Tellus at 10

Celebrating 10 years of Tellus in Geological Survey Ireland

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Geological Survey
Suirbhéireacht Gheolaíochta
Ireland | Éireann

Welcome & Introduction

Tellus is a national mapping programme that collects information on the geology of Ireland. The programme has been managed by Geological Survey Ireland since 2011. Over the last 10 years, hundreds of thousands of kilometres have been flown and thousands of fields and streams have been visited for sample collection, as part of the Tellus programme.

The survey collects geochemical and geophysical data across the island of Ireland, examining the chemical and physical properties of our soils, rocks and stream waters.

Tellus includes two types of surveys: (i) an airborne geophysical survey that takes measurements from the ground as the aircraft flies over and (ii) a ground geochemical survey that takes samples of soil, sediment, and water from streams. These samples are then analysed to reveal their chemical composition.

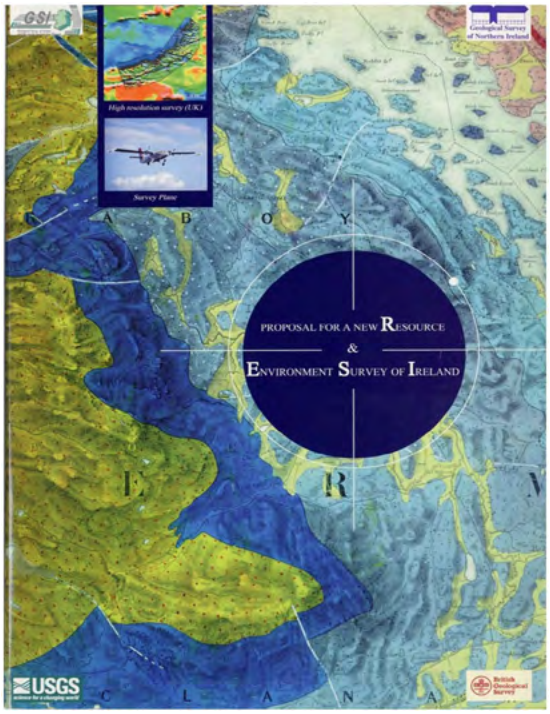
Once all the data have been collected, it is checked and processed and made freely available to all, on the Tellus website. The different survey blocks for each year are then merged together which will ultimately create a single dataset for the whole country.

Tellus has also been developing a number of applied products using the survey data for agricultural, mineral exploration and the environmental sectors.

Click below to explore progress and highlights from the last 10 years:

The History of Tellus

The Tellus programme gets its name from the Roman goddess of the Earth; Tellus Mater. The name fits the objectives of the project to inform us about the physical and chemical properties of the rocks, soils and water that make up the island of Ireland.



The original concept for the Tellus Programme dates back to the late 1990s and the development of the Resource and Environment Survey of Ireland (RESI) project by Geological Survey Ireland (GSI) with input from the Geological Survey of Northern Ireland (GSNI), the British Geological Survey and the United States Geological Survey. At the time funding was not available and it wasn't until 2004 that the GSNI, supported by the Department of Economy, commenced the Tellus Project in Northern Ireland. This project was essentially a geological resource mapping project with a primary focus to increase investment in the minerals industry in Northern Ireland. The project involving both airborne geophysical methodologies and geochemical sampling was completed in 2007 (Young and Donald, 2013).

2011 – Survey launch

2011-2013 – The EU INTERREG IVA-funded Tellus Border commenced. This was a joint project between GSI and GSNI.

2014 – The Jigsaw continues. Following Government funding, the Tellus survey moved into the north midlands, the east and the west. Following this, the survey extended southwards.

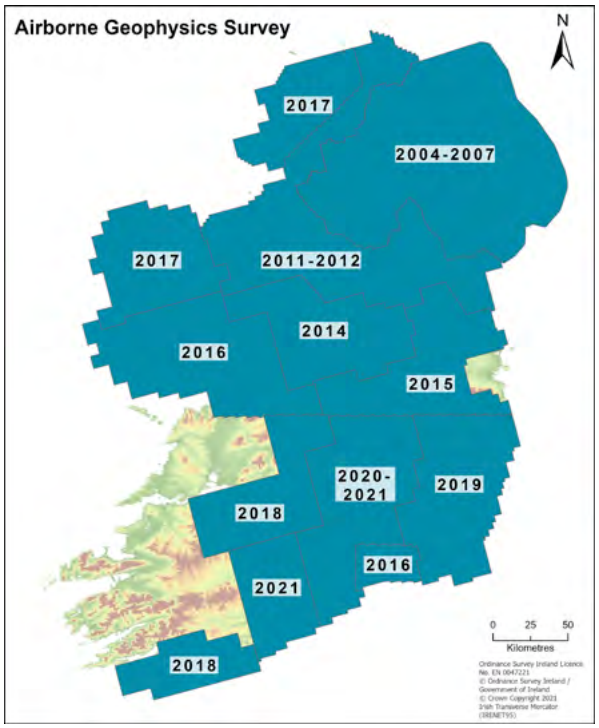
2015 – Awards. Tellus were winners in the Civil Service Excellence & Innovation Awards (2015) and IRGLOI awards (2016).

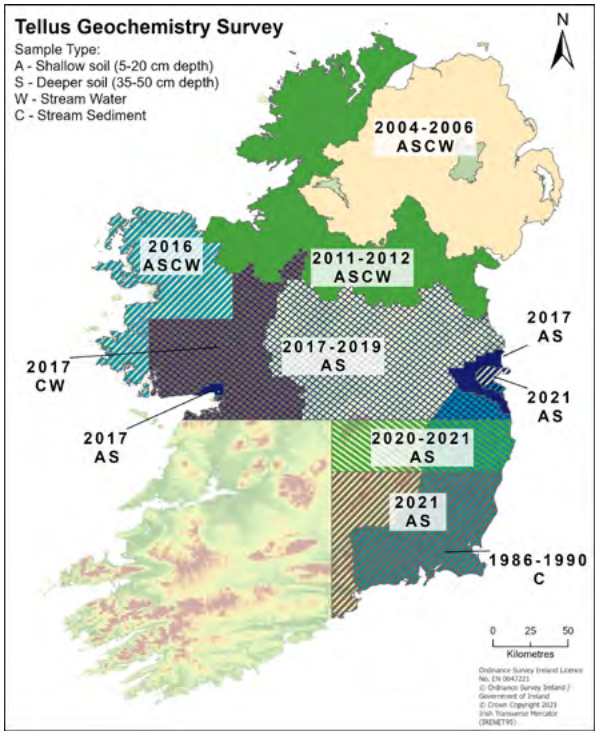
2017 – Halfway there. Tellus Airborne Survey of Ireland is 50% Complete.

In 2011, the Tellus Border project commenced with geophysical and geochemical surveys carried out within the border region of Ireland, part-funded by the EU INTERREG IVA programme. This was a joint operation between GSI and GSNI with the project completed in 2013. After this, GSI secured Government of Ireland funding to continue survey work southwards and eventually to complete national coverage across the country. Each year a new piece of the jigsaw is added with a new survey block of data acquired.

In recent years Tellus has not only collected new data but has developed a series of useful products and outputs to support work in the agricultural, mineral and environmental sectors and continue to look at new collaborations and research opportunities.

The Tellus Survey puts Ireland at the forefront of geological mapping internationally. When the survey is complete, Ireland will be one of the most extensively and detailed geochemically and geophysically mapped counties in the world.





2018

New workstream

Product development launches into 5 themes: Mineral Prospectivity, Smart Agriculture, Environment & Health, Climate Action and Education.

2021

Halfway there

2019

Tellus Soil Geochemistry Survey coverage reaches 50%.

The Communications Story

Tellus Communications supports the surveying activities of the Tellus Survey and ensures that the project is widely understood across all defined stakeholder groups as well as among the wider public. Now in its tenth year, Tellus Communications has identified over 100 national stakeholder groups, ranging from agricultural to community groups to government agencies. Stakeholder engagement is a core activity of Tellus and a comprehensive communications programme ensures that landowners and farmers are aware of the survey operations to minimize any potential disruption. Strong communications also allows data to be promoted to a range of key stakeholders.

Surveying operations involve a low-flying airborne geophysical survey and ground-based geochemical sampling. A series of communication measures, including phone calls, issuing of information packs, public notices, flyer mail-outs and media work, is undertaken to inform local interests in the survey area of the survey operations. Tellus collaborates closely with horse and other animal owners to ensure that flight plans don't cause disturbance to animals on the ground, and that the purpose of the survey is widely understood. Tellus also executes a programme of engagement that supports the needs of data users - informing government, academia and industry of the value and availability of the information and encouraging these sectors to use the new data to assist their functions or commercial interests.

Geophysical data acquisition is undertaken by an aircraft flying at 60 metres above ground level over rural Ireland. The management of the survey is data-intensive and requires geospatial information, flight plans and comprehensive records of stakeholder engagement. To manage this effectively, Tellus has developed an award-winning, easy-to-use system that combines all this data, known as the Tellus Communications Viewer (TCV. The TCV is a cloud-based solution with advanced functionality combining flight survey plans, a geographic record of stakeholders and flight tracking. It can be used remotely by multiple users and utilises a number of different geospatial information systems, namely Eircodes, Property Registration Authority of Ireland (PRAI datasets, GeoDirectory, townlands, Bing and Ordnance Survey Ireland (OSI maps.

The TCV harnesses the power of geospatial information systems and allows us to manage an internal database of local stakeholders, all of whom require accurate and timely notification of flight plans. It also enables us to present an outward-facing flight plan viewer on our website that allows for public interaction with the flight plans.

Press releases

More than 50

Tweets

1,471

Landowners contacted

2,710

Flyer delivery to households

More than 700,000


601234

The Geophysics Programme

Airborne Geophysical Survey

In the last 10 years, over 350,000 km have been flown across the island of Ireland (equivalent to flying over eight times around the world) by a low-flying aircraft collecting geophysical data. All that flying equates to over 315 million geophysical measurements. In fact, by the time the survey is complete, and including data from Northern Ireland, over half a billion geophysical measurements will have been made.

Survey Aircraft

The survey uses a specialist twin engine aircraft operated by Sander Geophysics Ltd and flies at 60 m above ground level. By flying as close to the ground as permitted we can get the best data. The aircraft collects three types of data:

Photo credit: Mateusz Koziatek

- A magnetometer to measure variations in the Earth's magnetic field, mounted on a rod on the back of the plane.

- A gamma ray detector to determine the natural radioactivity of shallow soil and rocks, housed inside the plane.

- A frequency-domain electromagnetic (EM) system to measure variations in electrical conductivity of the different soils and rock. This system is mounted in pods at the end of each wing.

Maps & Results

The geophysical data allow the different properties of the rocks and soils to be mapped.

The magnetic data are particularly useful at mapping changes in rock types due to variations in magnetic intensity of minerals within the rock.

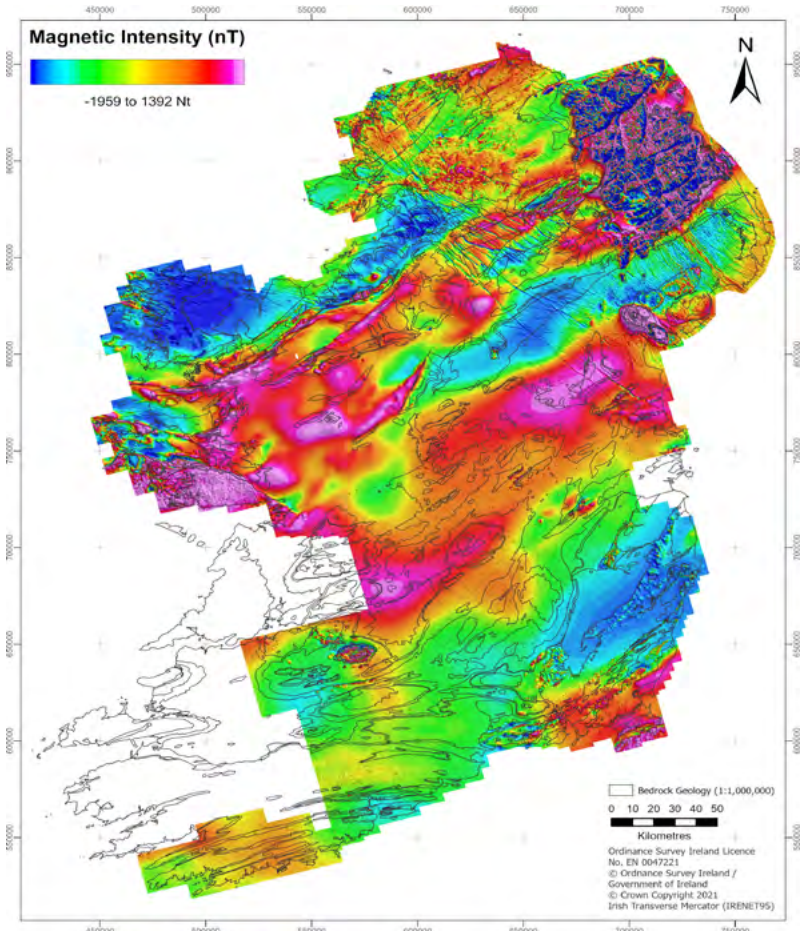
The highest magnetic values are usually associated with igneous rocks particularly the basalts in county Antrim, while Carboniferous limestone's in the Irish midlands show typically weaker magnetic responses.

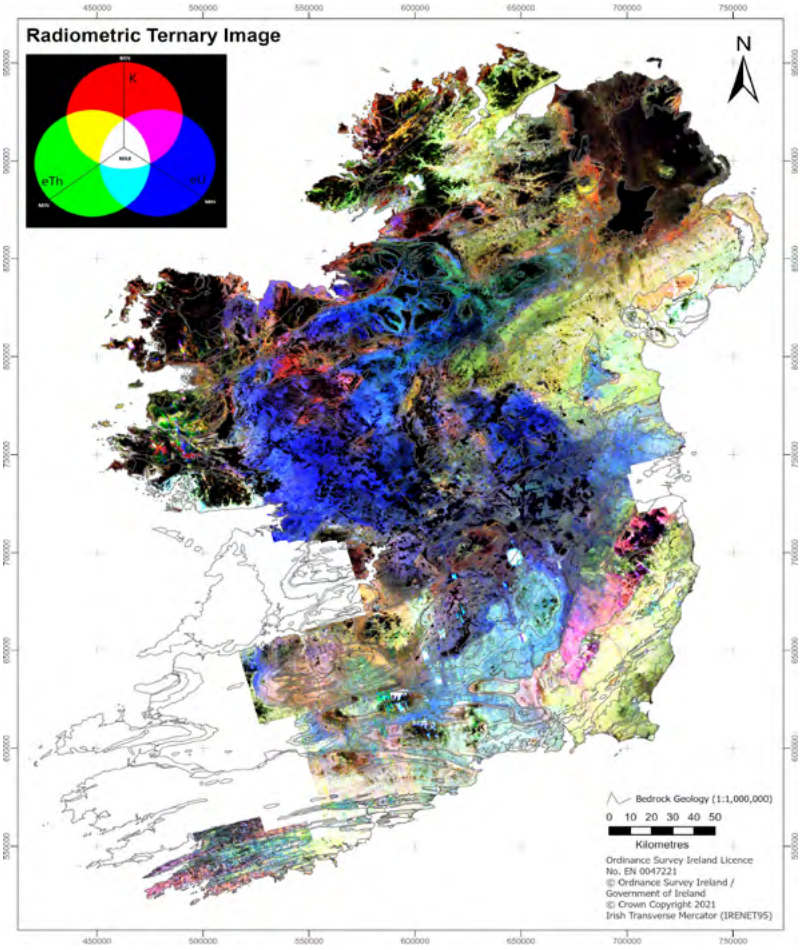
Note: the maps on the right show the preliminary data for 2021, new data are due to be released in 2022.

The Radiometric data record variations in potassium (K), thorium (Th) and uranium (U) concentrations at the Earth's surface, as measured by a gamma-ray spectrometer housed inside the aircraft. Therefore the radiometric survey is a pseudo-geochemical survey conducted from the air. The data help in mapping variations in both bedrock type and changes in soil and are also being used to help target areas prone to high radon gas levels.

From pods on the ends of each wing electromagnetic (EM) data are collected. This measures the conductive nature of the soils and rocks below. Data can be collected to depths of about 60-100m below ground but the instrument is very sensitive to interference from other EM sources such as power lines.

The data are used to map changes in rock and soil type and can also be modelled to produce cross sections through the ground. Conductive (low resistivity) rocks are generally associated with argillaceous (clayey) and shale -rich Carboniferous rocks while more resistive signals correlate with pure limestones, metasedimentary or granitic rocks.





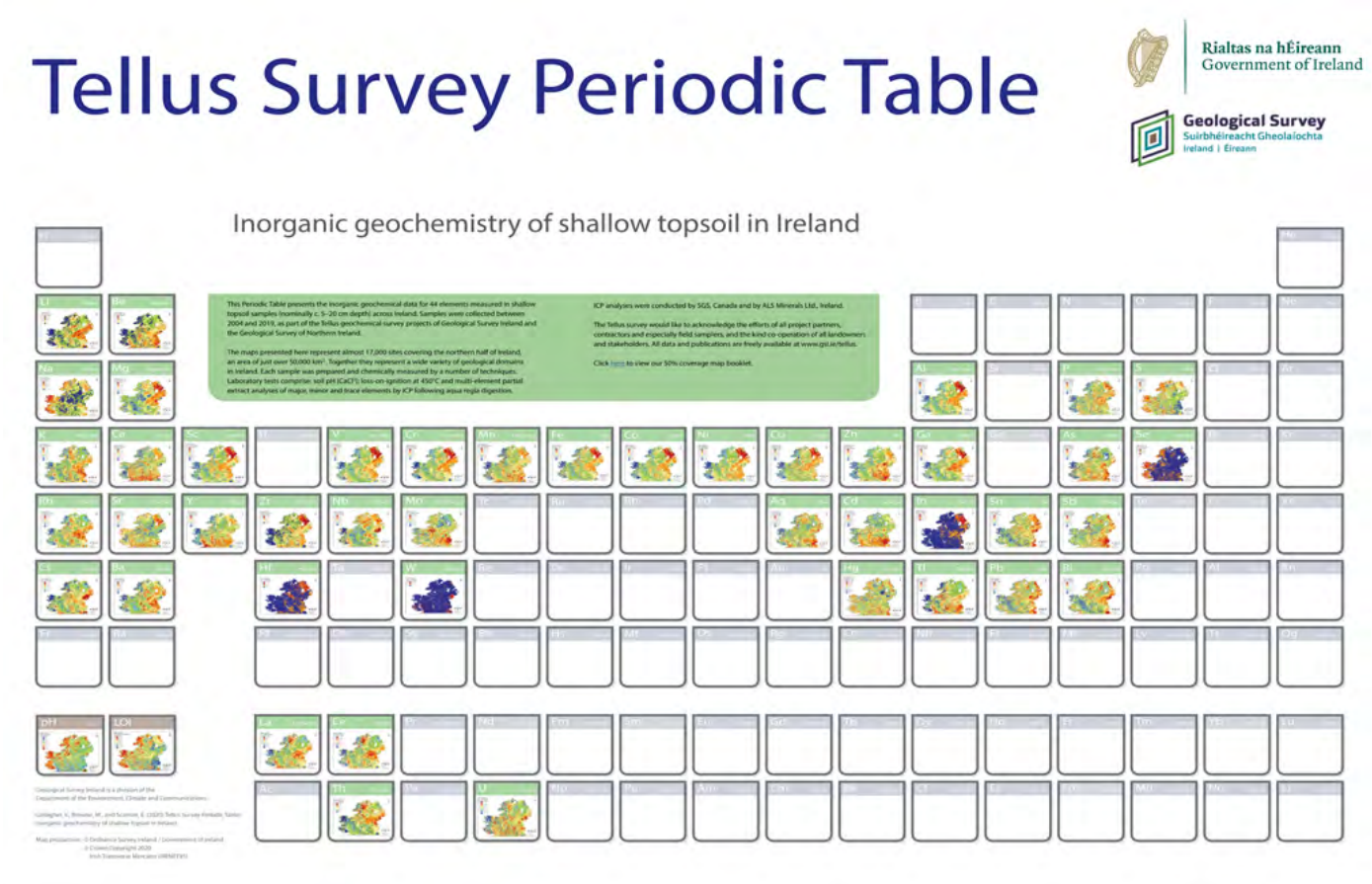
The Geochemistry Programme

Sample Collection

Tellus collects samples of soil, stream sediment and stream water in order to measure the chemical composition of the surface and near-surface environment in Ireland. The data collected by teams of samplers in the fields and streams of Ireland allow us to define a geochemical baseline against which any future changes may be measured, including environmental impacts from human and other activity. The data also provide information on the distribution of specific substances. These include elements that are potentially harmful to humans or the environment, such as lead and arsenic, or substances that are critical to agriculture, such as trace elements and nutrients. Mapping the distribution of economically important metals, such as zinc and copper, provides support to mineral exploration.

Tellus collects regional soil samples at a density of one sample per 4 km^2. At each site two samples are collected with a hand auger, one from the top-most 0.2 m and the second at 0.35-0.50 m depth. Samples are prepared by drying and milling to fine particle size prior to chemical analysis.

Tellus collects data for over 50 chemical elements, pH and organic matter. To date, almost 20,000 soil samples from the northern half of the country have been collected and analysed, while almost 9,000 sediment samples and 7,000 water samples have also been collected.

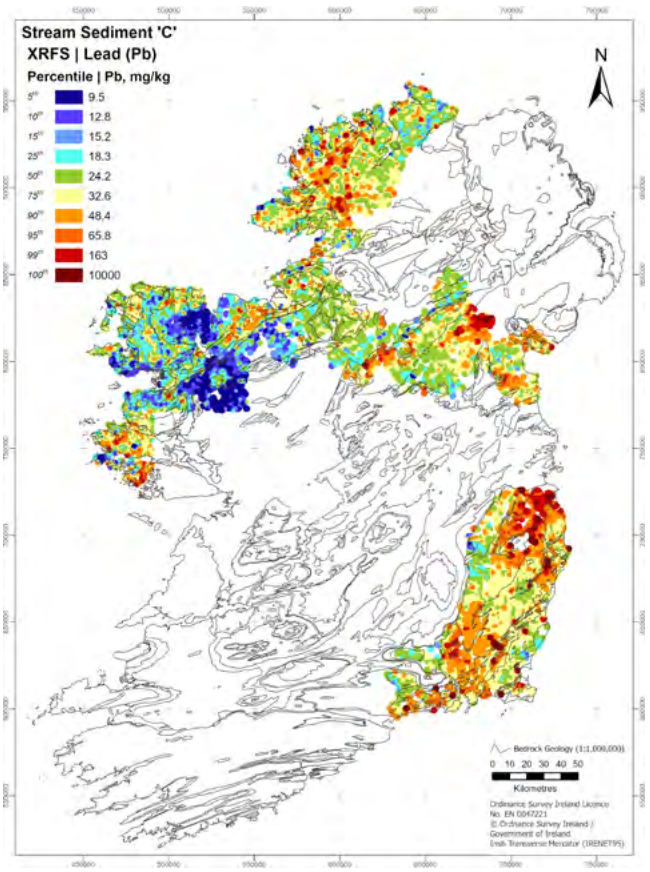


Maps & Results

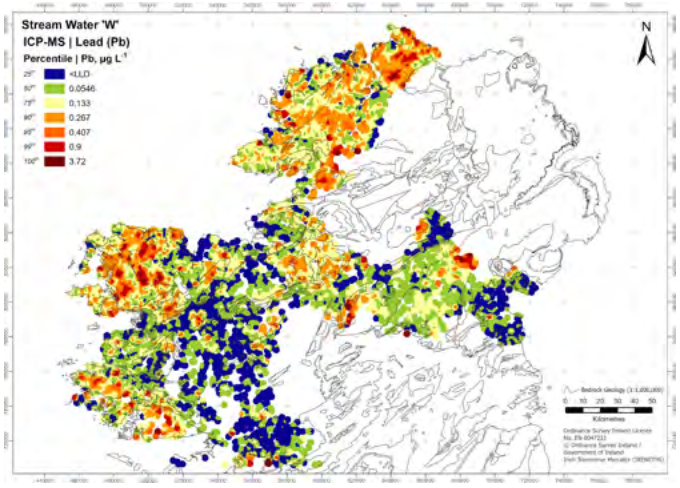
The chemistry of topsoil is controlled by the composition of the bedrock, the process of soil formation and the influence of human activities. Thus, Tellus soil chemistry maps generally reflect the underlying bedrock geology, for example relatively high calcium concentrations coincide with the Carboniferous limestone bedrock of the midlands. High rainfall on upland areas in the west has led to development of peaty soils that are clearly reflected in the organic matter content of the soil. Close to towns and cities, the influence of human activity can be detected in elevated tin concentrations that reflect fuel combustion.

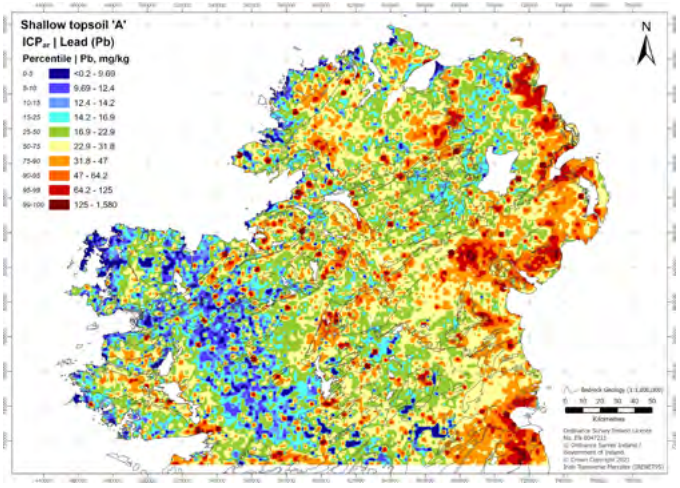
Stream sediments are formed by erosion of bedrock and soil. The sediment chemistry typically reflects the composition of the local bedrock and has been used to focus mineral exploration programmes.

Tellus surface water samples also reflect the composition of the local bedrock but surface water chemistry is also influenced by numerous other factors including rainfall, temperature, acidity, organic matter, topography, distance from the ocean and human activity. Agriculture is the most significant human influence on surface water chemistry, particularly nutrients such as nitrate and phosphorus, which are linked to tillage farming and pasture land uses.



The maps show lead concentrations by different sample media, the top right shows stream sediment, the bottom left shows stream water and the bottom right shows shallow topsoil.



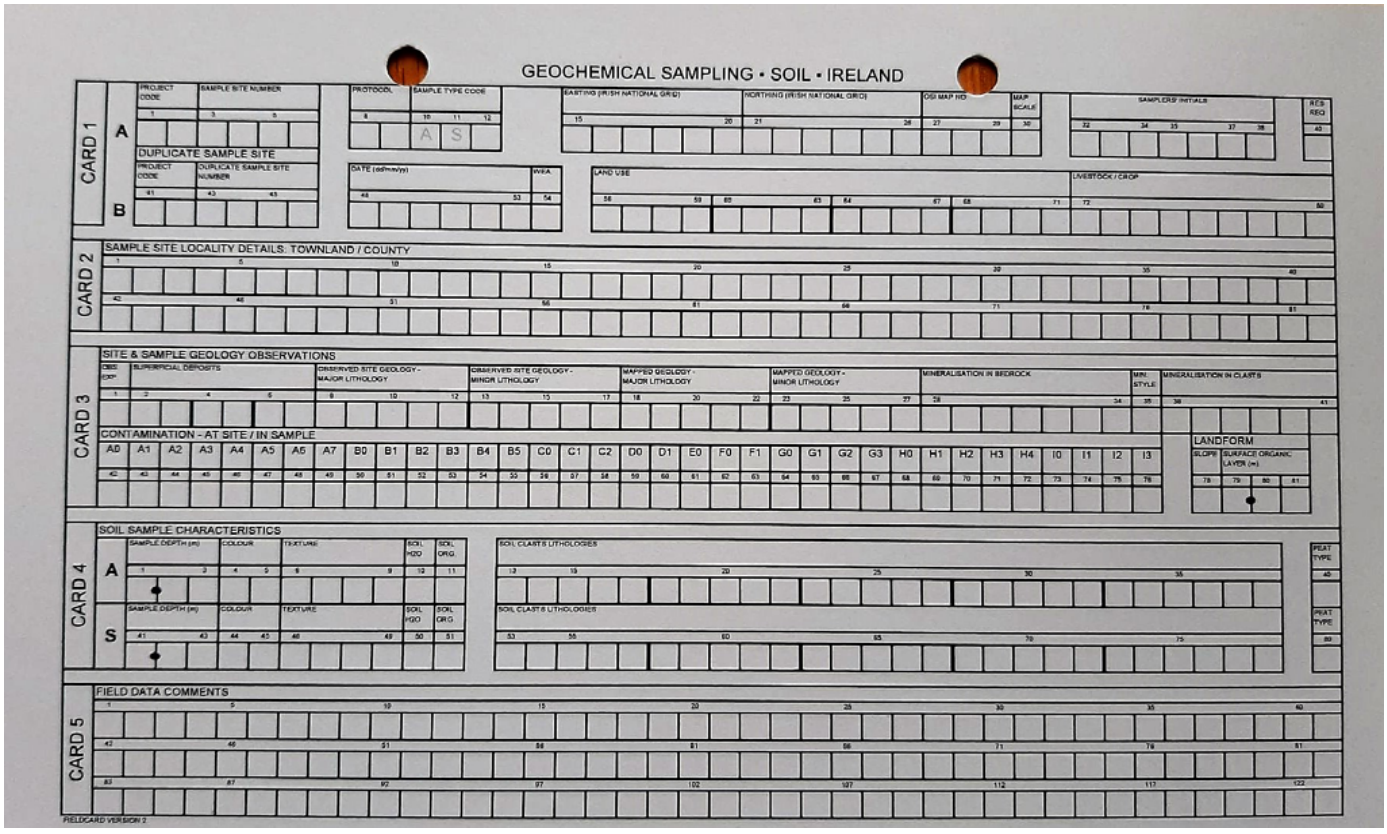


The Development of the Digital Data Capture System

While collecting 1000s of physical soil/stream water samples, our field teams also capture vital information about the sample characteristics in situ, as well as local observations about the sample site, such as land use, slope, observed geology, recent weather and many more. This is standard practice globally and assists with the interpretation of the data. Therefore, it is important that this data is collected in a standardized manner and retained for future use and reference.

Until recently, all site locations and field observations were captured using pen and paper at site. To do this, field samplers were issued with a small folder containing “field cards” and a crib sheet overlay with all the survey codes for land use, rock type etc., as well as a separate compass, roamer, paper OSi map and handheld GPS. As you would expect, accurately recording site locations and field observations by hand in the field was quite challenging, especially in typical Irish rainy weather.

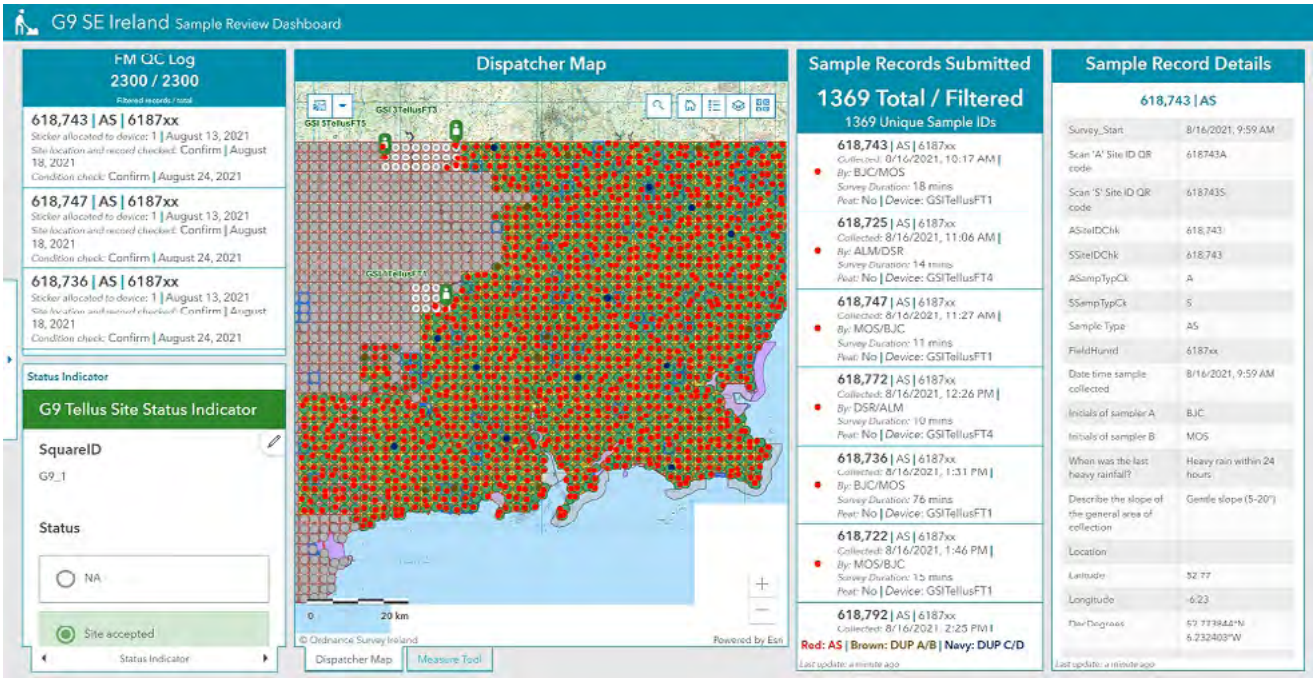
Once back at base, this data had to be manually entered into a database, which was both time consuming and had the potential to introduce transcription errors. However, although it may sound very cumbersome, the paper-based system was successfully implemented between 2011 and 2020.



In 2020, a new digital solution was developed to replace the paper-based system. Rugged field tablets, equipped with a high-accuracy global navigation satellite system, have replaced the need for pen and paper, and physical paper maps. in the field. Samplers now use just one hand-held device to receive their daily assignments, for navigation, site selection and to digitally capture the sample site location and field observation data as the samples are collected. The digital system captures the same fundamental data, but in a more streamlined, efficient and accurate way.

The adaptability of the digital system also allows other data to be captured, such as site photos during the 2021 Dublin urban survey, which will aid interpretation of results from this geochemically complex region. The flexibility of the digital system was also ideally placed to assist remote working and physical distancing during the Covid pandemic. It allowed for remote allocation of work assignments and removed the requirement for daily issuing of paper items and other equipment to field teams.

The system allows real-time monitoring of the survey progress and the Field Manager can perform daily and ongoing quality control checks as soon as the data are submitted in the field. To-date, the new digital data capture system has been used during our G7 to G9 ground soil surveys and will be continued to be used and further developed for all future geochemical ground surveys.

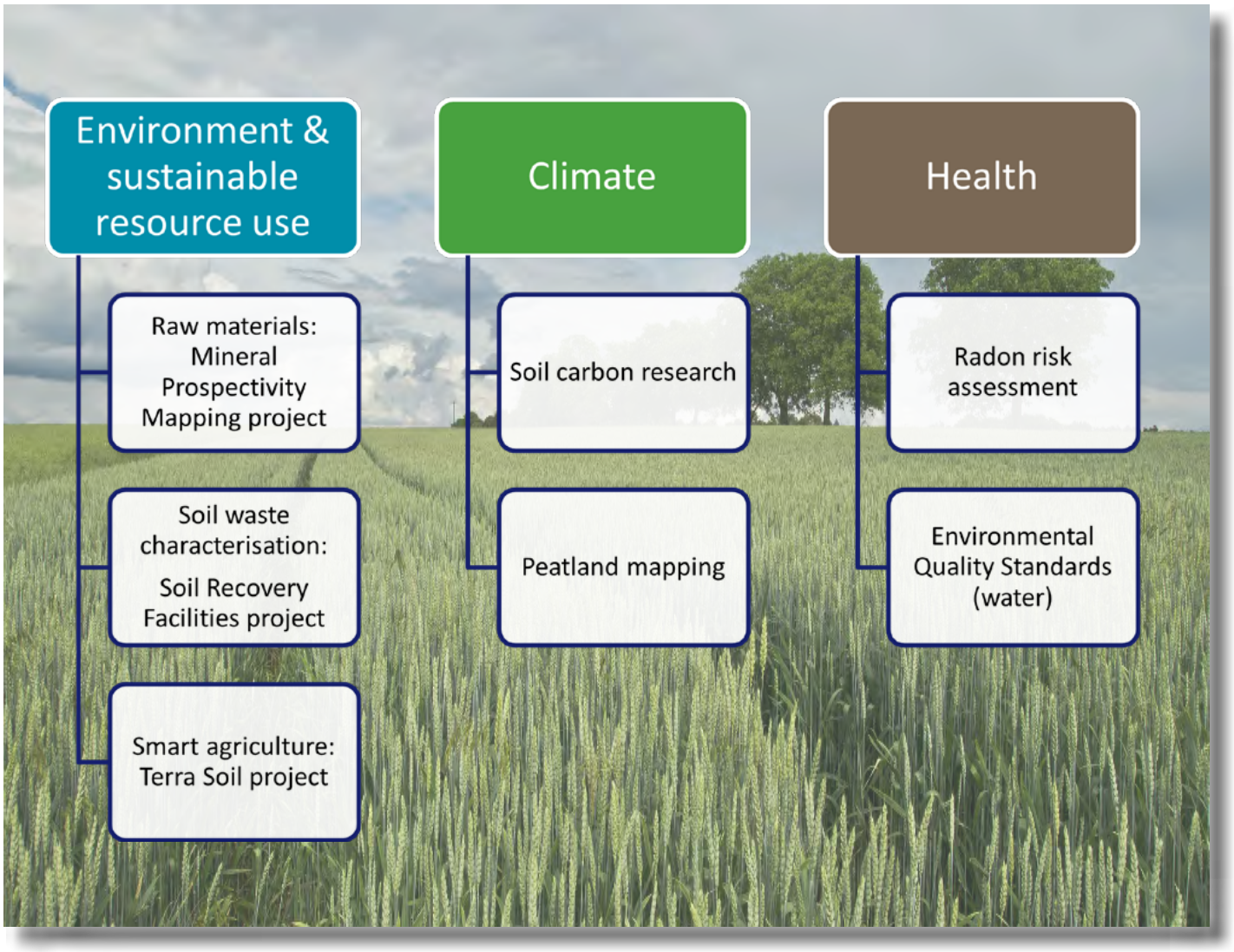


Product Development

Tellus is many things to many people. Tellus was primarily envisaged to be a means of de-risking mineral exploration investment, by providing high-quality, regional-scale geochemical data on base metal, precious metal and pathfinder elements. It quickly became clear that knowing the chemical and physical characteristics of the near surface can support our society and economy in a variety of ways, some of them unforeseen and innovative.

Since the inception of Tellus, Ireland's economic model has changed from economic growth to the circular economy. The circular economy is one in which we develop natural resources sustainably, keep resources in use for as long as possible, extract the maximum value from them whilst in use, then recover and regenerate materials at the end of life. The circular economy is a key context for Tellus products because it supports a sustainable economy, preserves environmental quality, addresses climate change and values wellbeing.

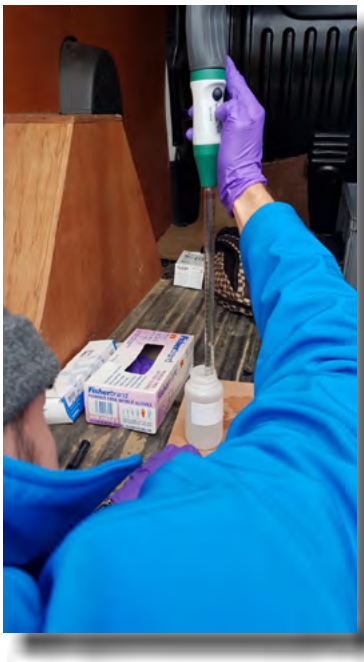
The diagram below shows some key themes of the circular economy and where Tellus products fit into these. As well as a suite of multidisciplinary projects underway and in development, Tellus also feeds into policy making and national expert forums on soil, water quality and land use.



Mineral Prospectivity Mapping

Minerals are required to support the transition to a low-carbon, green-energy future. Key technologies such as electric vehicles, energy storage batteries, solar panels and wind turbines rely on a secure, ethical supply of metals such as zinc, lithium, cobalt and Rare Earth Elements.

Ireland has world-class zinc deposits and this project aims to unlock the potential of historical mineral exploration data along with modern Tellus data to highlight new areas potentially prospective for zinc.



Radon

Radon causes about 350 cases of lung cancer and 255 deaths in Ireland each year. Many factors affect indoor radon concentrations, including local rock types and geological conditions.

Tellus is working with the Environmental Protection Agency to incorporate geological factors into radon risk mapping to create higher resolution radon risk maps for Ireland.

Soil Recovery

The beneficial recovery of excess soil and stone from building excavations represents a saving on the disposal of such material to landfill and in many cases significant reductions in transportation costs and carbon emissions. The Tellus programme has assisted the Environmental Protection Agency with the characterization of subsoil geochemistry in order to support the regulation of Soil Recovery Facilities in Ireland.

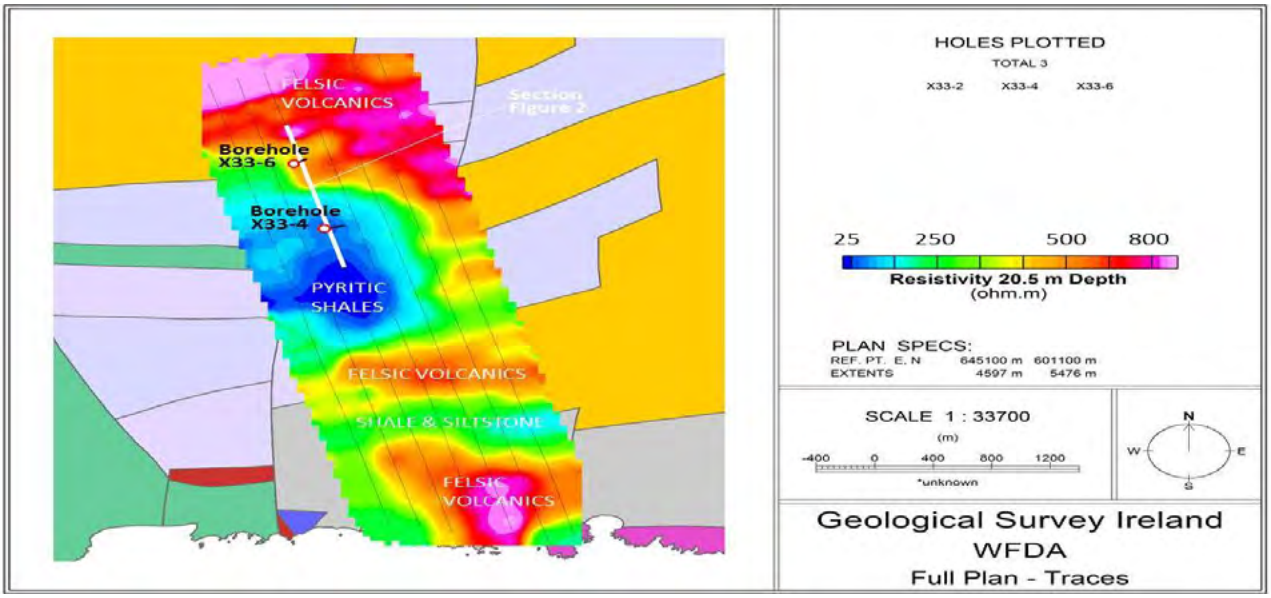
Electromagnetic (EM) Inversion | Example case study of using geophysics for geological interpretation

Electromagnetic data

The Tellus airborne geophysical survey acquires frequency-domain electromagnetic (EM) data at approximately 6 m intervals along flight-lines flown 200 m apart. At each location the EM system collects 4 measurements at different frequencies allowing resistivity data to be calculated at different depths. By modelling these data the electrical resistivity structure from near-surface to around 60 – 100 m depth can be resolved. As different rocks and superficial geological materials (e.g., soils, weathered rock, sand, gravel and alluvium) have different electrical resistivity signals, the EM resistivity models can be used to provide a slice through the ground helping to map both the vertical and lateral changes in the subsurface.

Inversion software

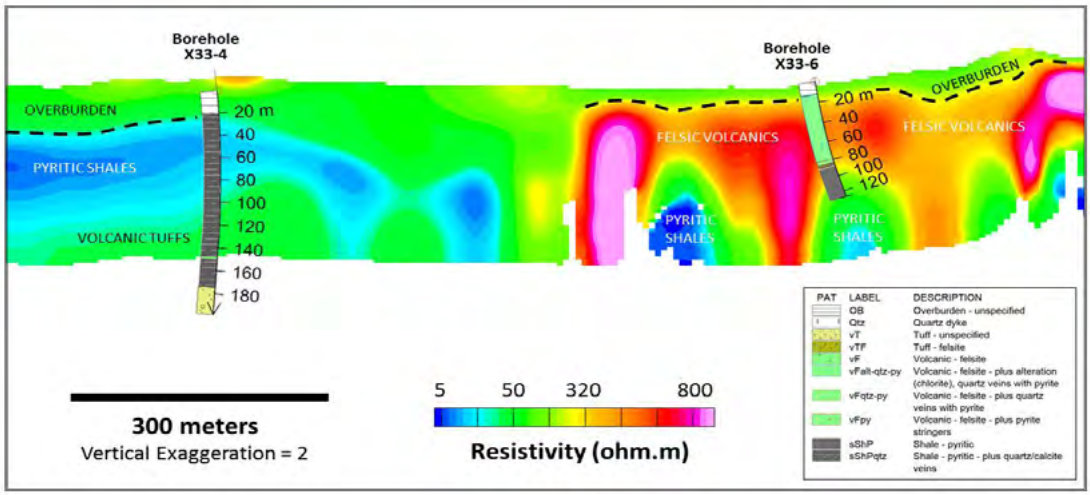
The models are created using aempy open-source software developed at Dublin Institute for Advanced Studies, to produce 1-D resistivity soundings (models of resistivity versus depth) at each measurement location along the flight lines. These 1-D resistivity models may be manipulated to provide resistivity maps at certain depth slices, or combined to create 2D cross sections through the ground.
By investigating a number of sections together we can obtain a pseudo-3D model, showing how different layers change both laterally and with depth across an area.



Airborne EM resistivity depth-slice at 20.5 m depth, overlain on GSI's 1:100,000 bedrock geology map, from Co. Waterford near the towns of Bunmahon and Kill.

Interpretations & Applications

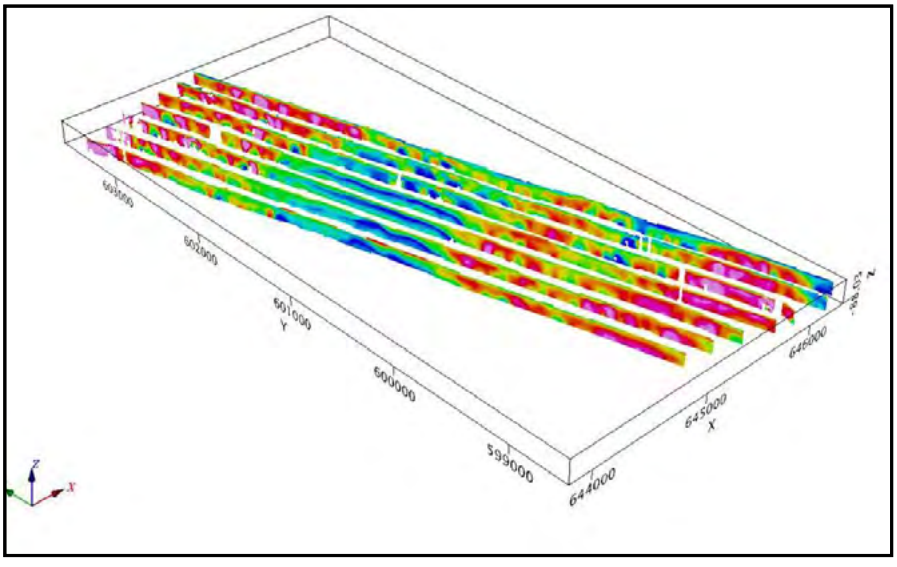
The ~60 – 100 m depth and the lateral and vertical resolution of the resistivity inversion models make them well-suited to a range of different applications, for example, estimating the depth to bedrock, mapping rock beneath overburden and high-resolution modelling of shallow geological layers; identification and mapping of shallow sand and gravel bodies; mapping of quaternary sedimentary deposits and overburden; soil mapping; thickness mapping of peat bogs; and shallow aquifer mapping.



Resistivity cross-section along a short portion of an airborne EM flight-line, shown to a depth of 100 m.

All geophysical surveys are interpretations and should be supported by other investigation methods such as drilling or field mapping. However, by using the EM inversion sections we can reduce the number of boreholes required and not only map changes in the geology at the surface but also at depth.

In areas of complex geology where the bedrock is covered by thick till or soils resulting in little exposed rock at the surface traditional field mapping is difficult. The geophysics data allow us to see the changes in bedrock below the soil, improving the detail of the geological mapping.



3-D fence-diagram display of resistivity cross-sections along seven airborne EM flight lines.

The People of Tellus

Over the last 10 years, the Tellus programme has been fortunate to have many excellent people who have helped to keep the programme going. From geochemists and geophysicists planning the surveys and checking the data, to field samplers collecting soil, sediment and water across the country, to pilots and aircraft crew flying the survey plane and the support team who help with survey communications and the data management.

The survey aircraft and field samplers have become a regular sight across the towns and fields in Ireland. Over the years a core Tellus team have kept an eye on the data quality of the survey data while numerous contractors, from field samplers to airborne crew, to laboratory technicians have helped collect and process the survey data.

2021 Tellus team: Ray Scanlon, Jim Hodgson, Mairéad Fitzsimons,, Vincent Gallagher, Judith Mather, Michal Szpak, Mark Muller, Mohammednur Ture, Emma Scanlon, Margaret Browne, Victoria Lowe, Sophie Lilburn and Eric Grunsky.

Previous members of the Tellus team since 2011: Shane Carey, Peter Heath, Kate Knights, Aoife Brady, Emilia Palenius, Kate Richardson, Carla Hickey, Donal O'Farrell, Aileen Doran, Hugh O'Keeffe, Richard Turley, Barry Crowley, Lawrence Collins and James Symons.

My name is Steve Gebhardt, I am from Ottawa, Canada.
I work as a survey pilot for Sander Geophysics Ltd

I've been flying for the Tellus project for the last ten years. I've come to see Ireland as few get the opppor-tunity to, through its people and at 200 feet above the ground. Prior to flying in Ireland , I'd flown bush planes in some of the most remote and inhospitable regions on the planet as well as airborne firefighting. Since coming to Ireland , I have fallen in love with the character of its people and the majesty of the land and have been happy to make Ireland home. The people have made this project a pleasure and have made it hardly seem like a work day even when we *fly so low and so similar areas, (200 meters spacing on generally our North/ South lines).*

We often do two flights a day and have been fortunte to have had enthusiastic help from staff at airports that we've been based in; Sligo, Kerry, Waterford, Weston and Eniskillen. It's not possible without the wonderful help from Air Traffic Control and the Irish Aviation Authority who make sure we are all safe in the air and on the ground. A mere parargraph hardly can do justice to my experience in Ireland and to the character of it's people, I only wish that they continue to welcome me back year after year and I will endeavour to do my best to appreciate such an opportunity and a view that sometimes I take for granted due to long hours in the air, (often 9 hours a day!). I hope to see you all soon and if you wave, I'll try to give you a wing waggle back. Thank you, Ireland, for such a wonderful opportunity.

My name is Alison McCleary, I am from Ottawa, Canada. I work for Sander Geophysics Ltd, as the crew chief.

I have been working on the Tellus Project for 10 years now. It's been a privilege and joy to have travelled to different locations around Ireland experiencing so much of its beauty and history. I work as the crew chief and scientist on the project. We gather airborne geophysical data in order to map the minerals and rock formations under the earth's surface. We have three main types of specialized equipment onboard the aircraft which flies only 60 m above the ground. Radiometric, magnetic and electromagnetic data is gathered and processed daily, when the weather allows.

I work closely with the fantastic and supportive GSI team and local airport staff in an effort to inform the public of our locations and intentions. I have been very fortunate to travel with my husband, and pilot of the aircraft, and our two sons. They go to the local schools, learn Gaelic and are immersed in the Irish culture. Together we have made many friends over the years who we stay in touch with. I have even learned the benefits of year-round sea swimming and have enjoyed this in both Kerry and Waterford. I am forever grateful for the opportunity to spend so much time in Ireland and look forward to continuing the adventure.

My name is Caroline Fitzgerald and I manage the Tellus Freephone Line on behalf of the RPS Project Communications Team.

I have a background in Geography and Environmental Management which allows me to have a technical understanding of all the exciting science that is being conducted on the Tellus Survey. At RPS, our team specialises in stakeholder engagement and communications and with my technical background, I communicate complicated information about the project to stakeholders and to anyone who has an interest in what the Tellus Survey involves!

Tellus is so important to understand what is beneath our feet and the data will continue to help us sustainably manage natural resources, public health and the environment into the future. I enjoy helping callers understand more about the project, informing stakeholders about upcoming surveys and communicating what is happening with the project every day in a transparent and simple way. I am delighted to have the opportunity to contribute to the GSI Tellus Team in making this important project a success!

My name is David Robb, I am from County Galway.
I'm currently working as a soil sampler with Aurum Exploration Ltd.
as part of the geochemical programme.

I studied General Science and then Earth and Ocean Science in NUI Galway and after my exams started work as a field sampler in 2021 as it was an opportunity to work in my area of interest. The job started in Dublin and has brought me through Carlow, Wexford, Tipperary, and Waterford over the past 6 months. The day-to-day routine of the job varies depending on the terrain found in our assigned grids. Some days I'll find myself up mountains or deep in the woods but for the most part my time is spent driving from farmland to farmland collecting and describing the soil in our assigned grids where we are required to take one set of samples using our trusty augers at 20 cm and 50 cm depth.

Some days are hard work when we are working through the tough conditions, but the good days make the bad days worth it! There are plenty of things I love about the job mainly being the places and the people I've got to meet. I've visited the various nooks and crannies of Dublin, The Blackstairs, The Comeraghs and the beautiful southeast coastline. I've also had the chance to meet a variety of interesting characters along the way moving from farm to farm and place to place. Through all this I've learned a lot about my country, and I can honestly say that through this job I've gained a newfound appreciation for what it means to be Irish and the connection that the people of this country have to the land.

My name is Aileen Doran, I'm currently a post-doctoral researcher at University College Dublin (UCD) with iCRAG, my first proper job was as a graduate geologist on the Tellus Project.

At the moment, my work focuses on mineral deposits. Specifically, I look at the use of geochemical techniques to investigate ore formation. As a graduate geologist on the project, I was involved in a lot of different activities, including working on some of the geophysical and geochemical datasets generated by Tellus, helping with soil sampling, and representing Tellus at conferences across Ireland. Another big aspect was looking at radon distribution across Ireland and thinking about possible geological controls. In this role, I was able to experience a lot of different areas of geology, while also engaging with local communities and people interested in the work.

Working for the Tellus Project led to me starting my PhD at UCD studying zinc-lead deposits in Ireland. Now, I am working on copper-cobalt deposits in the Zambian Copperbelt. But, working for the Tellus Project, and getting to meet so many new people was a great experience that helped me get to where I am now!

Tellus the Future

National Coverage

The Tellus programme in Ireland has evolved from an initial EU project investigating the border region to a national geochemical and geophysical mapping operation which produces high-quality data and applied products.

To date we have collected millions of scientific measurements, adapted operations to life under Covid-19, and by the end of 2021 we will have achieved approximately 70% and 80% coverage across the country with the soil sampling and airborne geophysics surveys respectively.

Therefore, the immediate plans are to complete national coverage for the geophysics and soil sampling survey over the next two years and then follow this by finishing the drainage surveys that collect stream waters and sediments. Once all the data is collected there is the exciting process of turning the data into maps that reveal the complex geology across Ireland.

New Products

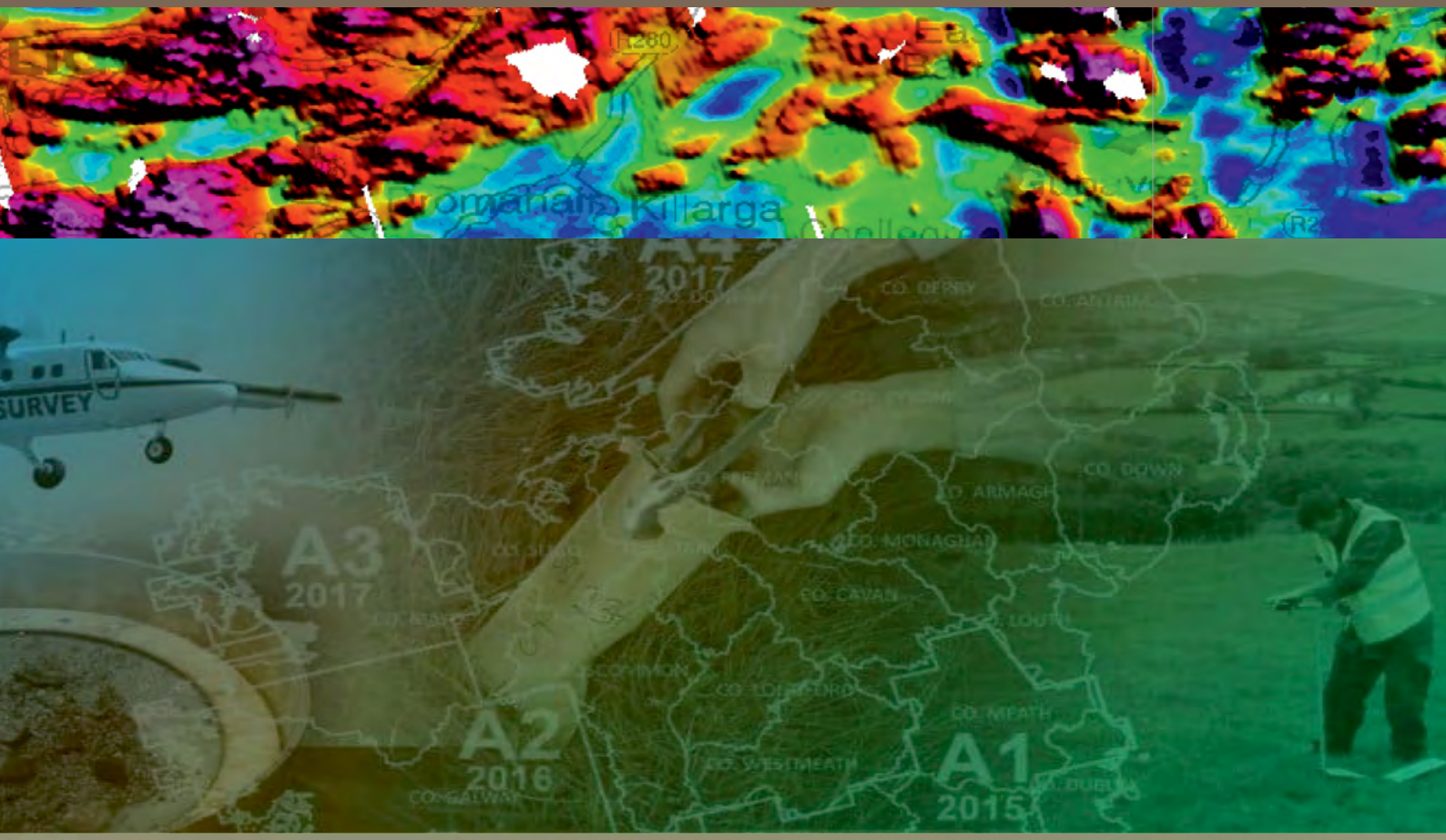
One of the big tasks to making the data usable and understandable by different sectors, is working with the agricultural sector to investigate soil fertility and to investigate the mineral potential of different areas or supporting climate research. Much of this will be done through collaboration with other agencies and organisations.

New Surveys

Once the current survey operations are completed there may be new opportunities or new technologies for Tellus. We might wish to investigate areas of interest in greater detail using drones to collect geophysical data at an even greater resolution or investigate other survey methods such as gravity or seismic surveys which would complement the existing data sets and allow us to look deeper or identify new features. We have also started to not just look at baseline geochemical properties across Ireland but also investigate the anthropogenic effects on the soil found in our cities and places where we live.

The Future is Green

Beyond data collection there are numerous new products and research areas for us to address and we are always looking for new ideas or projects. One area of growing interest is the green economy. There is an on-going need for improved understanding of our natural resources and the need for sustainable policies for both resources and energy. Therefore, quality data and research is of particular importance in the future of geothermal energy, sustainable mining and the circular economy. We will work closely with our Department of the Environment, Climate and Communications on strategic goals.



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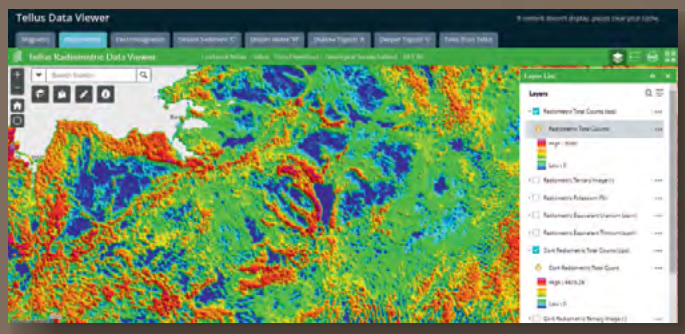

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