentration occurs in the Abbeytown deposit with elevated concentrations in the Silvermines-Calamine, Silvermines sulphides and Keel deposits.

(i) Results, scientific/engineering targets reached beyond the state of the art and conclusions

Specific conclusions include:

1) The QC samples and the laboratory work was very satisfactory.
2) Two outlier results are the presence of In in the Calamine at Silvermines and the Li at Moyvoughly.
3) Most of the mine tailings/ ore spoil samples which had been collected by the GSI team were high in trace elements, such as Ag, As, Co and Sb
4) The Ge:Zn relationship is positive, with economic benefits and whilst the Ga:Zn relationship is also positive, it's not as clear-cut as the Ge:Zn relationship.
5) In general, the increase in ECEs with grade of host mineralisation means that the possibility of ECEs being a significant factor in the economic assessment of lower grade or marginal deposits is unlikely.
6) As expected, the fusion method for Ge was clearly the better option, but it is felt that for routine exploration purposes the four acid digestion analysis is sufficient, however, for a more precise economic evaluation, the Li fusion method is more appropriate and is commented on further below.
"The examination of the multi-acid Ge dataset in comparison to the fusion dataset suggests that a multi-acid digestion dataset while not revealing the total Ge present in a sample may act as a robust discrimination method for exploration purpose and identification of elevated Ge samples in exploration targets." It could thus be a worthy exploration tool for investigation of past and future Ge results by the MEMS61 method of ALS OMAC."
7) The Pallas Green deposit, representing an early stage in the life cycle of an Irish style deposit should be examined in detail for ECE concentration and source mineral phases and mineralogical studies could be completed to define the host minerals of ECE in this locality.

The positive impact of this project could be and is quite wide-ranging. "Irish Type" deposits are currently a highly prized exploration target. Their large tonnage, high grade, simple morphology and good metallurgical characteristics make them desirable. The potential for ECE's to be present in Irish deposits has been demonstrated and may have gone unrecognised.

This research study and the research observations presented by Zhou (2021) are independent pieces of research on ECE in Irish Pb/ Zn deposits. This study confirms that in many cases the ECE geochemical signature of an Irish Pb/ Zn deposit can be similar at both the scale of micro-analytical geochemical observation (Zhou, 2021) and comparable bulk whole-rock

geochemistry (This study).

(ii) Implementation (milestones, deliverables, project management)

The original plan was to divide the project into five phases, with some overlap and iteration of analysis envisaged, based upon results received.

Phase 1: A Desk study / literature review. This included the identification and location of samples or areas / deposits where sampling would help meet the objectives of the study. Relevant stakeholders were contacted and permission to sample material (drill core, assay pulps, assay rejects, etc…) was obtained. It was anticipated this would take approximately 3 months and even with the impact of Covid this phase was completed roughly on schedule.

Phase 2: The Sample acquisition phase required personnel going to sites, meeting with stakeholders, and obtaining relevant samples. A sampling protocol / Standard Operating Procedure (SOP) was established for the anticipated range of sampling mediums and locations. This phase of the project was anticipated to overlap with Phase 1, however, Covid lockdowns and associated access issues severely curtailed our ability to visit core storage facilities, particularly during the first half of 2021. Accordingly, the sampling programme was not fully completed until late September 2021, four months behind schedule.

Phase 3: QA/QC and Sample analysis. An appropriate QA/QC system was put in place that provided confidence in veracity of the results obtained from the laboratory. The QA/QC system sourced appropriate Standards / certified reference material (CRM), blanks and duplicates. The sample analysis was carried out at the ALS-OMAC Laboratory in Loughrea, County Galway. The delay in obtaining the physical samples had a knock on effect and the results of the sampling were not received until late November / early December. We must acknowledge that ALS-OMAC were extremely accommodating giving us preferential treatment and rushing our samples through at a time when they were extremely busy.

Phase 4: Modelling and interpretation. The assay data was incorporated into a database and was to be assessed and interpreted using advanced geochemical software. The volume, scale and complexity of data generated was daunting and Dr Dermot Smyth was added to the team to provide his wealth or experience and expertise with this type of project. Review, interpretation and modelling of the data was meant to commence in August 2021, but this was delayed until assay results were received in late November

Phase 5: Preparation and submission of a factual and interpretative report. Detailing the methodologies employed, sources of data, assay results, QA/QC, interpretation and assessment of the results and recommendations for further work. This was planned to be completed in the final 2 months of the project and it commenced in February 2022.

(iii) Outputs to date

(iv) A full comprehensive report on the project delivered to the GSI including a set of recommendations arising from the work undertaken.

- A lithogeochemical dataset including all of the analyses undertaken in the course of the project
- Presentation to the Irish Association for Economic Geology (IAEG) at their 2022 conference is currently being prepared
- An ESRI GIS Storymap of the project with interactive map content and videos will go live at the IAEG conference. The link is https://arcg.is/1Kuf5f

(iv) Impact

- Relevance/application to GSI programmes, where applicable

The project has enhanced understanding of the incidence, concentration, and distribution of ECE's within the overall Irish Midlands Orefield and within specific deposits. This enhanced understanding can be used to develop and refine understanding of the incidence of ECE's, establishing the economic benefit to both mining companies and the state. In addition, the benefit of securing an internal and secure supply of these metals will meet current EU strategies with respect to Critical Raw Materials. The Geological Survey of Ireland's Research Roadmap Objective to identify and exploit natural resources, particularly for the production of green energy technologies has relevance to this study.

- Other impacts

To advance the conclusions and findings of this ECE geochemical project, further research should be completed on the project samples to identify ECE hosting mineral phases in the samples. Samples from a range of deposits in the project archive should be examined. These sample pulps should also be submitted for a sodium peroxide analysis of a comprehensive low detection limit suite of elements.

The Pallas Green deposit, representing an early stage in the life cycle of an Irish style deposit, could be examined in detail for ECE concentration and source mineral phases and mineralogical studies could be completed to define the host minerals of ECE in this locality.
It is recommended in order to facilitate future studies that a series of samples comprising drill core, hand specimens, sample pulps and concentrates should be maintained for each Irish Pb/ Zn deposit to enable the archive to act and provide sample material for future research studies on mineralisation style and composition. The requirement for this is ongoing and of increasing importance as new element commodities are identified as part of the creation and implementation of the global "green" economy.

4. Supplemental information/datasets

Attached is the Report - Energy Critical Element Characterisation of Irish Mineral Deposits

Appendix I – Excel Spreadsheet of Project data

Appendix II - Energy Critical Element Characterisation of Irish Mineral Deposits QA/QC Assessment

Appendix III - Energy Critical Element Characterisation of Irish Mineral Deposits – Spearman Ranking Correlation Coefficients

Appendix IV - Energy Critical Element Characterisation of Irish Mineral Deposits – Histograms of element concentration