"Enhancing research capacity at the Geological Survey of Estonia to accelerate the country's transition to green energy"

Deliverable 2.1

The current digital and data infrastructure at EGT

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List of Acronyms

Abbreviation	Description
GA	Grant Agreement
CA	Consortium Agreement
EGT	Geological Survey of Estonia
GTK	Geological Survey of Finland
BGS	British Geological Survey
UKRI	United Kingdom Research and Innovation
GEUS	Geological Survey of Denmark and Greenland

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EGT-TWINN Project in Brief

The EGT-TWINN project received funding through the Horizon Europe HORIZON-WIDERA-2021-ACCESS-03 call. It aims to enhance research and technical capacity at the Geological Survey of Estonia (EGT) to accelerate Estonia's transition from fossil fuel to green energy. The project will mainly focus on developing state-of-the-art geological, geochemical and geophysical survey skills, data management workflows, and subsurface modelling capability for exploration and geological resource assessment (including critical raw materials and geothermal energy) at EGT. The EGT geological capacity enhancement will be implemented via a range of joint activities such as scientific conferences and exchanges as well as through the delivery of specialized training programs provided by three leading geological surveys in Europe – the Geological Survey of Finland (GTK), the British Geological Survey (UKRI/BGS) and the Geological Survey of Denmark (GEUS). A further partner is the University of Oulu (UOULU), more specifically the Oulu Mining School (OMS), which provides a unique state-of-the-art platform for mining-related research and education. The project will contribute to the development of multidisciplinary research and innovation in geological studies in Estonia. It enables EGT to enhance its personnel's scientific excellence and collaborate with experts from leading international research institutions. One of the project priorities is to support early-career researchers at EGT who will gain state-of-the-art experience in the geology fields crucial to Estonia.

Project partners

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Deliverable Summary

This report summarises the current digital and data infrastructure at the Estonian Geological Survey (EGT) following initial scoping visits in February and April 2023. The primary aim of this report is to provide all partners with an understanding of how EGT currently creates, stores and manages digital geological data, information and materials. It highlights the areas relevant to the EGT-TWINN project and should not be seen as a definitive statement of capability. This report focuses on the digital systems at EGT and considers how EGT may wish to develop those systems in the future.

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Introduction

The EGT was established in its current form on January 1st, 2018 and now has around 55 employees. It is 100% funded by the Government of Estonia, with an annual budget of approximately 3 million euro. It is divided into five departments: GeoInformation, Mineral Resources, Geothermal Energy, Hydrogeology and Environmental Geology, Marine Geology and Geophysics. EGT has three offices, in Tallinn, Tartu and Rakvere, plus a research centre at Arbavere. The IT hardware and infrastructure is managed by the IT department of the Ministry of Economic Affairs and Communications, and is not managed in-house, there is a central shared drive accessible by EGT departments but it fills up rapidly. The current capacity of the drive is 3.9 TB of which about 3.65 TB is currently in use. Additional storage space is provided by the IT department on request. The central drive is regularly backed up to the Estonian Government Cloud (https://riigipilv.ee/en). EGT currently has an active field mapping program, is modernising its drill core repository at the Arbavere research centre and is developing a digital geological archive and 3D geological modelling program. It disseminates geological data through an online geoportal (in Estonian) at https://gis.egt.ee/portal/home/. This geoportal provides access to webGIS applications, with separate applications for visualising data such as the borehole data, 1:200,000 and 1:50,000 geological maps, areas of fieldwork, soil radon risk data and geothermal heat installations. This geoportal also enables access to download the 1:50,000 and 1:200,000 scale geological data. This portal is currently only in Estonian, but an English version is planned for the future.

The geology of Estonia comprises a moderately deep (150 – 700 m) Precambrian basement, overlain by Neoproterozoic to Palaeozoic sedimentary rocks. Much of the country is also covered by Quaternary deposits. The Palaeozoic sedimentary succession contains major deposits of phosphorite, but the mineral resource potential of the crystalline basement is under-explored.

Notably, the different departments within EGT work partly separately; for example, the Department of Geoinformation manages surface geological mapping, and has one set of databases, whilst the Department of Mineral Resources works with geophysical and borehole data to create its own interpretations and models, and has separate sub-databases. The parent database with borehole and locality metadata as well as other basic information is in common use with most departments having access. Work to integrate the borehole, geophysical, geochemical, and mapping databases is currently in progress and a new system expected in Q4 2023.

This report was compiled through on-site visits and workshops in February and April 2023 with the input of staff listed below:

- Tim Kearsey – British Geological Survey
- Kathryn Goodenough – British Geological Survey
- Mariliis Aren - Geological Survey of Estonia
- Markus Maido – Geological Survey of Estonia
- Eveli Sisas – Geological Survey of Estonia
- Hando-Laur Habicht – Geological Survey of Estonia
- Tavo Ani – Geological Survey of Estonia
- Ants Vain - Geological Survey of Estonia
- Jani Jäsberg - Geological Survey of Finland

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Drill Core

Historical drill core, which may have been obtained for a range of purposes, represents a significant source of information about the subsurface in any country. It is vital that core is well-stored and well-managed, together with appropriate metadata. EGT's core holdings are currently being consolidated at the Arbavere Georesource Research Centre, which is being modernised with a new core store system, core photography facility and a core scanner. Around 12,000 core boxes are being relocated from other storage locations, which will add to around 10,000 boxes already present at Arbavere. Boreholes are separated into crystalline basement, sedimentary rock and unconsolidated deposits. These different components are stored separately.

1.1. Digital Core Infrastructure

The digital infrastructure that supports the core store is:

- The master database of core material is an Excel spreadsheet, hosted on OneDrive which provides version control.
- Some borehole archives are available online through the geoportal (https://gis.egt.ee/). This includes a map of borehole locations, some scanned logs as PDF files and core photographs.

Digitisation of borehole records is challenging because stratigraphic terminology has changed significantly through time and descriptions need to be standardized to ensure consistency within the data and therefore ensure the usability of the borehole data. Additionally, many borehole records are written in Russian, posing further complications for digitisation.

1.2. EGT priorities for the future regarding core

EGT staff are keen to learn how other geological surveys manage their core stores and arranged a visit to BGS in March 2023 to visit the UK's National Geoscience Data Centre. This 3-day visit focused on the BGS core store and core scanning workflows during day one and was followed up on day two and three with demonstrations and discussions around BGS work with remote sensing data, radioactive waste projects, soil mechanics and database systems (specific to the core scanning and laboratory facilities). There is particular interest in using digital systems to manage the archive. The EGT team would like to move to a more comprehensive database where logs and reports are linked in the database to the core material. They are interested in using artificial intelligence to aid the digitization of borehole records.

EGT would like to collect bedrock information from third-party drilling projects, such as deep geothermal boreholes, in order to gain valuable knowledge from the Phanerozoic sedimentary units and Proterozoic basement with minimum cost.

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Geological Archive

EGT's Geological Archive contains a substantial number of legacy reports, dating back to 1923. These have been digitised with EU Regional Development Fund support to improve access to this valuable resource. Since spring 2020, these reports have been available in PDF format on the web application of the geological archive (https://fond.egt.ee/fond/). This website enables users to search the reports catalogue based on subject, mineral resource or year as well as carrying out a free text search. Search results (areas covered by reports) can be displayed on a map and documents can be downloaded and saved. The website is in Estonian, Russian and English with reports being in Estonian although many of the older reports are in Russian. In the same application, authors can also upload their reports for inclusion in the archive.

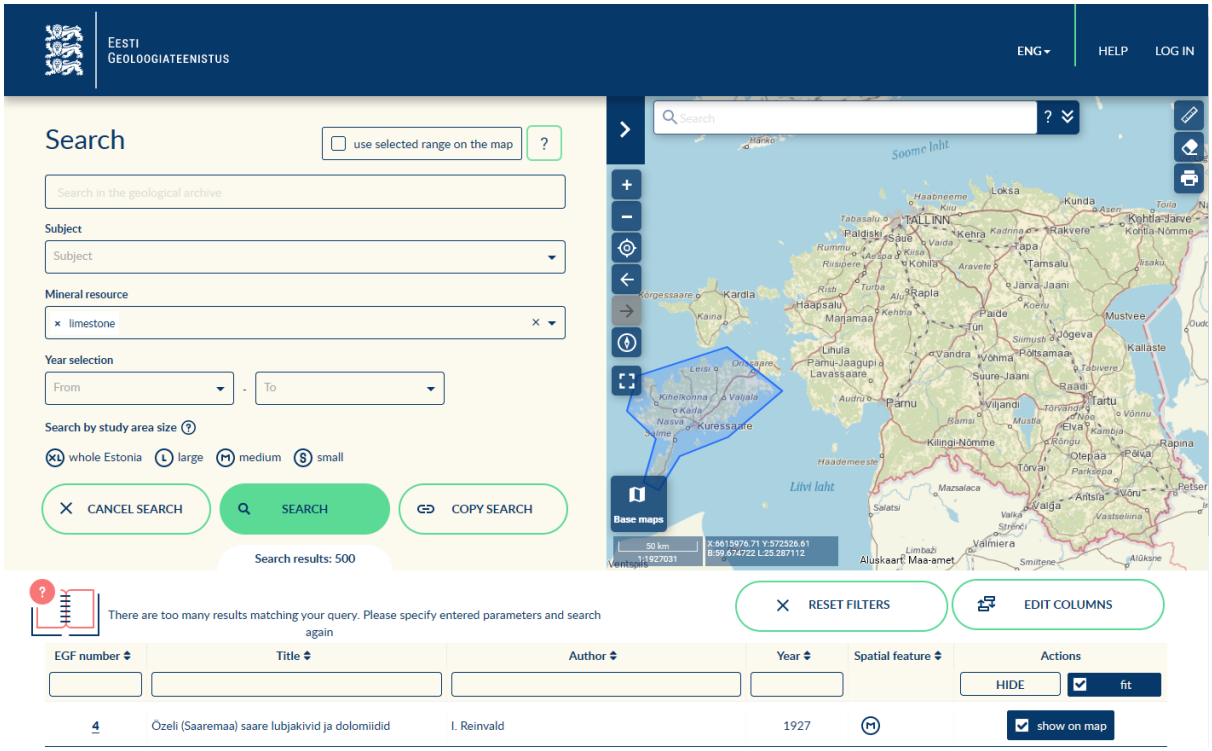

Figure 1: *Website and search capabilities of the Geological Reports Archive*

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Geological mapping

Digital geological mapping in Estonia has been progressing since 2003. The mapping used to be managed by the Estonian Land Board but has been managed by the Department of Geoinformation in EGT since 2022. Geological maps at a scale of 1:200 000, dating from the early 2000s, cover the whole country. Almost 40% of Estonia is covered by digital maps at a scale of 1:50 000, and this mapping is ongoing. The digital geological maps are available via the geoportal. Paper maps which have not yet been digitized also exist at a scale of 1:50 000; with these included, the 1:50 000 coverage is 60%. The geological map data includes several thematic subsets:

- 1:50 000 maps
    - Quaternary cover
    - Bedrock
    - Hydrogeology
    - Geomorphology
    - Mineral resources
- 1:200 000 maps
    - Bedrock (completed)
    - Aeromagnetic anomalies (completed)
    - Gravity anomalies (completed)
    - Radon risk (completed)
    - Basement (currently being revised)
    - Quaternary deposits (needing to be revised)
    - Hydrogeology (needing to be revised)
    - Groundwater and its vulnerability (needing to be revised)

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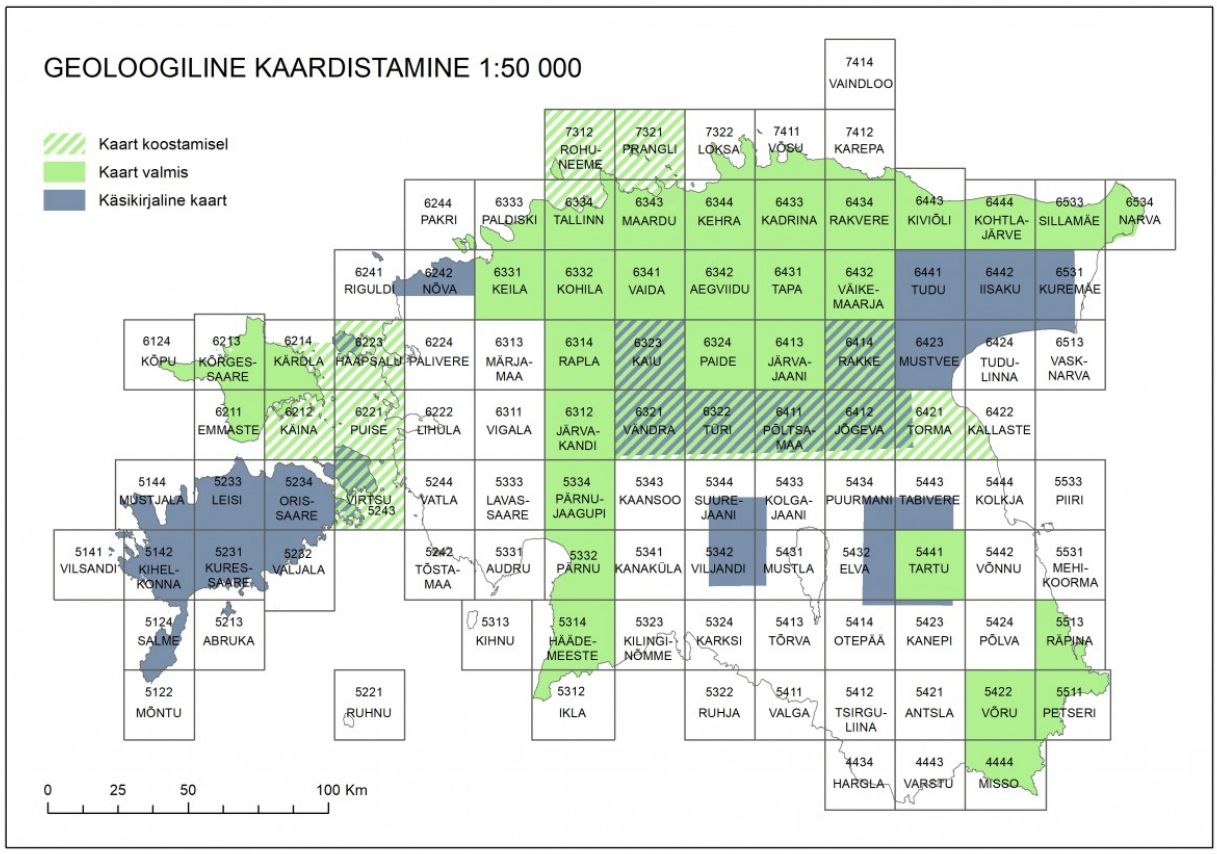

Figure 2 *Map showing the progress of the 1:50 000 mapping program as of January 2023. Translation of the key: green hashes = map in preparation; green solid – map ready; blue solid – paper map waiting to be digitised*

Quaternary deposits are classified by the age, origin, and lithological composition of the Quaternary sediments. Also, EGT's are supplemented by Quaternary thickness and geomorphology. The bedrock is divided primarily by age. Additionally, faults and stratotype sections are defined.

1.3. Field Mapping Methodology

Field mapping is usually undertaken in four groups with staff working in pairs and following a fully digital workflow built on ESRI software solutions. Fieldwork information has been captured using ESRI Field Maps since 2022; before that Collector for ArcGIS was used. All new data collected is added to an Enterprise Geodatabase. This is linked to the Enterprise portal and there is a dashboard showing the data that is synced to the database so data ingestion can be monitored in real time (Figure 3). This system has been used since 2020, and before that ESRI Cloud services were used. Fieldworkers use mobile phones or tablets and there is a pool of phones available to be used. The hydrogeologists and marine geologists also use this digital mapping solution.

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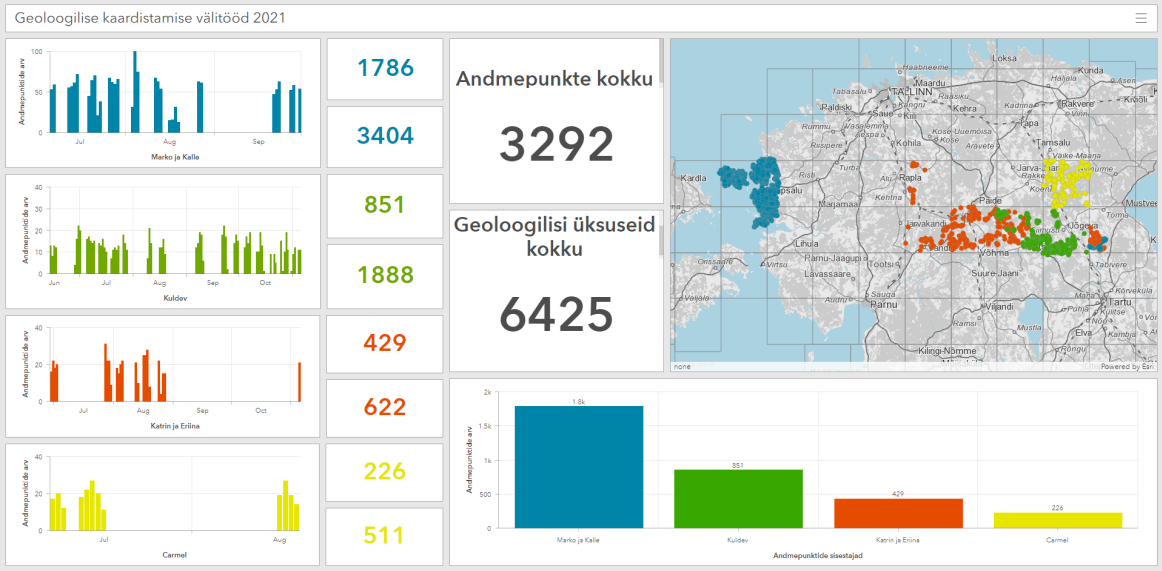

Figure 3 *Internal fieldwork dashboard showing the data that are syncing to the database.*

The EGT team worked with an external company to develop an ArcGIS Pro add-in called Faktika to provide a front end where geologists can view, edit and insert borehole and survey point data. This automatically puts data in the correct background databases, and includes some built in QC functions to make sure the correct data is captured. The data entered through Faktika are stored in an Enterprise (ArcSDE) geodatabase in a PostgreSQL database.

1.4. Map compilation and delivery

The creation of geological linework and polygons is now done in ArcGIS Pro, and the map topologies are checked using FME Desktop & Server with map data stored in an ArcSDE database. Mapping is currently done in local geodatabases that have the same structure as the main ArcSDE database. EGT has recently completed a project with the University of Tartu to develop new symbology for their maps, to ensure consistency.

The ArcSDE database provides the source for the web delivery platform https://gis.egt.ee/. Paper maps are no longer being printed and web maps are mostly only available in Estonian. There is an ambition to translate them into more languages to allow them to be used by stakeholders outside Estonia and released through an INSPIRE geoportal. Inspire services are currently in development with the aim to make that they will be available in the near future, hopefully this year.

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Geochemical mapping

Geochemical mapping is a valuable tool for mineral resource assessment and exploration, but limited data is available for Estonia. In the past the Geology Centre of Estonia was involved in some soil mapping with the Geological Survey of Finland (1987-1993). Previous data and reports exist but sampling density was very sparse, and interpretation limited. EGT is now aiming to rejuvenate geochemical mapping and will concentrate on urban areas.

Geophysics

Airborne geophysical surveys (aeromagnetic, gravity) were mostly flown in the 1980s and 90s. EGT holds some interpreted data, but the raw data is not available and is possibly lost. This is a key area for the EGT to grow and learn from the experience of others. There is currently some cooperation with the University of Tartu, who conduct small scale local studies (seismic and gravimetric) and EGT hope to expand this cooperation and knowledge exchange more widely.

3D modelling

EGT currently has 3D software capabilities in:

- ArcGIS, QGIS
- Leapfrog Geo
- ModelMuse

They have trialled the use of BGS Groundhog and WellCAD but concluded that they are not relevant to the data and geology of Estonia.

ArcGIS is used to generate bedrock surfaces because it connects to the Faktika drill core database. Scripts have also been written for exporting borehole data from the Faktika database into a Leapfrog ready format. EGT has one Leapfrog Geo licence, which is used by 9 users over 3 departments, with the most users in the Mineral Resources department.

In the Department of Geoinformation Leapfrog Geo has been used to model geothermal layers, assumed faults and barriers in Northern Estonia. It has been identified as the main tool for creating cross-sections and the team is looking at how to export and save models to the database and for stratigraphic and structural modelling.

In the Department of Mineral Resources Leapfrog Geo has been used for lithostratigraphical modelling; generating output take for mining calculations; hydrogeological modelling; statistical analysis for quality of mineral resources; geostatistical analysis; and generating block models for assessment of mineral resources.

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Databases

Within EGT, the different departments have their own databases in different formats, and so a project has been initiated to develop a common database for geological data (GEA). The aim is to link multiple databases such as their FME Server, ESRI solution, X-road data exchange service for stratigraphic classification and GeoServer and database (Figure 4).

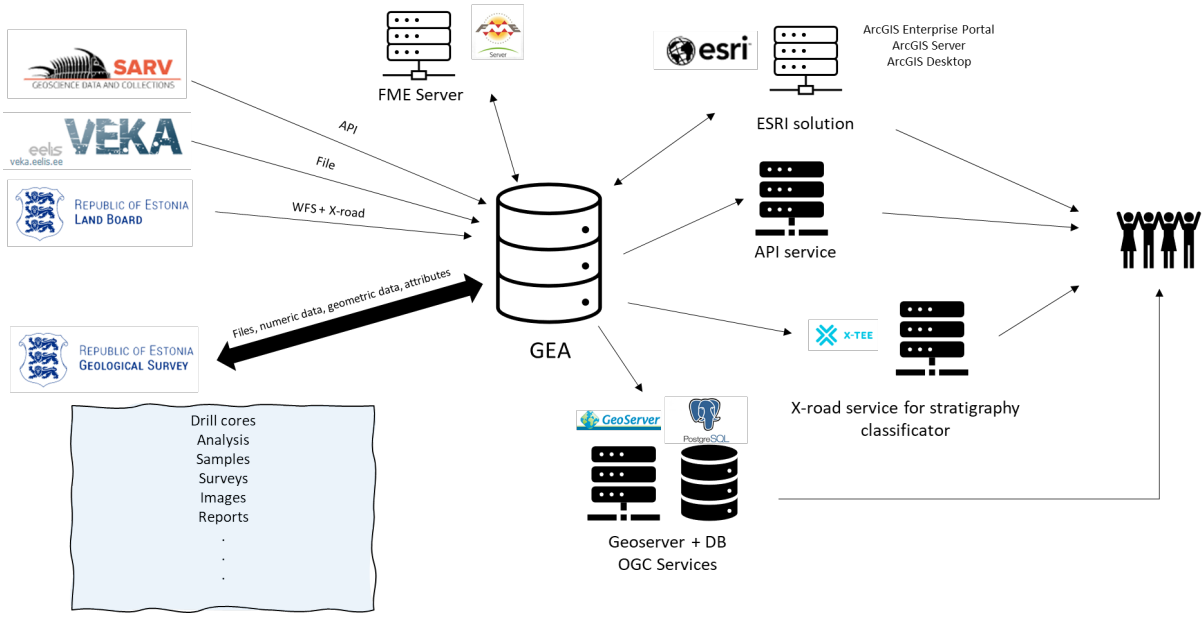

Figure 4 Plan for common DB for geological data (GEA)

This project is only a year old and EGT hopes to learn how other surveys link their databases so that they can future proof this work.

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Aims for the future.

EGT is already very advanced in their digital and data infrastructure and have benefited from being a relatively new geological survey with the ability to be agile and not being tied to legacy systems and processes, including not having to rebuild ageing systems as software changes.

However, EGT are very keen to progress their development and engage with other geological surveys to understand the range of systems and process that are in use, which can feed into their own decisions as they continue to develop their systems and follow their digital roadmap.

There were some key areas for collaboration that were identified during the digital and data infrastructure scoping visit including:

1. Data architecture - understanding the options for unifying and linking databases across the organisation to enable better internal access to data.
2. Data storage, pipelines and workflows such as Improving data workflows for the integration of additional data i.e., geophysics into the mapping programme.
3. Data standards
4. Delivery of data in the most accessible way to enable their stakeholders to gain answers to their questions.
5. Machine learning
6. 3D modelling – creation, storage, and delivery of 3D models.

These are areas of interest for all the organisations that are involved in this project, and it is anticipated that there will be an extremely useful exchange of knowledge and experiences that will enable EGT to build towards their goals.

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