Roinn Cumarsáide, Fuinnimh & Acmhainní Nádúrtha
Department of Communications, Energy & Natural Resources

Geoscience Research
GSI
Suirbhéireacht Gheolaíochta Éireann
Geological Survey of Ireland

Geological Survey of Ireland Research Programme
- Short Call 2015, Final Report -

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Date received:	*Ref. No.:*	
☐ **GSI Geoscience**	☐ **INFOMAR**	☐ **Tellus**

Name of Lead Investigator	Mark Holdstock
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Organisation name	Aurum Exploration Services		
Organisation type: Sector	☐HEI	☐Public Sector (other)	☒Private
Department/section			
Address	Unit 34 Kells Business Park, Virginia Road, Kells, County Meath A82 T2C8		

Project Title	Mineral Prospectivity Analysis utilising publically available datasets and Free & Open Source Software
Contract No.	2015-sc-060
Total financial support requested from GSI (as per proposal)	€22,000

The details presented in this report are a true and accurate reflection of the work undertaken and the associated financial expenditure. All work was carried out within the GSI Terms and Conditions and as per the Contract (unless formally amended).

M P Holdstock

Signed: _____
Lead Investigator

INFOMAR
Integrated Mapping for the Sustainable Development of Ireland's Marine Resource

1. **NEW Partner information** – (in addition to those named in project proposal)
please copy table as needed:

Co-applicant name			
Role in the project			
Organisation name			
Organisation type:	☐HEI	☐Public Sector (other)	☐Private Sector
Company Registration No. (if applicable)			
Department/section			
Address			

Co-applicant name			
Organisation name			
Organisation type:	☐HEI	☐Public Sector (other)	☐Private Sector
Company Registration No. (if applicable)			
Department/section			
Address			

Staff <u>funded</u> by the GSI Short Call Project (add lines if required)

Name	**Male/Female**	**Position**	**Expertise**
Steven Downey	**Male**	**GIS Manager**	**GIS Research**
Schalk van Lill	**Male**	**GIS Manager**	**GIS Research**
Graham Parkin	**Male**	**Senior Geologist**	**GIS / Geological analysis**
Sandy Archibald	**Male**	**Principal Geologist**	**Data Analysis**
Kate Ault	**Female**	**Senior Geologist**	**Prospectivity / Research**
Karel Maly	**Male**	**Senior Geologist**	**Data Analysis**
Caroline Fagan	**Female**	**Accounts**	**Data Entry**
Jessica Sharkey	**Female**	**Accounts**	**Data Entry**

2. **Project information**:

Title of project	Mineral Prospectivity Analysis utilising publically available datasets and Free & Open Source Software
Did you make any formal amendment to the project workplan / budget?	☐ yes ☒ no If yes, please specify:

<u>Project Report (*max 1500 words, excluding figures and headings*)</u>:
Historically, the availability and cost of compiling data has been a barrier for junior and major exploration/mining companies alike, when trying to assess the prospectivity of regions or countries. Together with the initial purchase and annual maintenance costs of proprietary software, these costs can

be prohibitively high and deter geoscientists from being able to perform prospectivity analysis of larger areas.

The research project aimed to show that with the amount and quality of publically accessible data, as well as the availability of free and open source software, that these barriers can, to a large extent be broken down. Through the integration of a wide variety of geoscientific datasets, a prospectivity analysis can be completed and made freely available, which can provide an added stimulus to mineral exploration through the use of Tellus and other publically available datasets.

(i) Objectives and scientific/engineering targets beyond the state of the art

The objective of the project was to demonstrate how regional scale prospectivity maps can be generated from public domain datasets. The research aims to test the effectiveness of free and open source software in handling and presenting datasets, in comparison with expensive proprietary software packages. A further aim was to investigate how such datasets could be made available over the web.

(ii) Implementation (including reference to timelines, milestones, management)

The time frame and progress of the project was severely disrupted by the loss of the principal researcher (Schalk van Lill) in the middle of the project. Steven Downey replaced him as lead researcher over the past 3 months but the inevitably this caused delays, duplication of research and relearning of software capabilities.

Gaining access to base data caused some delays. Data that had been anticipated as being digitally available through the Exploration & Mining Division had not in fact been submitted by Prospecting Licence holders and required additional data capture. Aurum supplemented this through the additional of company databases.

The delayed in the release of the Tellus soil geochemistry in the North Midlands until 2017 had not been anticipated. Whilst this didn't impact the research directly, it negated the ability to level the historical exploration geochemistry against a modern uniform dataset for the region, which would have been beneficial.

Selection of Study Area

The study area was selected due to the abundance of historical mineral exploration data and coverage of the Tellus North Midlands and Tellus Border surveys. The study area has the potential to host Carboniferous Irish Type Zn-Pb mineralisation (Keel and Garrycam) and Lower Palaeozoic Orogenic Lode Gold mineralisation (Clontibret).

Assembling of databases

- Geological Data – GSI Seamless Bedrock Geology 1:100,000 (DCCAE Spatial Data webpage) presented as ESRI shapefiles with additional attribute information linked to a Lexicon for geological polygons and structural / stratigraphic linework. The map is available in two formats, a map package and series of individual ArcGIS files and layers files. Translating the style and layer files from ArcGIS to QGIS proved difficult. A QGIS Layer Style File was created from additional colour attribute data exported from ArcGIS. No solution with QGIS was achieved.
- Historical Data – The coverage of historical exploration data is extensive over the project area, with data captured from maps, logs and tables from historical company exploration reports from the Geological Survey of Ireland Open File archive and Exploration Reports held by the Exploration and Mining Division. Soil geochemistry is extensive across the project area but can be limited to selected elements. Stream sediment geochemistry limited primarily to the Au-associated Lower Palaeozoic units. Drillhole coverage focused to target areas.
- Tellus Data – The project area is part of the Tellus North Midlands which was surveyed in 2015, acquiring Airborne Electromagnetic, Magnetic and Radiometric geophysical data on behalf of

the Geological Survey of Ireland. The downloadable data is presented in the form of an ungridded ASCII text file (*.xyz). The data archive description defines the archive file layout. Accompanying the data is the Logistics and Processing Report, describing the survey specifications and parameters, survey operations, data quality control and data processing. Additional data is available via the ArcGIS REST Services Directory, including ArcGIS JavaScript, ArcGIS Online map viewer, Google Earth and ArcMap. Gridded images as Geosoft .grd files. For the purposes of this research project, the ungridded ASCII data needed further editing to remove unwanted line annotations and imported directly into GRASS 7.0.2. All other available data was not easily imported, including Geosoft .grd and ASCII grids .asc

- Landsat Data – Landsat ETM+ was integrated into the research project from a remote sensing (structural and alteration) study carried out in 2006 as part of the Lough Gowna block to define the structural framework and to identify mineral exploration targets. GRASS GIS features a set of modules and add-ons for processing Landsat satellite imagery. No additional processing of the Landsat data was completed for this research project.

Data Integration

- Validate and combine datasets – All available spatial data was added to a QGIS Project folder. The coordinate reference system (CRS) was set as IRENET95 / Irish Transverse Mercator (EPSG: 2157). Additional attribute tables were added to the project, including drillhole data (lithology, alteration and mineralisation), stratigraphic details
- Develop prospectivity criteria -
  MPM Evidence layers for Orogenic Lode Gold:
  Lithological criteria: Ordovician mafic greywackes of the northern portion of Longford
  Structural Criteria: Orlock Bridge Fault or major, regional NE-trending shear zone, compressional structures, and vicinity to second order north-south structures, within 3km.
  Chemical criteria: Soil data (As/Sb/Au) and stream sediment data (pan concentrate, LGC data), normalised, and ranked Au-As-Sb, based on mineral association at Clontibret..
  MPM Evidence layers for Irish Type Pb-Zn:
  Lithological Criteria: Waulsortian and Pale Beds, limiting the modelling area to the Carboniferous units and inliers.
  Geochemical criteria: Pb/Zn in soils dataset, stream sediment (pan concentrate or LGC data), ranked geochemistry by Zn-Pb-Cd-Cu-Mn. Mn used to infer dolomitization for potential alteration layer.
  Mineral Occurrence: Sulphide and barite occurrences within Waulsortian and Pale Beds, exclude any MinLoc not Zn-related or outside the Carboniferous domain, buffer according to data density (soils versus streams)
- Prospectivity Maps – Using the prospectivity criteria, evidence layers were modelled for each selection criteria. Further refinements to the criteria were made to the evidence layers. The results were aggregated in an attempt to form the prospectivity map.

Processing issues with FOSS

During the processing stage of generating the outputs for the prospectivity mapping, unforeseen issues arose which limited the output of the prospectivity maps. The following briefly describes some of the issues encountered and attempts to resolve them:

- Previous prospectivity modelling undertaken by Aurum using MapInfo Pro adequately demonstrated the 'additive' approach, whereby individual evidence layers were added together. Typically, binary evidential maps containing two class scores, maximum and minimum score were produced. Multiclass evidential maps were generated where more than two classes were required, with each class weighted in terms of importance.
- Alternative approaches to mineral prospectivity mapping, including Weights of Evidence and Fuzzy Logic, were identified and attempts made to replicate the process using FOSS. The aim

was to determine the most effective method for automating the prospectivity mapping and the appropriate tools to achieve this.

- The method of aggregation, as previously tested by Aurum, of the individual evidence layers required further work than what was anticipated, resulting in a re-evaluation of the processing methodology.
- The processing framework within QGIS, the geoprocessing environment, makes spatial analysis tasks more productive. The toolbox is the main element of the processing GUI, containing all of the algorithms. Further refinement and research into the steps in the processing will be required to achieve the desired outcome.
- An attempt will be made rectify the issues encountered with developing a suitable methodology using FOSS. The prospectivity maps and associated report on the methodology and software used throughout the process will be presented with the digital appendices.
- Metadata was created using the Metadata Editor on the INSPIRE GEOPORTAL. A new INSPIRE Spatial Dataset is created; the metadata elements are entered using the tabs. The metadata is saved and the 'Validate' is executed. The Resource Validation Report lists the Schema Validation Issues and Inspire Validation Warnings. The template for the Metadata Editor is not up to date, with several metadata elements missing. This results in the validation producing several errors that cannot be resolved using the online editor. Open source software, including Geonetwork, was tested in order to generate the INSPIRE compatible metadata but was unsuccessful.

(iii) Outputs (please use bullet points)

- Mineral Prospectivity Maps (submitted with digital DVD)
- Poster presented at Geoscience 2016
- An INSPIRE compatible dataset of the prospectivity analysis for the research project.

Impact/value of the project (M*ax 500 words*):

The research project attempted to demonstrate that effective mineral prospectivity mapping could be achieved with the use of free and open source software (FOSS) and publically accessible data. However, critical attention needs to be made to ensure thorough workflows are defined based on the complexity of the data used for the prospectivity mapping.

As FOSS is becoming more widely adopted within the industry, further development is required as to how to migrate existing publically available datasets from proprietary software formats to open source formats.

The research has been unsuccessful in demonstrating that free and open source software is currently capable of producing prospectivity maps similar to those that can be generated using proprietary software. Despite a considerable investment of time a number of problems in getting fully functioning datasets remain and these requires further research. At present free and open source software remains an apparently attractive alternative but developing techniques for manipulating data is extremely time intensive, which makes the more expensive proprietary software competitive.

Further emphasis should also be placed on making publically accessible datasets easier to access. The use of data portals should be widely promoted across government organisations, given the requirement of INSPIRE data compliance.

3. **Project Expenditure** *(double click on table below to activate). The GSI reserves the right to request evidence of expenditure if required.*

Item	*Cost €*
Personnel costs	56243.75
Student fees	0
Consumables	162.68
Travel (incl. Fieldwork)	0
Other (access to proprietary software)	2500
Total	**58906.43**
Contribution (cash & in-kind), if applicable	38250
Total requested from GSI	**20656.43**

Explanation of budget deviation, if applicable *(max 500 words)*:

This was almost entirely desktop research and the only variance occurred in the time required for capture and manipulation of data sets from historical documents with the Geological Surveys Open File system. There was less digital data available through the Exploration & Mining Division than had been originally anticipated, which resulted in a larger amount of time being required to assemble the dataset for use in the project.

4. **GSI Funding programme**

Please provide some comments on the GSI Short Call funding programme (max 500 words):

Positive: The funding available through this programme has allowed research into some of the issues surrounding the use of free and open source software. The extremely time consuming nature of this work means that this wouldn't normally have been possible.

Negative:

Appendix 1 – Publications & Presentations:

[Conference Poster] Downey S. (2016) Mineral Prospectivity Analysis utilising publically available datasets and Free & Open Source Software *Geological Survey of Ireland Geoscience 2016 Conference,* Dublin Castle, Dublin, Ireland, November 2016

Appendix 2 – Any additional information not included above:

Digital databases assembled for and used in the project will be forwarded on DVD**.**