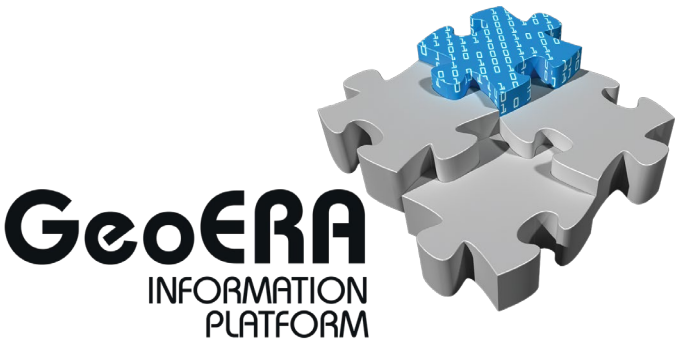

Authors and affiliation:
Jørgen Tulstrup, GEUS

E-mail of lead author:
jtu@geus.dk

Deliverable

Final Project Report

Version: 25-11-2021

This report is part of a project that has received funding by the European Union's Horizon 2020 research and innovation programme under grant agreement number 731166.

Deliverable Data		
Deliverable number	D1.4	
Dissemination level	Public	
Deliverable name	Final Project Report	
Work package	WP1, Coordination	
Lead WP/Deliverable beneficiary	GEUS	
Deliverable status		
Submitted (Author(s))	25/11/2021	Jørgen Tulstrup
Approved (Coordinator)	29/11/2021	Jørgen Tulstrup

1.1 Background for the report

This report was originally planned to be describing a Final Project Conference of the GIP-project (GIP-P), but due to the travel restrictions related to the COVID-19 pandemic it has been decided to not have a final conference.

Instead, this report will give a brief overview of the results achieved during the project. It can be seen as a supplement to the Final Project Progress report for GIP-P which will be delivered to the GeoERA Monitoring team and form the basis for the final review. With this report D1.4 we will try to give a relatively short overview of the project's main promises and results.

1.2 Background for the project

The reason to include a project for an information platform in the GeoERA programme was that it was considered that such a project would be able to handle the geospatial and other scientific results from the 14 GeoERA scientific projects (GSPs) in the most cost effective way and with the highest quality. If the 14 different GSPs would have had to invent their own ways of standardising, storing and disseminating their data many very different solutions could be expected and the chance that the results could be used in conjunctions would be low. But it was from the beginning clear that almost all the GSPs would produce large amounts of data, services, documents, etc. and that handling all this material in a professional way would be vital for the overall outcome of the whole GeoERA programme.

1.3 Primary focus of the project

In the GIP-P we have therefore had most of our focus aimed at understanding, mapping and describing the needs of the 14 GSPs and at building the information platform to suit them.

At the same time, we have, however, had to also promote certain principles, methodologies and specific technologies even though they were not formulated by the GSPs, to ensure wider dissemination and exploitation by a broader audience of users and platforms. This was first of all the FAIR principles.

1.4 What did we plan to do and how did it go?

In the following section we have extracted major elements of the Excellence section of the project proposal. It is not an exhaustive list of everything that was described in the proposal, but we believe that it gives a good representation of what we set out to do and deliver at the time we wrote the proposal. We then explain which results we have achieved in relation to these "promises". The full version of the Excellence of the proposal is included in this report as Annex 1.

1. From proposal: *By setting up shared rules, guidelines and standards the project will act as a catalyst for the successful and interoperable integration of the results coming from the other GeoERA projects into one single information platform with user-friendly as well as machine-oriented interfaces that are targeted at all relevant categories of end users and fitting into the broader European e-infrastructure landscape.*
   Relevant results: Using the European Geological Data Infrastructure (EGDI) for

all data has ensured that the results from all GeoERA projects are accessible on one single, user-friendly platform through the web-GIS interface and the search systems. It also gives access to the results in machine-readable forms via the availability of the OGC services whereby it fits into the broader European e-infrastructure landscape. Great effort has been put into helping the GSPs find and implement relevant standards, and guidelines have been developed for uploading, specifying metadata and thematize the results in a common way in order to provide results that can be understood by the vast majority of users.
Through the user-friendliness of the platform the GIP-P has contributed to the ambition of the GSPs to reach their target groups.

2. From proposal: *The overall aim of the GIP-P is to support the GeoERA Geoscientific Projects (GSPs) in organising, disseminating and sustaining their results in terms of digital data, interpretations, reports and services thereby indirectly supporting the sustainable use and management of the subsurface. For this to happen, the GSPs' results must be FAIR meaning Findable, Accessible, Interoperable and Reusable thereby making them as valuable as possible for the stakeholders.*
   Relevant results: The sustainable use and management of the subsurface has to a high degree been supported through the chosen approach of giving very high priority to supporting the GSPs.
   Furthermore, we have had very much focus on achieving FAIRness. We have been requiring comprehensive metadata descriptions for all uploaded data and the INSPIRE compliant metadata system itself ensures a high degree of FAIRness. We have also been testing a FROST server to make data regarding observations and measurements accessible through that standard.

3. From proposal: *The GIP-P will aim at doing this with higher quality and more cost efficient than would have been possible if the GSPs had to manage their digital results individually.*
   Relevant results: We are convinced that our approach has been very cost efficient. We have built on the existing EGDI infrastructure which already provided a long range of functionalities needed by the GSPs and we have extended this to accommodate what the GSPs have specified. The quality has been ensured by basing the work in the GIP-P on a group of experts with long experience in IT solutions for geoscientific data and the needed disciplines.

4. From proposal: *… the GIP-P will ensure that data and information will be organised and disseminated in a coherent and standardised way based on state-of-the art database and web technologies.*
   Relevant results: All types of data and information of the same type is handled by the same technologies. Some of the major components of the extended EGDI are a central PostGreSQL database which holds all geospatial data, a document repository based on the Solr technology which holds all documents (reports, images, spreadsheets, etc.), a triple store which holds all information about project vocabularies, and OGC services to give access to maps and underlying data in a standardised way.

5. From proposal: *The project will aim at supporting the establishment of the spatial data infrastructure for Europe by using the existing standards for data*

exchange like INSPIRE and extending those following the INSPIRE recommendations where necessary.
Relevant results: Through dialogues with each GSP we have identified which European and International standards would be relevant to map their data to. This has to a certain degree resulted in more standardised data from the GSPs, but we had hoped for a higher outcome in this respect. Some of the GSPs have obviously not seen the benefit of converting their data to standards that they are not using in their normal work. Other GSPs have been more used to working with international standards and quite a few have also contributed to the standardisation efforts by suggesting new terms where relevant. These have been added to the Geoscience Registry and can be suggested to for instance INSPIRE.

6. From proposal: *The project will aim at contributing to the establishment of a single access point for European geological information by combining the access to pan-European and cross-border data from GeoERA and earlier projects originating from the huge amount of national and regional data generated and gathered by the Geological Survey Organisations.*
   Relevant results: Already before GeoERA, EGDI contained results from earlier projects by the European Geological Survey Organisations covering a broad range of geoscientific disciplines including on- and offshore geology, raw materials, geoenergy, hydrogeology, geohazards, etc. So, from Day 1 of GeoERA there was a single point of access to those in combination with GeoERA results. The architecture of EGDI can be customized to implement new maps containing the layers that are relevant for a given case. This has been used to make dedicated maps for each of the GSPs with their own results to be shown on their individual project pages on geoera.eu. It has also been used to make a combined GeoERA map in addition to the thematic maps on the EGDI website itself.
7. From proposal: *GIP will significantly contribute to the development of the EGDI platform with new data and functionality based on the requirements from GSPs (see Figure 1).*
   Relevant results: The GSPs have added close to 300 new layers to EGDI. Regarding functionality the following major new modules have been implemented:
   a. A generic 3D geological model database where data from 7 models generated in different 3D modelling tools are stored in the same point-cloud based format.
   b. Two connected 3D model viewers.
   c. Project Vocabularies implemented in a triple store. 15 Project Vocabularies created for 6 different projects (GeoConnect3D, HIKE, HotLime, MUSE, HOVER and EuroLithos) altogether contains 8386 scientific concepts including 1286 bibliographic references. This has also been utilized in the GeoERA HIKE project for that project's so-called Knowledge Share Point.
   d. A Multilingual Keyword Thesaurus with 2596 terms. Terms were translated into a total of 21 languages and 9 of those include more than 80% of the terms. The search systems and metadata catalogue take advantage of the multilingualism and hierarchical relationships of this vocabulary to enhance the functionalities developed by each of these systems.

e. A Document Repository for “unstructured” data like reports, images, spreadsheets, etc. and a dedicated search system. It contains currently 694 PDFs, 231 Images and 59 DOIs.
f. A tighter integration between the EGDI metadata catalogue and the web-GIS making the metadata information accessible together with the map layers.
g. An Administration module which enables the users who have produced geospatial or unstructured data to upload these to the EGDI platform, connect it to metadata records, specify thematization, attach layers to maps, etc.
h. A general free-text search system which enables end-users to find information in all the modules of EGDI and display the results according to a ranking algorithm based on the relevance of the result to the search performed by the end-user.

8. From proposal: *EGDI is proposed to serve as the source of geological information to a wide range of users and other platforms, in particular to the European Plate Observing System (EPOS), to The European Commission’s Raw Materials Information System (RMIS 2), to the European Union Programme Copernicus for satellite and in situ Earth Observations, etc.*
   Relevant results: There is a formal EGDI agreement between EGDI and EPOS about delivering OGC services on surface geology, raw materials, boreholes and 3D models. These are in a testing phase currently because EPOS has not yet entered into an operational phase.
   Together with MINTELL4EU (one of the Raw Materials GSPs), we have had dialogues with the Joint Research Centre (JRC) about integrating information from EGDI about raw materials into their RMIS 2. It has turned out, that the JRC will not allow a tight integration between the two systems. Instead a few simple EGDI web-GIS maps have been included in web pages for the RMIS 2. See for instance https://rmis.jrc.ec.europa.eu/?page=geological-data-157d8a.
   Regarding Copernicus, no formal integration has been agreed, but because the GeoERA map layers are all accessible as OGC services (WMS and WFS), the information can be combined with Copernicus data in standard GSI tools.

9. From proposal: *The GIP will implement common standards (OGC, INSPIRE, ISO, …) as well as define community standards based on the requirements from GSPs… close contact will be maintained with SIEG, OGC GeoScience Domain Working Group, INSPIRE Thematic Clusters, etc. during the course of the project in order to ensure the highest possible level of interoperability and accessibility of the results from the GSPs.*
   Relevant results: As mentioned, EGDI supports the delivery of OGC services (both view and download). To the degree that the GSPs have followed the recommendations from the GIP-P their data and services are INSPIRE compliant, and the EGDI metadata catalogue is ISO as well as INSPIRE compliant.
   There is a large overlap between the GIP-P participants and the members of the EuroGeoSurveys Spatial Information Expert Group (SIEG) and the exchange of views and ideas between the GIP-P and the SIEG has been extensive. There are also individuals in the GIP-P consortium who are members of the INSPIRE Maintenance and Implementation Group just like there is an overlap in terms of members between the GIP-P and the OGC GeoScience

Domain Working Group.

10. From proposal: *We will demonstrate how information access can be augmented beyond dissemination by providing exemplar research infrastructure functionality that facilitates tailor-made processing and analytical tools to enable science to be undertaken and knowledge derived.*
    Relevant results: Specific functionality has been developed for some of the GSPs beyond the standard EGDI functionality. Functions give access to sensor recordings of groundwater parameters under the TACTIC project and data delivered in the NetCDF format containing model estimates of Nitrate in the unsaturated zone under the HOVER project can be examined at different points in time. The 3D model database and viewer also provide the possibility to make virtual boreholes and slice through the layer sequence, and together with the HIKE project a so-called Knowledge Sharepoint has been developed based on the GIP-P Project Vocabularies and Document Repository providing access to a guided search regarding the risks and hazards of human subsurface activities and the mitigation and management of it.

11. From proposal: *Importantly, we will provide training and technical support to both data providers and users.*
    Relevant results: We have had a dedicated work package for supporting first of all the data providers. This includes operating a support network, triaging questions relating to data provision to EGDI, ensuring the questions were directed to those best placed to answer them and documenting the answers to the questions in a public GitHub forum so that they can be referenced by other users experiencing similar issues. A centralised GeoERA data provider support hub was established as well as a buddying system where GIP user support staff assist the GSPs in managing and preparing their spatial datasets and in providing spatial data services for inclusion in the information platform. A number of cookbooks have been made (see for instance Metadata cookbook and EGDI documentation for data providers) as well as five videos.
    Finally a series of e-Learning resources have been made available on a specific platform at http://elearning.europe-geology.eu/. This platform is planned to be substantially extended for the general EGDI project and other future projects.

12. From proposal: *… functionality based on GeoSciML that allows users to query varied geological models and databases to discover what information is held about the Lower Carboniferous might be integrated into EPOS as an ICS-D provided by the European Geological Survey community.*
    Relevant results: WFS Services delivered from EGDI to EPOS include surface geology (GeoSciML) and mineral resources (ERML). Currently the EPOS core services (ICS-C and ICS-D) do not contain functionality to take advantage of this, but that may happen in the future depending on the priorities in EPOS.

13. From proposal: … *enables cross querying of multiple information sources including geological databases and 3D models and integrating the results into research software on a geologist's desk such as a 3D modelling package.*
    Relevant results: The 3D database implemented in EGDI has a generic format which makes it possible to deliver 3D geological models generated in many different tools in formats compatible with other tools. This enables the reuse of the models together with other kinds of geological information on the platform of

the scientists' choice. It also makes it relatively easy to integrate models from different sources and maybe using different tools into one combined model thereby enabling analysis of for instance competing uses of the subsurface.

14. From proposal: *Our methodology will rely on community building and networking to ensure a successful outcome. GIP will be developed in cooperation with users and for users.*
    Relevant results: One group of users has been very tightly connected to the GIP-project. That is the scientists and data providers from the GSPs. We have worked directly with them through our WP2 and liaison persons with responsibility for each their own GeoERA theme (Raw Materials, GeoEnergy and Groundwater).
    Regarding external users we have had direct dialogues with DG GROW about the Raw Materials data which they have needed in different formats, with JRC (see point 8 above), with Danish Software companies regarding EGDI service to be used in their products, and with users and developers from EPOS.
    Finally we have also very close contact to other geoscience information experts through participation in the EGS Spatial Information Expert Group (SIEG) and the global Geoscience Information Consortium (GIC).

15. From proposal: *Furthermore, the successful results of the project will be widely disseminated among the interested stakeholders and the geological community as a whole by the project Communication and Dissemination plan.*
    Relevant results: Unfortunately, the Mid-Term event in Ljubljana in March 2020 was cancelled due to the COVID pandemic. It was the plan to demonstrate the platform to a large number of stakeholders at that occasion and to get their feedback on the solutions. It has not been possible to arrange other networking events physically since, but the following is a list of some of the other dissemination activities that have been undertaken:
    a. We have contributed to 6 issues of the overall GeoERA Newsletter telling about achievements of our project to more than 600 subscribers.
    b. Three videos have been produced explaining about the objectives of the project, about the importance of an information platform, and about the possible applications and users of the project's results.
    c. A total of 11 blog posts have been produced accessible on the GIP-P part of the GeoERA website and on Twitter.
    d. The GIP-Project was a main topic during a general presentation of EGDI at the 2021 GeoKarlsruhe conference.
    e. A webinar was organised to show the GIP-P project to ASGMI (Association of Iberoamerican Geological and Mining Surveys) with the aim of demonstrating an information platform that could be replicated in a similar way in Latin America.
    f. During the project 9 meetings have been carried out of the SIEG where the GIP-project has exchanged information on the concepts and design of the platform.
    g. The annual conferences of the GIC consortium has also been a valuable occasion for the exchange about the GIP-project and similar initiatives in other parts of the world.

16. From proposal: *contribute to EOSC by providing access to a wide range of geoscientific data*

Relevant results: The strong focus on OGC services for the GeoERA geospatial data has the consequence that now approx. 600 new sets of geospatial data have become accessible from EOSC. EGS is currently not an official member of EOSC and is therefore not in a position to influence the direction in which this initiative is evolving, but there are considerations about changing this is a possible future continuation of GeoERA.

In addition to the above-mentioned results it is relevant to mention important achievements that were not described in the proposal:

1. A free text search system has been developed which allows the user to search through metadata, the uploaded datasets, and pdf-files in the document repository. This is a major extension to the EGDI.
2. It has been made generally possible – in addition to getting the data through OGC web services – to download copies of the uploaded GeoPackages. These are ready-to-use GIS dataset including the thematization of the layers and very attractive for many GIS users.
3. A report with the title “Licensing Data and other material” was produced. It contains an explanation of the different Creative Commons license models and is targeted at the scientists in the GSPs enabling them to find the most appropriate license model for their own data. In general, the CC-BY model is recommended, and this has been followed by the large majority of GSPs. This in combination with a requirement that all geospatial data uploaded to EGDI must specify a license has contributed to the FAIRness of the results.

1.5 Conclusion.

We believe that the GIP-project to a very high degree has delivered what was promised in the proposal. There are a few elements that could have been developed further, but we believe that the extra elements, that were not initially identified but finally achieved (the free text search system, the download of GeoPackages and the achievement related to licensing models), brings more value to the GeoERA programme and its projects.

Annex 1: Excellence section from project proposal

Excellence

Sustainable use and management of the subsurface has a truly multidisciplinary character and the need for uniform access to multi-domain data is drastically increasing. Numerous previous European projects have produced valuable data and information related to raw materials, groundwater, geoenergy and other themes. Such projects, however, have typically focussed on issues associated with individual geoscientific domains and the results have been disseminated through dedicated web portals that often have been abandoned shortly after the end of the projects. To meet the increasing needs of European stakeholders for sustainable, usable and easy findable data, the EuroGeoSurveys community has initiated the establishment of the European Geological Data Infrastructure – EGDI (www.europe-geology.eu), where results from previous European projects relating to different geoscientific domains have been made available in a homogeneous but not entirely harmonised way. The overall GeoERA programme is a unique opportunity to bring this a big step further by extending the EGDI and integrating the results from the research-oriented GeoERA projects from the groundwater, geoenergy and raw materials themes.
The GeoERA Information Platform Project (GIP-P) is a proposal related to the GeoERA Information Platform Specific Research Topic "IP1 – Development of an Information Platform to support management and provision of data for the three other themes". By setting up shared rules, guidelines and standards the project will act as a catalyst for the successful and interoperable integration of the results coming from the other GeoERA projects into one single information platform with user-friendly as well as machine-oriented interfaces that are targeted at all relevant categories of end users and fitting into the broader European e-infrastructure landscape.

Aims and objectives

The overall aim of the GIP-P is to support the GeoERA Geoscientific Projects (GSPs) in organising, disseminating and sustaining their results in terms of digital data, interpretations, reports and services thereby indirectly supporting the sustainable use and management of the subsurface. For this to happen, the GSPs' results must be FAIR meaning Findable, Accessible, Interoperable and Reusable thereby making them as valuable as possible for the stakeholders.
The GIP-P will aim at doing this with higher quality and more cost efficient than would have been possible if the GSPs had to manage their digital results individually. This will be made possible by taking advantage of the large group of experts from the GeoERA partners who will be developing the GIP. These experts have been involved in building information systems for geoscientific data for many years, both at national and at European level. It will furthermore be possible due to the fact that the GIP-P will ensure that data and information will be organised and disseminated in a coherent and standardised way based on state-of-the art database and web technologies. Finally, the development of the platform will be given a jump start as it will be built as an extension to the already existing EGDI platform, thereby saving a very large amount of work.

The project will also aim at making the platform and thereby the results of the GSPs sustainable for a long period of time after the end of the GeoERA programme. This will be achieved by building on the EGDI, which is supported by EuroGeoSurveys (EGS) and by adhering to European and international standards to as high degree as possible. The project will furthermore aim at supporting the establishment of the spatial data infrastructure for Europe by using the existing standards for data exchange like INSPIRE and extending those following the INSPIRE recommendations where necessary. This will be to the benefit of a broad range of stakeholders in the public as well as in the private sector who will be in a better position to get value out of the geological data and information.
Finally, the project will aim at contributing to the establishment of a single access point for European geological information by combining the access to pan-European and cross-border data from GeoERA and earlier projects originating from the huge amount of national and regional data generated and gathered by the Geological Survey Organisations.

Relation to existing programmes and projects

The GeoERA Information Platform (GIP) will be built by extending the European Geological Data Infrastructure (EGDI) to support the work in the GSPs. In the version 1, EGDI was developed in 2016 based on the needs of EuroGeoSurveys (EGS) to provide the technology and know-how to sustainable access to the specific geological data, information and knowledge of the EGS members, and in particular to secure results of already finished European geoscience-related projects performed by the members of EGS (OneGeology-Europe, EuroGeoSource, Minerals4EU, EMODnet, and others). GIP will significantly contribute to the development of the EGDI platform with new data and functionality based on the requirements from GSPs (see Figure 1). The basic operation of EGDI is financed by EGS and is closely connected to the existing 10ocusing10ional set-up of EGS, including the Spatial Information Expert Group (SIEG). The primary responsibilities of SIEG involve the coordination of the INSPIRE Maintenance and Implementation Framework and participation in EU projects.

Figure 1 GeoERA as an extension to the EGDI

EGDI is proposed to serve as the source of geological information to a wide range of users and other platforms, in particular to the European Plate Observing System (EPOS), created as an integrated European research infrastructure for solid Earth sciences, to The European Commission's Raw Materials Information System (RMIS 2), to the European Union Programme Copernicus for satellite and in situ Earth Observations, etc.
The GIP will implement common standards (OGC, INSPIRE, ISO, …) as well as define community standards based on the requirements from GSPs. As several members of the consortium are also participating in relevant panels and working groups like the SIEG, OGC GeoScience Domain Working Group, INSPIRE Thematic Clusters, etc. close contact will be maintained with those during the course of the project in order to ensure the highest possible level of interoperability and accessibility of the results from the GSPs.

Concept and methodology

The overall concept behind the proposed information platform project is to support the overarching GeoERA aim to provide integrated access to data, information, interpretations and models derived from projects within the three GeoERA themes (geo-energy, groundwater and raw materials) in a standards-based and interoperable manner. We would endeavour to build a platform that supports innovation and research across scientific disciplines (within and beyond the themes of GeoERA), societal challenges (energy, raw materials, environment, food, security, health, transport) and sectors (academia, industry, policy) in need of geological data and information. GeoERA Themes share the objective to provide and disseminate spatial information relating to their respective resources and underpinning geological data. Our proposal will create a

common geoscience information platform capable of integrating up-to-date data, interpretations and models from different and distributed sources, both within and across GeoERA Themes. We will utilize sound data management planning and FAIR data management principals to help ensure data assets within the GIP are Findable, Accessible, Interoperable and Reusable.

Our methodology will address the key stated requirements for GIP by including a central database, a web-portal and a digital archive and basing the content and functionality on the requirements from the GSPs. Collaboration will be core to our project ensuring we engage fully across all GeoERA themes to extract their requirements for the proposed platform. We will ensure cross-domain integration and provide facilities for making information available in a user-friendly way for all stakeholders by providing metadata-driven systems for discovering data and data access services. We will ensure future sustainability by aligning with wider EU funded research infrastructure projects (such as EPOS and the European Open Science Cloud) and building on the work of previous projects regarding harmonisation, organisation, exchange and dissemination of geoscientific data. To that end, central to our proposal will be expanding the existing infrastructure provided by the European Geological Data Infrastructure (EGDI). We will provide a better integration of the MICKA metadatabase into EGDI; advance semantic harmonisation through extending vocabularies and linked open data publishing; 12ocusin central storage in combination with access to national/regional data sources; implement a digital archive for holding and publishing unstructured data.
We will demonstrate how information access can be augmented beyond dissemination by providing exemplar research infrastructure functionality that facilitates tailor-made processing and analytical tools to enable science to be undertaken and knowledge derived. The resulting platform will facilitate an improved ability of GSOs to effectively define future actions with regards to improving key knowledge on geo-energy, groundwater and mineral resources, through provision of a sustainable and expandable spatial information framework. It will enable end-users to combine geospatial (2D and 3D) databases, developed in GeoERA or at national/regional level, with other environmental data and information sources. We will establish pan-European and more local (cross-border) databases with a coordinated structure to store raw data, interpretations, and models and enable integration and consolidation. We will develop standards for interoperable cross-border and pan-European scale geological base maps and datasets (including stratigraphic correlation schemes and structural geological definitions) that are valid across different data scales and resolutions. We will register and disseminate metadata including uncertainty about maps, databases, products and services in a user-friendly way facilitating access to data and assess its relevance for particular uses. We will set up services to make data available according to INSPIRE and other standards facilitating the use of data from different sources and thematic areas in combination. This will enable users to address real-world questions such as those concerning competing interests in certain geospatial areas or geological formations. We will build portals with user-friendly functions for search, visualization, analysis and download of data for management as well as research purposes in a regional to Pan European context. Importantly, we will provide training and technical support to both data providers and users.

Our methodology for ensuring the success of cross-thematic integration will be to ensure data providers and end-users alike:

1. have full knowledge of the GIP capability and functionality
2. understand how it can help their science
3. know how to utilize/exploit that capability
4. appreciate and value the benefits it provides
5. have awareness of stepping stones to wider E-Infrastructures

By creating an information platform that aligns and integrates with wider e-infrastructures across Europe and beyond (such as EPOS, EMODnet, Copernicus, European Open Science Cloud, GEOSS) we will open up data from the European geological surveys to be integrated with a wider range of earth science data. Our approach will be to build the information platform in a modular way to produce core components that can be plugged in to other interfaces, initiatives and infrastructures. For example, functionality based on GeoSciML that allows users to query varied geological models and databases to discover what information is held about the Lower Carboniferous might be integrated into EPOS as an ICS-D provided by the European Geological Survey community. We will provide a reusable research infrastructure for geology that can be used in isolation or plugged in to other initiatives helping to secure sustainability into the future and providing a modern data architecture for European geological surveys. Building on the good work already undertaken by the European Geological Surveys on initiatives such as GeoSciML, OneGeologyEurope, and focussing on metadata, standardisation and harmonisation, functionality will be provided that enables cross querying of multiple information sources including geological databases and 3D models and integrating the results into research software on a geologist's desk such as a 3D modelling package. By building on what has gone before in projects such as Minerals4EU, EMODNet, GeoMol and European Geological Data Infrastructure (EGDI), and by aligning with wider European research infrastructures such as EPOS, we will extend current capabilities to support advanced use cases for handling 3D/4D models, parameterized models and uncertainty data and develop and extend 3D-modelling strategies in GeoERA. Our project will conform to data models and standards from INSPIRE, Open Geospatial Consortium (OGC) and the IUGS Commission for the Management and Application of Geoscience Information (CGI).

Our proposal will employ a collaborative approach to ensure the effective integration of spatial information from the other three GeoERA Themes. Our methodology will rely on community building and networking to ensure a successful outcome. GIP will be developed in *cooperation with* users and *for* users. We already have a good network of contacts with many of the GeoERA Theme SRTs who create a pool of users from many science domains represented by the research organisations that will take an active part within GeoERA.

Furthermore, the successful results of the project will be widely disseminated among the interested stakeholders and the geological community as a whole by the project Communication and Dissemination plan.

Ambition

The GIP will provide the tools and infrastructure for the GSPs enabling them to disseminate their results on the platform that will serve as the long-term sustainable geological information system for Europe. This is ambitious but also realistic based on the fact that the GIP will be built as an extension to the existing EGDI platform that has already proved to be robust and well-functioning.
The GIP will, moreover, position itself in the new European landscape of scientific information platforms, ambitioned by the EU through EOSC (European Open Science Cloud) which will help science, industry and public authorities in Europe access world-class data infrastructures and cloud-based services. By design, the GIP will contribute to EOSC by providing access to a wide range of geoscientific data to a large community of users. Based on the vast experience in data management and stewardship collectively held by the partners in this consortium, the GIP will provide FAIR data to a wide range of users (scientists, industry and the public sector).
With the contribution to the project of lead experts in the development of international standards for geoscience (including new developed standards for 3D geology in OGC IUGS/CGI, or cooperation between OGC and W3C), the GIP will guarantee the highest level of semantic interoperability with other disciplines in Europe, as well as with geoscientists from all over the globe. Being positioned as an advanced infrastructure in EOSC, the GIP will facilitate the reuse of geological information in multidisciplinary areas such as climate change.
Through the participation of a large number of European geological survey organisations in the project consortium, best practices and technologies will be shared across Europe, facilitating their implementation at the national as well as regional scale. The connection with the ESFRIs will be developed in particular through the partnership between EPOS and EGS.
At the international scale, the partners are already cooperating with the most advanced projects of the domain such as Auscope in Australia and EarthCube in the USA.
This open and generic platform will also be made available to integrate data from other domains of the geological surveys not covered by GeoERA such as geohazards, geochemistry, earth observations, etc..