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Geosphere Infrastructures for Questions into Integrated Research



D4.1 WP4 Status of research infrastructures at M6



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1 Introduction

WP4 activities focus on the provision of access to data and transnational access to facilities through the following infrastructures: EPOS GIM, EPOS AH, and ECCSEL. The main objective of this work package is to increase the coverage, the use, and number of users of geosource data and facilities by improving access to data services based on European FAIR research infrastructures and supporting curiosity-driven geosource researchers. The content of WP4 is a key element for accessing data products, services, integrated data access, and transnational access with respect to subsurface characterisation. The geoscientific focus will be on geological information and modelling (GIM), anthropogenic hazards (AH), as well as CO₂ capture, use and storage (CCUS).

All data related to this work package is currently, or will soon be, fully integrated into existing research infrastructure services (mainly EPOS and ECCSEL), which are or will be connected to the European Open Science Cloud, further improving their visibility, interoperability, and capacity to contribute to curiosity-driven science. Improving and expanding their use will be achieved by integrating new data and enhancing services, continuously assessing them through user feedback.

Concretely, the objectives of WP4 can be summarized as a set of actions, operations, and services that will improve access to geosource data in line with the scientific objectives of Geo-INQUIRE, in particular:

- Further implement the BoreholeView data model (EPOS TCS GIM) and offer access to complex borehole logs, stratigraphy, etc. in addition to the integration of new boreholes in the neighbourhood of TCS AH Episodes + addition of 3D model metadata (primarily in France, Italy, Spain)
- AH Episodes: (1) extend the multidisciplinary aspects of the TCS AH episodes, and (2) multi-scale approaches with new families of episodes;
- ECCSEL ERIC: Improve the access the experimental lab data at RI level (open data dissemination platform) rather than at lab facility level as it is presently;
- ECCSEL ERIC: Facilitate transnational access to five ECCSEL ERIC lab facilities.
- Training to access the data and services and extend the user communities of the EPOS and ECCSEL RIs and Geological Surveys.

General introduction and explanation of the infrastructures and their installations

Large amounts of geological data are collected, stored, analysed and published by the national Geological Surveys as well as universities and regional/national research centres. Through interpretation and processing of the observation data, the value chain produces information, knowledge and predictive models derived from multidisciplinary sources. These are used to characterise natural processes, locate underground resources and to predict phenomena and



mitigate them. Such tasks require a well-developed data infrastructure that supports cross-domain science.

From this perspective, the European Geological Surveys established over the recent years the European Geological Data Infrastructure (EGDI). Through a series of thematic and data harmonisation projects, European geoscientific data and information are now available from a common location and, complying with widely used interoperability standards. EGDI covers onshore and marine geology, mineral resources, geohazards, energy, groundwater and soils

In the framework of the European Strategy Forum on Research Infrastructure (ESFRI), the European Plate Observing System (EPOS - <https://www.epos-eu.org/>) is a multidisciplinary pan-European research infrastructure for solid Earth science. It is a single and distributed infrastructure that harmonizes and integrates multidisciplinary solid Earth data acquired through diverse scientific systems and disciplines and optimises their open access to make a step change in developing new concepts and tools for innovative research. Formed in 2018, EPOS ERIC now counts seventeen member countries and eleven countries participating to the EPOS integration plan.

EPOS integrates a series of domain-specific service hubs (Thematic Core Service, TCS) such as the Geological Information and Modelling (GIM) and Anthropogenic Hazards (AH). The geological information working group selected a subset of the EGDI data layers to be used as reference knowledge and background by the data and products services of other EPOS thematic groups, such as seismology, near fault observatories and volcanoes. These are (i) the geological map of Europe at 1:1,000,000 scale, (ii) boreholes (geotechnical and scientific drilling, underground water, mineral resources exploration), (iii) 3D/4D geological models and (iv) mines. TCS GIM virtual access services are hosted by a group of European Geological Surveys and a couple of national research organisations.

The borehole data set considered in Geo-INQUIRE WP4 activities includes onshore and offshore drillings made available by the TCS GIM members (over 2.2 million boreholes), and particularly from France (BRGM VA-42-001), Italy (ISPRA VA-42-003) and Spain (CSIC VA-42-004).

Virtual access in WP4 is two-fold: georesources and geohazards. For the latter, the infrastructure includes (i) EPOS Thematic Core Service Anthropogenic Hazards platform (TCS AH/EPISODES - <https://episodesplatform.eu/>), (ii) the three AH-Nodes of EPOS-AH (CNRS-CDPG eNode, IGF PAS eNode and GFZ EPOS AH federated eNode) (iii) other complementary data from other TCSs of EPOS available through EPOS Integrated Core Service (ICS). Thematic Core Service Anthropogenic Hazards mission is to integrate the research infrastructures related to studies of geo-hazards of anthropogenic origin, in particular those caused by the exploration and exploitation of georesources. It relies on specific datasets defined as episodes. An Episode is a set of time-correlated geophysical, technological and other relevant geodata that relates comprehensively anthropogenic seismicity to its industrial cause. Each affiliated user is provided an own workspace where individual data processing and analysis can be carried out using pre-defined applications that relate seismicity and technological factors for hazard assessment and other scientific targets.



WP4 also includes the transnational access (TA) to selected research facilities of the ECCSEL research infrastructure. ECCSEL ERIC, the European Research Infrastructure for CO₂ Capture, Utilisation, Transport and Storage (CCUS - <https://www.eccsel.org/>) is making five of its facilities available for transnational access to the Geo-INQUIRE project. Data from access provided will be made available through the project. Four of the facilities are boreholes in different parts of Europe (France, Italy – mainland, Italy – Sardinia and Norway). They differ in depth, geology, and instrumentation. Typically, there is a central injection well and several monitoring wells located at varying distance around the injection well. At all four locations, it is possible to inject gases (for example CO₂) or liquids (for example H₂O) into the subsurface and do various measurements of the underground behaviour as well as the migration of the injected compound. Own instruments can be tested too, in the measuring wells at the test-sites. The fifth facility from ECCSEL is a mobile seismic grid which can be deployed anywhere in Europe for performing measurements for example at own sites or at any other site. 33 self-contained stations can operate individually or together in an array of flexible size and perform seismic measurements in depths between 100m and 5000m.

ECCSEL itself is a distributed, integrated research infrastructure encompassing interlinked national nodes and facilities. The ECCSEL infrastructure consists of over 90 research facilities. It is a registered legal entity, an ERIC (European Research Infrastructure Consortium) and it is included on the ESFRI Roadmap as a Landmark.

ECCSEL covers research infrastructure across the CCUS value chain, such as:

- Capture: various technologies;
- Storage: pressure/injection, migration, caprock/well integrity, leakage, mitigation/remediation, microseismicity, reactivity/mineralisation, leakage, monitoring, static modelling, dynamic modelling;
- Transport Storage: various areas;
- Utilisation: a broad range of fields.

2 Description of the survey

The survey was conducted between February and March 2023 using LimeSurvey, an open source tool provided to the project by the Helmholtz IT Federated Services (HIFIS). It targeted all 159 individual installations integrated in the Geo-INQUIRE work programme, being mandatory for the 137 directly funded by the project (installations Level 2 and 3). The main goals of the survey were: 1) to validate the status of service provision, improvement and integration plans at the project start; 2) to provide an initial evaluation of metrics and data collection about users, including conformity with the General Data Protection Regulation; 3) to define specific actions for WP6 and 7 towards harmonisation of the Geo-INQUIRE service portfolio

The questionnaire included six mandatory sections about description of the installations and their capabilities, status of service provision, usage of the service and user groups, service availability and



risks. One additional optional section about Key Performance Indicators (KPIs) was also included, in preparation of the deliverables of M12. Most of the questions were structured as single or multiple-choice with open, non-mandatory, free-text comment boxes, to improve efficiency for the respondents and facilitate aggregation for reporting. Information collected through the descriptive sections will be, at least in part, made publicly available in the project website. Installations with similar characteristics, such as nodes of federated services or components of distributed resources, could be grouped to avoid redundant work.

Data were collected anonymously and no personal data of users were recorded. A generic subset of the collected data is presented in this document and the remaining subsets will be used to tailor harmonisation and further FAIR data management activities within the project. Only aggregated information will be made public. Considering the Level 2 and 3 installations (those directly funded by the grant), all of the 137 were able to provide their input, resulting in a coverage of 100%. When considering also Level 1 installations (those receiving support through cross-cutting activities), 147 out of 159 answers were collected, resulting in a coverage of about 92%. In both cases, the number of responses is highly significant and representative of all installations supported by the project.

General statistics about the survey responses – WP4

Installation groups	VA-42-00x	VA-43-00x	TA1-44-x
Responses/installations	3/3	4/4	5/5

3 Status of the research infrastructures at M6

3.1 VA3-42-001 – BRGM EPOS GIM centralised and distributed services

As part of their public service mission, the regional and national geological surveys expose both exploration and commercial boreholes. Most boreholes drilled for the purpose of scientific research are located in areas that are of particular interest for understanding the structure and composition of the subsurface and which are not sufficiently investigated by commercial wells. Therefore, data from scientific drillings are of particular interest for the solid Earth sciences community despite their marginal number. Then, EPOS TCS GIM also provides access to boreholes from the International Continental Scientific Drilling and International Ocean Discovery Programs (ICDP/IODP).

VA-42-001 offers a couple of services to the users, both accessible on the EPOS Data Portal (<https://www.ics-c.epos-eu.org/>):

- The Borehole View Service enables the user to discover and interact on a map with the available boreholes. A click on a Borehole provides the user with a set of descriptors (e.g., depth, purpose, drilling method, availability of borehole logs, link to monitoring equipment, etc.),



- The Borehole Download Service enables the user to search for boreholes matching a set of criteria such as location, and several other properties (e.g., drilling method, core length, access to the physical core, to logs, to water level, etc.).

When code list registries were not available from INSPIRE and/or the Commission for the Management and Application of Geoscience Information of the International Union of Geological Sciences (IUGS/CGI) level, specific entries were added in the European Geoscience Registry.

Each data provider according to the TCS GIM specifications based on a community standard (EPOS-GeoSciML-Lite profile) initially exposes borehole data services. They are in-turn harvested at the TCS GIM central node level hosted by BRGM, France, to populate a Borehole Index. This enables the European consolidation and exposition of very large data sets to EPOS Data Portal. Being a one-stop shop portal, this is the place where FAIR principles and practices are implemented thanks to the adoption of a co-development approach and harmonization actions across communities of developers and data providers. VA-42-001 virtual access includes data sets served by VA-42-003 (ISPRA, Italy) and VA-42-004 (CSIC, Spain).

Hereafter is a complementary description of the virtual access service VA-42-001 as collected through the Geo-INQUIRE dedicated survey. The target user communities include the public administration, industry, land use planners, academic research, non-governmental organisations, citizens, media, and other virtual data infrastructures. There is no logging system to distinguish the unique users. They are presently estimated at 100 to 1,000 per year. There is no authentication on the borehole services. A Data Management Plan is in place at EPOS ERIC level and in progress at BRGM as part of the building of a corporate scientific data repository. All the data and data products provided by TCS GIM borehole service are open. Quality assurance and documentation are provided to the end users describing the data sources and the various parameters made accessible on the portal.

Machine-readable metadata about the service(s) are provided through the EPOS_DCAT_AP but EPOS ICS-C does not yet allow to give external access to the internal content of EPOS_DCAT_AP. Regarding the persistent identifiers, each provider assigns a unique URI to each borehole instance served by the Borehole Index. The borehole data and data products are accessible under CC BY 4.0 license. The versioning of the data itself is not tracked. The TCS GIM plans to track the versions of the data model specification in line with the evolution of the concerned international data specification standard, i.e. OGC GeoSciML, which is documented. User support is provided on line through a dedicated documentation available on EPOS Data Portal.

3.2 VA3-42-003 – ISPRA EPOS GIM centralised and distributed services

The virtual access service delivered by ISPRA, Italy, consists of harmonised stratigraphic, lithological, structural and chronostratigraphic data derived from the logs of approximately 1,000 deep boreholes for oil exploration conducted in Italy onshore and offshore, free of industrial concessions.

Deep borehole service enables stratigraphic and structural correlation analyses for three-dimensional subsurface reconstructions aimed to stratigraphic-structural studies, evaluation of



subsurface resources and for CO₂ capture studies. Deep borehole data are initially delivered in Geography Markup Language (gml) or GeoPackage (gpkg) formats. As described for the central node VA-42-001, the virtual access service of Italian borehole data uses the GeoSciML-Lite data model developed by the EPOS TCS GIM community as an extension of OGC GeoSciML. It is a basic model, aligned to INSPIRE, for data exchange in geology.

A first level of virtual access to the borehole data is provided by the Geological Survey of Italy web map portal and on the INSPIRE geoportal. After conversion using GeoSciML-Lite, the data is exposed for harvesting by the TCS GIM European Borehole Index made accessible on the EPOS Data Portal (<https://www.ics-c.epos-eu.org/>).

The service is oriented to a target population composed by researchers, technicians, scientists, data management users and private companies. Presently, there is no monitoring to check data accesses. However, it is estimated in the range of dozens per month.

An ISPRA management plan will provide for the harmonisation of lithological, chronostratigraphic and structural data derived from the boreholes log using the INSPIRE vocabulary. Then, we will perform the transformation and validation towards the INSPIRE data model. The harmonised result will be produced in gml formats for validation in the INSPIRE geoportal and in other formats for reuse, such as WFS, GeoPackage, OGC API. All data will be released under a CC BY 4.0 license.

3.3 VA3-42-004 – CSIC EPOS GIM centralised and distributed services

CSIC (IGME-Geological Survey of Spain) holds a national core repository managing the descriptive data of more than 12,000 boreholes. Drilled mainly onshore, they come from oil industry, mining, hydrogeological and geological exploration. The virtual access service is presently not operational. When available, it will expose borehole records (view and download) as main descriptive data and metadata as depth, availability of logs/samples, location, basic drilling description, research subject. The service will offer useful data for subsurface studies in the fields of hydrogen/CO₂ storage; mineral/energy resources, 3D geology. The services will comply with EPOS TCS GIM GeoSciML-Lite data model. Similarly to VA-42-003, the Spanish borehole data will be both accessible on IGME national map portal and harvested to populate the European Borehole Index made accessible on the EPOS Data Portal (also refer to VA-42-001).

Although the expected virtual access is not yet available as such, the core-repository data set is partially available online through the IGME institutional website. However, no distinguished users can be identified as an authentication system is not in place. The data content is publicly available under license. When operational, 100 to 1,000 users per year are expected. The service will be used by academia, public and private research institutes, industry and governmental/ non-governmental organisations, citizen and other virtual infrastructures.

The IGME institutional web page provides open data access to several fields of the national core database. No evaluation of FAIRness of the data and/or data products and/or software has been conducted so far. Open data in compliance with the FAIR principles will be a must in the future virtual access implementation. Presently, the core data sets are accessible under license based on



national rules https://www.igme.es/Ayuda/LicUsoIGME_GENERICA_EN_2022.pdf equivalent to CC BY 4.0. Support to the users is provided on demand through email. Data Management Plan will be implemented along with the setting-up of the virtual access.

3.4 VA3-43-001 – CNRS EPOS AH federated node

The CNRS eNode for the TCS-AH platform provides Episodes metadata and data to the EPISODES platform (<https://episodesplatform.eu/>). It is located at EOST (Ecole et Observatoire des Sciences de la Terre – Strasbourg, France). Provided episodes are related to deep geothermal energy (EGS) site located in Alsace, France. They consist of seismological data (catalogues, waveforms, source mechanisms, etc.); industrial data (pressure, injection rate, etc.); other related geophysical data (seismic profiles, GNSS monitoring, velocity models, etc.).

There are two types of usage of the CDGP infrastructure. On the one hand, it provides episodes metadata and data to the EPISODES platform through web services with limited access to the administrators of the EPISODES platform. On the other hand, the eNode is also directly accessible publicly at <https://cdgp.u-strasbg.fr/> as a data center for deep geothermal energy (CDGP – Centre de Données de Géothermie Profonde). CNRS eNode is not directly connected to the EPOS Data Portal but its Episodes are accessible on the portal (<https://www.ics-c.epos-eu.org/>) through the AGH EPOS AH centralised and distributed services. Also refer to VA-43-004).

The users are scientists, industry operators and the general public with interest in anthropogenic hazards, and/or deep geothermal energy. Less than 100 users have been identified. 20 to 50% of the data sets are restricted to academic scientists using an AAI (Authentication, Authorization, Identification) infrastructure.

The CNRS eNode complies with a Horizon 2020 FAIR DMP (Data Management Plan). CC BY-NC licences are assigned to the open data. Access restrictions are set by data owners. The FAIRness evaluation is done using CoreTrustSeal requirements (<https://www.coretrustseal.org/>). DOIs are attached to each dataset (episodes) which provide persistent identifiers.

3.5 VA3-43-002 – IGF PAS EPOS AH federated node

IGF PAS eNode for TCS-AH platform provides virtual access to data on the EPISODES Platform (TCS-AH). Geographically located in Poland, Warsaw (backup in Krakow, Poland). A bespoke software, CIBIS, is installed on the eNode, that manages data: seismic, industrial, geophysical, and geological along with the appropriate metadata. The service can be reached at the following URL: <https://cibis3.igf.edu.pl/>. Data provided to the EPISODES Platform are available at <https://episodesplatform.eu/>.

IGF PAS eNode is not directly connected to the EPOS Data Portal but its Episodes are accessible on the portal (<https://www.ics-c.epos-eu.org/>) through the AGH EPOS AH centralised and distributed services. Also refer to VA-43-004.



The target community for the eNode itself are admins and data management users. There are no unique users as access is denied for anonymous logins and users can be only assigned by admins. The total number of users is less than 10.

The role of the eNode is to provide machine-readable data and metadata. The CIBIS software is equipped with an internal Quality Control mechanism that does not allow publishing data without a complete set of metadata, checked against previously established rules. Moreover, Quality Control software, Redmine, is being used to manage consecutive updates of data. The versioning mechanism is provided for metadata. In addition, CIBIS has a built-in versioning mechanism for single files. Data stored on the eNode is 100% restricted and controlled, however, data on the EPISODES Platform is not. By its nature, the EPISODES Platform provides open access to data. Only a small amount of data is limited to scientific users (every user can apply for 'Researcher' status and then they are verified by TCS AH Team). FAIR principles are not applicable to the eNode as it provides access to the raw data. However, the EPISODES Platform is actively implementing FAIR principles. Every dataset is supplied under the individual Supplier Letter - a written agreement with the Data Provider.

3.6 VA3-43-003 – GFZ EPOS AH federated node

GFZ EPOS AH federated eNode for TCS-AH EPISODES platform is under development. It will provide access to data/metadata via the EPISODES Platform (cf. VA-43-004). The data and metadata will be stored at GFZ Potsdam, Germany. The eNode is merely a backend that will allow for data upload, metadata and data management by designed data administrators and serve the data and metadata to the external client (EPISODES Platform). The GFZ eNode is specifically designed as a new data service infrastructure to integrate induced seismicity data related to hydraulic stimulation and mining-induced seismicity at different scales (Task 4.3 of WP4 of Geo-INQUIRE project).

Data administrators are the GFZ eNode's primary target community. As access is blocked for anonymous logins and users can only be assigned by admins, there are no distinct/direct users. It is expected no more than 10 data administrators will have an access to the eNode at GFZ. The primary eNode's function is to deliver data and metadata that is machine readable which will be achieved by using the CIBIS software provided by IGF PAS. A quality control mechanism built into the CIBIS software prevents posting of data without a complete set of metadata that has been compared to previously agreed standards. For metadata, a versioning mechanism is offered. In addition, CIBIS includes a versioning system for single files. The eNode will offer access to the raw data, hence FAIR principles are not relevant (these are secured by GFZ eNode client, which is EPISODE Platform (cf. VA-43-004). All data stored by GFZ eNode are properties of the GFZ Section 4.2 Geomechanics and Scientific Drilling and they will be provided as open-access. The current progress of data integration can be viewed via established discord server #[1048177284839919626](https://discord.com/invite/1048177284839919626).



3.7 VA3-43-004 – AGH EPOS AH centralised and distributed services

EPOS AH centralised and distributed services are constituted by the EPISODES Platform (<https://EpisodesPlatform.eu/>), which integrates the research infrastructure of EPOS TCS AH (<https://tcs.ah-epos.eu>). The Platform provides access to Episodes - complex datasets, Applications - software solutions providing means for advanced data analysis and visualisation, Workspace - user's private space for storing data and running applications, and extensive Document Repository. Episodes are time-correlated encapsulated collections of both geophysical data (representing geophysical processes), technological data (representing technological activity, which is the cause of the geophysical process), and all other relevant geo-data describing the environment. The EPISODES Platform applications are services uniquely designed for the analysis of correlations between technology, geophysical response, and the resulting hazard that may be executed in High Performance Computing (HPC) environments.

The data is not directly stored on the EPISODES Platform but provided by the federated nodes: CNRS EPOS AH federated node (VA-43-001), IGF PAS EPOS AH federated node (VA-43-002) and GFZ EPOS AH federated node (VA-43-003)¹. The nodes provide the data exclusively to the Platform, therefore, they are not responsible for managing the users or access control². The EPISODES Platform stores metadata describing all data from the nodes, which enables the data discovery. Only the data uploaded by the users is stored on the Platform, but they are not visible to the public or other users (unless they are shared by the owner).

The platform enables data products download and sharing: the data products are results of running the EPISODES Platform applications – custom software integrated within the Platform or software created by the users.

The EPISODES Platform is accessible on-line at <https://EpisodesPlatform.eu/>. A read-only access to most of the data is available for all visitors, while downloading data or using the applications is provided only to registered users. Some of the data are restricted to certain user groups - e.g. academia (the restrictions are specified by the federated nodes, only the access control is realized on the platform). All registered users must accept the [Platform's privacy policy](#) and have possibility to remove all their data. The portal logs do not contain any sensitive user information (they are anonymized).

The EPISODES Platform serves a total number of over 1,600 users from 60 countries, affiliated with over 380 institutions. The users usually come from academia, education institutions and industry. The data from the EPISODES Platform are also provided to the EPOS Data Portal (<https://www.ics-c.epos-eu.org/>) and available to its users through Anthropogenic Hazards virtual access services.

¹ The GFZ EPOS AH federated node (VA-43-003) is not yet operational, but when it is, it will be plugged in in the same way as the other nodes.

² The access control is the responsibility of the platform, however, the restrictions of the data visibility, if any, are specified by the nodes through metadata.



The EPISODES Platform is actively implementing FAIR principles. All the data integrated within the Platform have to pass [quality control](#). Episodes are assigned DOIs and have information about the owner of the data and how to cite the usage. The data restriction policies, data management plan, licences, as well as responsibility for ensuring their availability is on the data providers - the federated nodes (CNRS EPOS AH federated node, IGF PAS EPOS AH federated node and GFZ EPOS AH federated node). An exception to this rule is the data uploaded by the users to their private workspace and visible only to them. These data are stored directly on the EPISODES Platform and are subject to regular backups.

4 TA provision at WP4

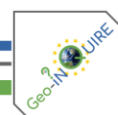
Transnational Access to all ECCSEL facilities is in the first-place physical access. A researcher travels to the facility location after their project proposal has been selected in the project's peer review procedure for conduction their research. At the facility they receive the typical technical and scientific support required for successfully conduction their research. An exception is TA1-44-5 which is transported and deployed at any site in Europe. Here the necessary scientific and technical support will come with the facility deployed.

4.1 TA1-44-1 – Svelvik CO₂ Field Lab

ECCSEL Svelvik CO₂ Field Lab is a unique lab for development and testing of methods for quantitative monitoring of CO₂ storage. The lab fills the gap between bench-scale and pilot-scale experiments allowing rapid and cost-efficient research and field testing of new methods and technologies. The lab is situated in a glaciofluvial-glaciomarine Holocene environment and has an injection well and facilities for injection of either water or CO₂ in a screened interval at 64-65 m depth. The injection well is surrounded by four monitoring that are completed with PVC casing and instrumented behind the casing with:

- capillaries for pore pressure measurements at three different depths, including the injection depth,
- capillaries for water sampling at the depth of injection,
- sensors measuring pressure and temperature at the depth of injection,
- electrodes for electrical resistivity tomography (ERT),
- commercial fibre optic cables from SOLIFOS: Straight DTS (Distributed Temperature Sensing), DSS (Distributed Strain Sensing) and DAS (Distributed Acoustic Sensing),
- fibre optic cables provided by Lawrence Berkley National Laboratory (LBNL): Straight (DSS and DAS) and helical (DSS and DAS).

In addition, the interior of each monitoring well is available for non-permanent monitoring equipment like seismic P- and S-wave borehole sources used together with 3C borehole receivers or hydrophone chains, creating high resolution seismic cross-well data sets. Seismic sources are



available at the site. The inside of the wells will also be available for development and testing of future monitoring systems.

The lab is mainly accessed physically, but access to basic operational information is also remotely accessible.

Mandatory support (see below) for operation of the site's injection facilities will be provided by SINTEF and costs for such personnel is provided as part of the TA provision.

In total, 4 weeks of access to the resources described above will be provided in the period 10.23 – 10.25. Publication of calls will be coordinated via ECCSEL with two calls per year. It is likely that the 4 allocated weeks is only sufficient for a single TA provision, but in case of smaller-size experiments, the allocated funding may be sufficient for more. In the budget there are no costs for travelling, which will have to be taken from other budget items from the project or paid for by the user.

Special needs of the TA installations (with respect to organisation of TA)

HSE (health, safety and environment) instructions are necessary in order to minimise operational risks. One experienced person from SINTEF will always be present as the on-site HSE manager. Only trained SINTEF personnel are allowed to operate the injection infrastructure. Most important risks are related to handling of equipment brought by external users and possible CO₂ leakages from the CO₂ tank and injection system. Users must adapt to local security and HSE instructions.

Legal issues: Access to the labs of SINTEF is dependent on compliance to all relevant procedures and policies of the institute relating to HSE and protection of the intellectual property.

4.2 TA1-44-2 – PITOP

PITOP offers both physical and remote access, providing a website (<https://pitop.ogs.it>) compliant to the FAIR principles where water table levels and gases measurements in the well are available to the download. Soon the weather station's data will be included as well. Internet connection is provided. User support for TA is not available for travel and subsistence costs, but PITOP is providing technical assistance in situ, for the use of instrumentation and logistics.

In the period 10.23 – 10.25 we can provide 4 to 5 accesses (depended on project's TA budget availability).

The resources accessible to the user are:

- Possibility to perform seismic measurements in well/at surface,
- Sensors cemented in well (geophones, DAS),
- DAS (Distributed Acoustic Sensing) for surface seismic acquisitions,
- Seismic sources (P and S waves),
- Seismic nodes and telemetric system,
- Geoelectrical instrumentation,
- Water table level, gases and weather station's measurements.

PITOP is available to evaluate requests and satisfy them by meeting the needs of the user as far as possible .



Special needs of the TA installations (with respect to organisation of TA)

Considering the type of services available in the site, if instrumentation testing is proposed, it is important to know in advance the type of instruments, weight, dimensions, and the support tools needed (e.g. crane, trellis, special energy supply and all the necessary safety and security information).

4.3 TA1-44-3 – Sotacarbo Fault Lab

The Sotacarbo Fault Lab is designed to study gas migration processes in faults and to test a wide range of monitoring technologies. The facility is based on a borehole to inject small amounts of CO₂ near and through a selected fault located in Matzaccara (SW coast of Sardinia, Italy). The facility includes a system for CO₂ compression and temporary storage and a wide network of piezometers for monitoring the groundwater. Several vertical observation wells have been drilled in order to collect reliable data on CO₂ diffusion process.

The research facility requires currently physical access. On site, full scientific and technical user support is provided. Travel and subsistence costs of the visiting researchers are not included in the transnational access budget.

The amount of access provided in the period (10.23 – 10.25 with last call opened in 04.25) depends on funding availability in Geo-INQUIRE, but budget allows for at least one access.

The site will be fully accessible from after the summer 2023 once upgraded equipment is installed and fully tested.

4.4 TA1-44-4 – CATLAB

CATLAB is an injection site in underground environment with controlled conditions and in situ measurements devices, coupled with advanced laboratory facilities at Ineris to study gas-water-rock interaction. Located 20 km from Ineris, the injection site can easily be operated and monitored. For most experiments, at least a month is necessary to prepare the injection (or push-pull). Besides the in-situ measurement, dedicated samplings and lab measurements can be carried out. The facility requires physical 'in person' access. Up to 2 accesses can be provided in the period 10.23 – 10.25 (in spring or early summer). Full scientific and technical user support is provided by Ineris. Travel and subsistence costs of the visiting researchers are not included in the transnational access budget.

Special needs of the TA installations (with respect to organisation of TA)

Instructions are necessary in order to reduce operational risks. Experienced persons from Ineris will always be on-site. Only Ineris personnel are allowed to operate the site infrastructure. Most important risks are related to handling of equipment and possible CO₂ leakages from the CO₂ tank and injection system. Users must adapt to local security and HSE instructions.

Legal issues: Access to the labs of Ineris is dependent on compliance to all relevant procedures and policies of the institute relating to HSE and protection of the intellectual property.



4.5 TA1-44-5 – MOBSEIS

The MOBSEIS array currently consists of 64 seismic nodes holding 3-component accelerometers plus communication, power and acquisition infrastructure. The nodes can individually be placed and once turned on will record acceleration/seismicity. The MOBSEIS array can be used in passive seismic campaigns lasting weeks or even month as well as active seismic campaigns where relocation of the nodes happens much more frequently. They can be deployed anywhere in the world.

The nodes have internal power which lasts 2 days. The nodes come with external batteries, which depending on conditions and use can last up to 2 weeks. Beyond that charging or an external power supply (12V) is required.

The nodes have internal memory which depending on the sample rate can store up to 12 days of data. The data can be retrieved via a wifi connection. Common use is to mount an industrial grade antenna on a pole, giving up to 1km range (in 360deg). Another possibility is to visit the nodes with a tablet like field computer to “pull” the data via wifi. Once the memory of the nodes is full the oldest data will be overwritten with new seismic data.

Access to the MOBSEIS array can be remote (via the internet) and physical (on site)

Support can be provided for mobilisation, operation, demobilisation, processing and interpretation of the results. On- as well as offsite.

Travel and subsistence costs of the visiting researchers are not included in the transnational access budget. The amount of access provided in the period (10.23 – 10.25 with last call opened in 04.25) is dependent on funding availability in Geo-INQUIRE, but at least one access is to be provided during the project.

Special needs of the TA installations (with respect to organisation of TA)

Need to be shipped to deployment site.

5 Final considerations

As far as the EPOS GIM services are concerned (VA-42-001, VA-42-003, VA-42-004), the survey designed and conducted at this early stage of the Geo-INQUIRE project is representative of the present situation. The centralised view and download services are operational and CSIC borehole assets using the standards and procedures established by the GIM community will complete the data content. Regarding the KPIs, those about data holdings (number and volume of providers’ data sets) can already be described. However, GIM services depend on the EPOS Data Portal ICS-C (Integrated Core Services-Central) for monitoring the knowledge and number user requests as well as the volume of data shipped through the portal. Then, any progress from EPOS ICS-C will benefit to the EPOS TCS services. As on date, no reduction of service availability and access are expected in



relation to the increase of energy and salary costs consequently to the recent evolution of the complex geo-political and post-pandemic situation. However, this will be monitored and updated over the project lifetime.

As AGH EPOS AH centralised and distributed services (VA-43-004) is strictly connected to CNRS EPOS AH federated node (VA-43-001), IGF PAS EPOS AH federated node (VA-43-002) and GFZ EPOS AH federated node (VA-43-003) - the latter services are data providers to the former – it would be more representative to have single survey for all the four services as a whole. None of these four installations anticipates a reduction of service availability and access in relation to the recent increase of energy and salary costs.

Regarding the ECCSEL TAs, the survey was seen as representative enough from a general perspective. However, it is worth noting that the survey questions were mainly focussed on the provision of data and virtual access and not so much on physical in-person transnational access. The definition of a service differs for data, virtual and physical access. In addition, several facilities were in the early stage of providing open access to data, whereas other ones have been doing that for several years.

For the ECCSEL facilities, some of the KPI's are new, with no available baseline. For example, the Ineris facility has not had any external users accessing the platform so far. Again, some KPI's are less relevant for physical access. Research data is planned to be made available through EPOS and therefore it is foreseen that some of the KPI' are measured directly at EPOS level. For ECCSEL facilities it will be difficult to differentiate between some of the measured categories due to the nature of access. Other KPI's are dependent on the application procedure deployed by Geo-INQUIRE and data will be collected there. ECCSEL facilities will try to implement as many of the KPI's as possible from M12.

As for the potentially increasing costs as a result of increase of energy and salary costs triggered by the geo-political and post-pandemic situation, it is clear that the physical access to research facilities is more sensitive to cost increases. Costs of travel, accommodation, subsidence, costs for consumables and energy costs have risen and salary costs have increased. The level of impact however is different from one facility to another.



Appendix 1 – List of Installations, hosting organisation and their description

Installation name	ID	Hosting Institution	URL
BRGM EPOS GIM centralised and distributed services	VA3-42-001	BRGM	EPOS-GIM: https://www.ics-c.epos-eu.org/ View service direct access: https://data.geoscience.earth/api/wmsBorehole Download service direct access: https://data.geoscience.earth/api/wfsBorehole
<p>Description: BRGM hosts both the EPOS-GIM centralised borehole service and the French borehole data service as being one of the national nodes of EPOS-GIM. The centralised service results from the harvesting of onshore and offshore borehole data. Presently, they include national data exposed by a group of seven European Geological Surveys, as well as a regional set of boreholes in Germany and drillings from the International Continental Scientific Drilling and International Ocean Discovery Programs (ICDP/IODP). Presently, 2.2 million boreholes are proposed with general data publicly accessible including: depth, drilling method, availability of borehole logs, and link to monitoring equipment.</p>			
<p>Target community/ Users: Public administration, industry, land use planners, academic/research, citizens, other virtual data infrastructures / 100 to 1,000</p>			
<p>Community Standards: The data follows the community standards: EPOS-GeoSciML-Lite, an extension of OGC GeoSciML</p>			

Installation name	ID	Hosting Institution	URL
ISPRA EPOS GIM centralised and distributed services	VA3-42-003	ISPRA	https://data.geoscience.earth/api/wxsBorehole
<p>Description: This virtual access service consists of harmonised stratigraphic, lithological, structural and chronostratigraphic data derived from the logs of approximately 1,000 deep boreholes for oil exploration conducted in Italy onshore and offshore, free of industrial concessions. A first level of virtual access to the borehole data is provided by the Geological Survey of Italy web map portal and on the INSPIRE geoportal. After conversion using GeoSciML-Lite, the data is exposed for harvesting by the TCS GIM European Borehole Index made accessible on the EPOS Data Portal. Also refer to VA-42-001.</p>			
<p>Target community/ Users: Researcher/technician, scientists, data management users.</p>			
<p>Community Standards: GeoSciML-Lite</p>			



Installation name	ID	Hosting Institution	URL
CSIC EPOS GIM centralised and distributed services	VA3-42-004	CSIC	https://www.igme.es/
<p>Description: CSIC (IGME-Geological Survey of Spain) holds a national core repository managing the descriptive data of more than 12,000 boreholes. Drilled mainly onshore, they come from oil industry, mining, hydrogeological and geological exploration. The virtual access service is presently not operational. When available, it will expose borehole records (view and download) as main descriptive data and metadata as depth, availability of logs/samples, location, basic drilling description, research subject.</p>			
<p>Target community/ Users: Academia, public and private research institutes, industry and governmental/ non-governmental organisations, citizens and other virtual infrastructures.</p>			
<p>Community Standards: GeoSciML-Lite when operational</p>			

Installation name	ID	Hosting Institution	URL
CNRS AH EPOS federated node	VA3-43-001	CNRS	https://cdgp.u-strasbg.fr
<p>Description: CNRS eNode for TCS-AH platform provides virtual access to deep geothermal data on the EPISODES Platform (TCS-AH). Located in Strasbourg, France. It provides metadata to the Episodes platform, and data in the specific format required by the platform.</p>			
<p>Target community/ Users: Academia, public and private research institutes, industry and governmental/ non-governmental organisations, citizens.</p>			
<p>Community Standards: mseed, station XML, quakeML</p>			

Installation name	ID	Hosting Institution	URL
IGF PAS AH EPOS federated node	VA3-43-002	IGF PAS	https://cibis3.igf.edu.pl/
<p>Description: IGF PAS eNode for TCS-AH platform provides virtual access to data on the EPISODES Platform (TCS-AH). Geographically Located in Poland, Warsaw (backup in Krakow, Poland). A bespoke software, CIBIS, is installed on the eNode, that manages data: seismic, industrial, geophysical, and geological along with the appropriate metadata.</p>			



Installation name	ID	Hosting Institution	URL
Target community/ Users: The target community for the eNode itself are admins and data management users. There are no unique users as access is denied for anonymous logins and users can be only assigned by admins.			
Community Standards: mseed, station XML, quakeML			

Installation name	ID	Hosting Institution	URL
GFZ AH EPOS federated node	VA3-43-003	GFZ	N/A
Description: GFZ EPOS AH federated eNode for TCS-AH platform will provide access to new data to the EPOS TCS AH EPISODES Platform, and a back-end for data and metadata administrators at GFZ Potsdam.			
Target community/ Users: Data and metadata administrators.			
Community Standards: miniseed, station XML, quakeML			

Installation name	ID	Hosting Institution	URL
AGH AH EPOS centralised and distributed services	VA3-43-004	AGH	https://episodesplatform.eu
Description: EPOS AH centralised and distributed services are constituted by the EPISODES Platform, which integrates the research infrastructure of EPOS TCS AH. The Platform provides access to Episodes - complex datasets, Applications - software solutions providing means for advanced data analysis and visualisation, Workspace - user's private space for storing data and running applications, and extensive Document Repository.			
Target community/ Users: Scientists, industry, general public, education			
Community Standards: mseed, station XML, quakeML			



Installation name	ID	Hosting Institution	URL
Svelvik CO ₂ Field Lab	TA1-44-1	SINTEF	https://eccsel.org/catalogue/143

Description: Svelvik CO₂ Field Lab is a small-scale laboratory in an easily accessible geological environment, which fills the gap between bench laboratory experiments and pilots. Due to its size, the controlled environment, and the potential of repeatable experiments, the field laboratory provides excellent possibilities to perform rapid and cost-efficient development and testing of CO₂ monitoring methods and equipment.

The laboratory is established in the glaciofluvial-glaciomarine Holocene deposits of the Svelvik ridge and occupies a non-active part of a sand and gravel quarry in the outer part of Drammensfjorden, about 50 km south-west of Oslo in Norway. Down to approximately 30 m, the test site consists of unconsolidated to weakly consolidated sand. Below, rather heterogeneous, and interlayered sand, silt and clay layers in varying proportions exist, displaying a large span of porosity and permeability.

The field laboratory consists of an injection well and four monitoring wells. The injection well is designed for injecting water and/or CO₂ at 64-65 meters depth. Tracers may be added to the CO₂ stream. The four monitoring wells are 100 m deep and positioned at the corners of a rhombus with the injection well (#2) in the centre. The monitoring wells are located 9.9 m (M3 and M4) and 16.5 m (M1 and M2) from the injection well.

State of the art: Svelvik CO₂ Field Lab enables cost-efficient studies of quantitative CO₂ monitoring methods and technology where high-quality data can be acquired under controlled conditions; where pressure and CO₂ saturation can be varied independently; where a cross-well setup yields clean data undisturbed by "outside" or surface effects; and where experiments are repeatable as CO₂ is not stored permanently in the subsurface. Svelvik CO₂ Field Lab is unique as no other test sites can offer this combination.

Areas of research at Svelvik CO₂ Field Lab include different aspects related to CO₂ monitoring and leakage detection:

- Development and testing of seismic and non-seismic techniques
- Quantitative CO₂ monitoring including pressure and saturation determination
- Fibre optic-based monitoring including testing of new cables, interpretation of recorded signals, and comparison with conventional methods
- Surface detection methods for CO₂ leakage
- Testing tracers for CO₂ storage and leakage detection

Instrumentation of monitoring wells

The monitoring wells are completed with PVC casing and instrumented behind the casing with:

- Capillaries for pore pressure measurements at three different depths, including the injection depth
- Capillaries for water sampling at the depth of injection
- Sensors measuring pressure and temperature at the depth of injection
- Electrodes for electrical resistivity tomography (ERT)
- Commercial fibre optic cables from SOLIFOS: Straight DTS (Distributed Temperature Sensing), DSS (Distributed Strain Sensing) and DAS (Distributed Acoustic Sensing)
- Fibre optic cables provided by Lawrence Berkley National Laboratory (LBNL): Straight (DSS and DAS) and helical (DSS and DAS).

The interior of the wells is available for non-permanent monitoring equipment as the permanent instrumentation has been installed behind the casing. For instance, seismic P- and S-wave borehole sources may be used together with 3C borehole receivers or hydrophone chains, creating high resolution seismic cross-well data sets. The collocation of conventional seismic receivers and DAS cables will provide additional opportunities for the development and testing of fibre optic cables and processing techniques for this type of data. The inside of the wells will also be available for



Installation name	ID	Hosting Institution	URL
development and testing of future monitoring systems.			
<p>Fibre optic cable installation</p> <p>The commercial fibre optic cables are thin and flexible and could therefore be installed in a continuous loop through all four wells without splicing. Terminated ends are located inside an instrument cabin. While the DTS cable consists of four multi-mode fibres; two 50 mm and two 62.5 mm fibres, the DSS and DAS cables are composed of one and four single-mode fibres, respectively.</p> <p>The straight cable from Lawrence Berkeley National Laboratory is a standard tactical fibre cable, whereas the helical cable is constructed using optical fibres wound at a 30° angle on a low durometer central mandrel. Both cables are relatively thick and stiff and had therefore to be cut off at the well-ends. To facilitate looping comparable to the commercial cable installations, the fibres inside the cables were spliced at the well-ends, creating down- and upgoing branches, connected at the well bottom. The cables will be looped in a future project.</p> <p>Scientific Environment</p> <p>Skilled scientists and technicians are available to assist visiting researchers, both on-site and remotely. One experienced person from SINTEF will be on-site as the on-site HMS manager during the project execution. Only trained SINTEF personnel are allowed to operate the injection infrastructure.</p> <p>SINTEF has implemented and maintains a quality management system that fulfils the requirements of the standard NS-EN ISO 9001:2008 within research and development in materials technology, advanced materials and nanotechnology, applied chemistry and biotechnology, oil and gas, and green energy and process industry.</p> <p>Areas of Research:</p> <p>Research Fields: Geology/Geophysics, Mechanics/Geomechanics, Remote sensing, Monitoring, Modelling</p> <p>STORAGE technologies: Pressure/injection, Migration, Caprock/well integrity, Leakage, Monitoring</p>			
<p>Target community/ Users: scientific and industrial communities</p>			
<p>Community Standards: NS-EN ISO 9001:2008 (quality management system)</p>			

Installation name	ID	Hosting Institution	URL
PITOP	TA1-44-2	OGS	https://www.eccsel.org/catalogue/126 https://pitop.ogs.it
<p>Description: The site was designed and developed with the aim of providing a facility for the study and testing of geophysical methods, technologies, and well/surface tools under realistic conditions.</p> <p>The site is equipped with permanent laboratories for the acquisition of geophysical data and provides four wells of different depths (max. 450 m) and different diameters. The wells are cemented, two at the bottom-hole and two up to 250 m with a further 150 - 180 m of uncovered hole. One of the wells offers the possibility of being further drilled, offering the possibility of performing seismic while drilling (SWD) experiments. Two wells are equipped with permanent sensors (geophones and DAS (Distributed Acoustic Sensing)), cemented in the casing, for geophysical measurements. Buried in a</p>			



Installation name	ID	Hosting Institution	URL
<p>trench about 50 cm deep, two orthogonal lines of fiber optic cables (DAS) were deployed to test this innovative technology in seismic data acquisitions.</p> <p>There are sensors in well for measuring gases (CO₂ and radon) and a piezometer for measuring the height of the water table and other environmental parameters, including electrolytes. The data comply with the FAIR data policy (Findable Accessible Interoperable Reusable), being available and downloadable online at https://pitop.ogs.it.</p> <p>A weather station has been installed and its data will soon be available online.</p> <p>Thanks to the opportunity offered by the PNRR (National Recovery and Resilience Plan), PITOP will be further enhanced with the purchase of new equipment. DAS fiber optic cables and their new generation interrogator were purchased, which will allow the acquisition of seismic data with a better signal/noise ratio, high sensitivity, and high spatial sensor density.</p> <p>A new wireless system for electrical tomography at great depths was purchased: the 3D wireless IRIS Instruments Full Waver, which will make it possible to obtain highly reliable images. Furthermore, an array of electrodes will be cemented in a planned new well 250 m deep, and another array will be used for investigations up to 450 m, making surface-to-well and cross-hole investigations possible between wells</p> <p>Areas of Research:</p> <p>Research Fields: Geology/Geophysics, Mechanics/Geomechanics, Monitoring, Modelling</p> <p>STORAGE technologies: Pressure/injection, Migration, Caprock/well integrity, Microseismicity, Static modelling, Dynamic modelling, Monitoring</p>			
<p>Target community/ Users: scientific and industrial communities</p>			
<p>Community Standards: YES</p>			

Installation name	ID	Hosting Institution	URL
Sotacarbo Fault Lab	TA1-44-3	SOTACARBO	https://eccsel.org/catalogue/168
<p>Description: The Sotacarbo Fault Lab is designed to study gas migration processes in faults and to test a wide range of monitoring technologies. The facility is based on a borehole to inject small amounts of CO₂ near and through a selected fault located in Matzacara (SW coast of Sardinia, Italy). The facility includes a system for CO₂ compression and temporary storage and a wide network of piezometers for monitoring the groundwater. Several vertical observation wells will be also drilled in order to collect reliable data on CO₂ diffusion process. The purpose of the research is to better understand gas migration along the faults (via observations and fluid flow modelling), to improve monitoring technologies and to develop a protocol to define the fault permeability to gas migration. This infrastructure will include a 200 m deep vertical injection borehole, 7 shallow piezometers / monitoring wells, a 200 m deep vertical monitoring well, and the CO₂ injection system. Leakage through the faults will be characterized (discrete vents vs. diffuse leakage at the surface, continuous vs. intermittent). In order to develop a monitoring strategy, a good understanding of the impact of CO₂ injection in the aquifer must be developed. A toolbox, based on water-gas-rock interaction on the potential reactivity of CO₂ within a potable aquifer, will be tested on these sites. The effectiveness of this tool will be validated in the field. It will identify the geochemical changes to be expected and therefore steer the definition of the groundwater</p>			



Installation name	ID	Hosting Institution	URL
<p>geochemical monitoring strategy by highlighting the most sensitive parameters to monitor. Geophysical measurements will be undertaken using downhole tools and surface techniques, to examine if the migration of CO₂ along the fault and its proximity can be tracked. Seismic techniques will include borehole measurements using wireline and cross well applications. These will be integrated and compared with other geophysical and well results, such as electric and electromagnetic logs and surveys, to demonstrate the most effective integrated geophysical approaches for monitoring CO₂ migration. The Sotacarbo Fault Lab is still under construction. It will be operative by the end of 2020, but the facility is partially available for several tests.</p> <p>State of the art: The uniqueness of the facility is given by the specific configuration of the selected fault located in Matzaccara (SW Sardinia). Moreover, the Lab will be a part of a wider infrastructure, which includes a test site for pilot-scale CO₂ injection and an underground laboratory. All these facilities will operate in integration with the other Sotacarbo facilities for CO₂ capture and utilization. Due to its specificity, the Sotacarbo Fault Lab offers a rare opportunity to advance understanding of technologies for monitoring CO₂ leakage through faults beyond the state of the art</p> <p>Scientific Environment: In the facility site there are no technical services or analysis instrumentation. The Fault Lab will be supported by the other facilities of the Sotacarbo Research Centre, located nearby. Sotacarbo laboratories are equipped for water and gas analysis, as well as rocks analysis (XRF, multi-stage triaxial test system, drill core scanning and structural analysis)</p> <p>Areas of Research:</p> <p>Research Fields: Geology/Geophysics, Monitoring</p> <p>STORAGE technologies: Migration, Leakage mitigation/remediation, Microseismicity, Leakage, Monitoring, Pressure/injection</p>			
<p>Target community/ Users: scientific and industrial communities</p>			
<p>Community Standards: tbc</p>			

Installation name	ID	Hosting Institution	URL
CATLAB	TA1-44-4	INERIS	https://eccsel.org/catalogue/120
<p>Description: The CATenoy experimental site and gas-water-rock interactions LABORatory in Oise is an injection site in underground environment with controlled conditions and in situ measurements devices at Catenoy, coupled with advanced laboratory facilities at Ineris to study gas-water-rock interaction.</p> <p>Brief technical description with picture and/or diagram</p> <p>The injection site is unique in France and probably in Europe. It is located 60 km North from Paris and comprises:</p> <ul style="list-style-type: none"> • >10 piezometers of 25 m depth, in the chalky aquifer of Paris Basin • 4 less deep "piezairs" of 11 m (drilled in the not saturated zone), • a technical shed including station dedicated to continuous gas monitoring 			



Installation name	ID	Hosting Institution	URL
<ul style="list-style-type: none"> • a weather station. <p>7 piezometers are aligned in the flow direction of the aquifer, covering a 60 m distance. One is devoted to injection, another is upstream to control the baseline environment, the others are downstream.</p> <p>CO₂ (or any other fluid) can be injected in the chalk aquifer at a depth to be chosen between 13 and 25 m, in order to simulate a leakage from a gas storage that is supposed to be located beneath. Push-pull experiments can also be performed, that consist of re-pumping the water after injection.</p> <p>In order to study the effects of the injected fluid on the environment, Ineris and partners can use i) in situ monitoring in the saturated and un-saturated zone, ii) adequate gas or water samples and iii) advanced laboratory measurements in the neighbouring Ineris site in Verneuil-en-Halatte city. The laboratory is dedicated to gas-water-rock interactions.</p> <p>The laboratory facilities include, among other:</p> <ul style="list-style-type: none"> - High-precision (0.01 mg) magnetic suspended balances to measure the gas adsorption on rock. - Determination of the isotopic signature of CO₂ (d13C) to trace the origin of the gas. - Batch reactors to perform experiments in underground conditions (P and T°). - Calibration benches and sandpits to calibrate gas flux measurement devices. <p>State of the art: The injection site can be operated at lower cost. The aquifer and its natural flow were thoroughly characterized through previous projects. Other sensors or measuring devices can be installed on the site in the request for a given experiment.</p> <p>The use of such a site for monitoring for direct CO₂ injection and for push-pull experiments is unique in France.</p> <p>The laboratory includes several advanced facilities and allows to run parallel experiments on 6 different lab stations. The lab measurements are usually performed to characterize processes such as gas production and migration, gas sorption, geochemical processes, effects on water quality in the short term or the longer term.</p> <p>Scientific Environment: Located 20 km from INERIS, the injection site can easily be operated and monitored. For most experiments, at least a month is necessary to prepare the injection (or push-pull). Besides the in-situ measurement, dedicated samplings and lab measurements can be carried out.</p> <p>Areas of Research:</p> <p>Research Fields: Geology, Geochemistry, Monitoring, Modelling, Sorption</p> <p>STORAGE technologies: Migration, Leakage mitigation/remediation, Reactivity/mineralisation, Leakage, Monitoring, Static modelling, Dynamic modelling</p>			
<p>Target community/ Users: scientific and industrial communities</p>			
<p>Community Standards: Accredited to Standard: ISO 9001</p>			



Installation name	ID	Hosting Institution	URL
MOBSEIS	TA1-44-5	TNO	https://eccsel.org/catalogue/130
<p>Description: The mobile seismic array allows TNO to acquire their own seismic data which fits their position as an independent research institute. The equipment can be applied for different domains (Carbon Capture and Storage, Geothermal, Energy storage and production), and to evaluate new technologies. The set-up of the mobile seismic array currently consists of 64 self-contained stations that can operate both stand-alone basis as well as in an array. Therefore, the station spacing and layout of the network is flexible and can be tailored for the specific target to be addressed. Seismic data can be acquired both continuously and periodically and data is wirelessly transferred from the stations to a data server. The wireless capabilities of the seismic array allow fast data acquisition and enables rapid mobilization and deployment of the array. The system consists of Sercel Unite acquisition units coupled to an integrated three component (xyz) digital accelerometer (DSU3-428). The accelerometers have a broad frequency response ranging from approximately 0-800 Hz and are therefore able to record seismic waves in a broad range of frequency, making it suitable both for active high-resolution seismic surveys, and for earthquake and noise monitoring. The acquisition units can operate without external power supply up to ~10 days without recharging the batteries.</p> <p>State of the art: The mobile seismic array allows acquisition of accurate and continuous seismic data, both to accurately monitor subsurface processes and to evaluate new production strategies. TNO has broad experience with the operation of permanent seismic arrays and analysis of both passive and active seismic data. The seismic array has a flexible character, such that it can be used both for continuously acquiring passive seismic data to monitor earthquakes and subsurface processes, as well as for acquiring active seismic surveys for subsurface characterization studies. Furthermore, the seismic array is suited for field conditions (rugged and water-proof), and easy to deploy in the field. The scale of field deployment of the seismic array is flexible, with a depth of investigation ranging from approximately 100 m to 5000 m, depending on the local site conditions.</p> <p>Scientific Environment: Seismic acquisition, processing, interpretation, reporting</p> <p>Areas of Research:</p> <p>Research Fields: Geology/Geophysics, Characterization and Monitoring of the sub-surface, detection and localization of seismic events</p> <p>STORAGE technologies: Active and Passive seismic</p>			
<p>Target community/ Users: scientific and industrial communities</p>			
<p>Community Standards: not applicable</p>			

