

EuroGeoSurveys: from a non-profit association to a geological service for Europe



J. VIDOVIC^{1*}, Y. SCHAVEMAKER², T. WITTEMAN³, J. TULSTRUP⁴,
S. VAN GESSEL³, K. PIESSENS⁵ & S. SOLAR¹

¹*EuroGeoSurveys, Rue Joseph II 36-38, 1000 Brussels, Belgium*

²*Delft University of Technology, Mekelweg 5, 2628 CD Delft, Netherlands*

³*TNO Geological Survey of the Netherlands, Princetonlaan 6, NL-3584
CB Utrecht, Netherlands*

⁴*Geological Survey of Denmark and Greenland, Øster Voldgade 10,
1350 Copenhagen, Denmark*

⁵*Royal Belgian Institute of Natural Sciences, Rue Vautier 29, 1000 Brussels,
Belgium*

KP, 0000-0002-9228-2089

*Correspondence: vidovic.jelena@gmail.com

Abstract: EuroGeoSurveys (EGS) is a not-for-profit organization representing 37 national geological surveys and some regional surveys; it has an overall workforce of several thousand experts. EGS members provide official, interoperable, homogeneous, reliable, INSPIRE (infrastructure for spatial information in the European Community)-compliant public data on the subsurface for the benefit of society in terms of circular economy development, sustainable management of the subsurface resources, understanding and combatting climate change and the development of infrastructures and mitigation of geology-related natural hazards. The EGS is committed to establishing a geological service for Europe based on three pillars: (1) joint research with impact on EU policy level, which is being implemented through the GeoERA programme (Establishing the European Geological Surveys Research Area to deliver a Geological Service for Europe); (2) harmonizing and sharing pan-European geological data, through the European Geological Data Infrastructure (EGDI); and (3) sharing knowledge, capacities and infrastructure, through the pan-African support to the EGS-Organization of African Geological Surveys (OAGS) Partnership (PanAfGeo project). The EGS will continue to support the EU in its transition to a low-carbon, climate-neutral, resource-efficient, socially and environmentally resilient economy, in full compliance with the United Nations 2030 Agenda and the 17 Sustainable Development Goals.

The early development of EuroGeoSurveys

In 1970 the directors of several national geological surveys in Europe developed the idea of forming an association to promote the important role of geoscience in all aspects of everyday life in Europe (Annells 1996). The first network of the European geological surveys was established in Orleans, France in 1971 with the foundation of the Western European Geological Surveys (WEGS – for a full list of acronyms used in this paper, please see Appendix A), an informal discussion group that comprised national geological surveys of western Europe and Scandinavia, as well as Cyprus, Greece and Turkey. Gradually WEGS Directors established a number of thematic working groups which encouraged staff to both share experiences and to develop joint projects.

In 1992 WEGS published its first co-ordinated and comprehensive statement (Lumsden 1992) on behalf of its 21 members, entitled ‘Geology and the Environment in Western Europe’. It was intended to demonstrate the types of issues to which geological surveys contribute at the national and European level. The WEGS statement marked a key stage in the development of EuroGeoSurveys (EGS). It also highlighted the need for future actions for the further improvement of accessibility and exchange of geoscientific information to enable more enlightened and informed management of the environment.

The collapse of the Soviet system in the late 1980s and the following expansion of the European Union (EU) membership had a major impact on the practice of geoscience across Europe. Geological surveys in western and central Europe took a greater

interest in each other's activities, wished to share experiences and aspired to co-operate with each other. This effectively led to the transformation of WEGS into the Forum of European Geological Surveys (FOREGS), still an informal association, with the latter established by 1993. By the mid-1990s the membership of FOREGS increased to over 30 members, reflecting the desire of surveys in central and eastern Europe to affiliate. FOREGS promoted the value of geological surveys, thereby enhancing their reputation and influence, and represented a network that would increase the exchange of experience and ideas, as well as participation in collaborative European projects. Moreover, new members wanted to participate in specialist working groups, with their potential for establishing and maintaining international standards. Most urgent in this regard was the need to transit to digital databases. In addition to information management, FOREGS then developed active working groups in remote sensing, geochemical mapping, marine and industrial minerals.

During the same period, the directors of surveys within the EU felt it was time to develop a new, formal association. In 1995, encouraged by the European Commission, 16 geological surveys (Christmann 2007) decided to create and register the EGS as a formal not-for-profit association under French law which could provide European institutions with balanced and authoritative geoscientific policy-relevant advice and decision support in the area of subsurface resources, natural hazards and global environmental issues.

The EGS was founded with the following objectives: (1) to jointly address European issues of common interest, (2) to promote the contribution of geoscientists to EU affairs and action programmes, (3) to assist the EU to obtain technical advice from members, and (4) to provide a permanent network of members and a common gateway to each member and their national networks.

The pace of European integration accelerated the EGS agenda after the Millennium and EGS membership rose to over 30 members. The new organization quickly found its feet and its members saw benefits in participating.

Today, the EGS brings together 37 national geological surveys and some regional surveys in Europe, with a collective overall workforce of several thousand experts (Fig. 1). EGS members provide official, interoperable, homogeneous, reliable, public data on the subsurface, its resources and its related risks.

The relevance of the EGS to the EU

To achieve its objectives, the EGS co-ordinates a number of permanent and temporary expert groups that integrate information, knowledge and expertise

derived from the member geological surveys in fields including natural hazards, water, soils, energy, mineral resources, marine geology, spatial data, CO₂ capture and storage, geochemistry, Earth observation and international co-operation. The EGS expert groups have contributed significantly to the definition of fundamental legislative initiatives and policy provisions, such as the Water Framework Directive (EC 2000a), the Coastal Zone Policy (EC 2000b), the Thematic Strategy on the sustainable use of natural resources (EC 2005), the Mining Waste Directive (EC 2006a), the Soil Thematic Strategy (EC 2006b), the Infrastructure for Spatial Information in the European Community (INSPIRE) Directive (EC 2007), the Raw Materials Initiative (EC 2008), the CO₂ Capture and Storage Directive (EC 2009a), the EU Maritime Policy (EC 2009b), and the Resource Efficiency Policy (EC 2011).

Geological surveys are major contributors to the EU Research Area, having participated in EU co-funded research and development and policy support projects since 1998, thus contributing to addressing important societal challenges and promoting sustainable and competitive growth. Several notable examples are given in the publication of the EGS Strategy Task Force (EGS 2014). Since then, challenges along the entire non-energy and non-agricultural mineral raw materials (metallic minerals, industrial minerals, construction materials) value chain were addressed in the Raw Materials section of the Horizon 2020 programme (H2020), Societal Challenge 5: 'Climate action, environment, resource efficiency and raw materials'. This effort was undertaken to help EU Member States tap the full potential of primary and secondary raw materials and to boost the innovation capacity of the EU raw materials sector. Some examples of projects implemented by the EGS and its members are the African-European Georesources Observation System (AEGOS) (<http://www.aegos-project.org/>), the Pan-African Support to the EuroGeoSurveys–Organisation of African Geological Surveys (EGS-OAGS) Partnership (PanAfGeo) (<http://panafgeo.eurogeosurveys.org/>), the Prospecting Secondary Raw Materials From the Urban Mine and Mining Waste (ProSUM) (<http://www.prosumproject.eu/>), and the Mineral Intelligence Capacity Analysis (MICA) (<http://www.mica-project.eu/>) projects and others (Vidovic & Solar 2018).

Towards a geological service for Europe

The knowledge provided by the EGS can contribute to the following: (1) optimal use and management of the subsurface for raw materials, soil and groundwater, storage and ecosystem services, while minimizing environmental impacts and footprints; (2) maintenance of the environmental status of the

GEOLOGICAL SERVICE FOR EUROPE

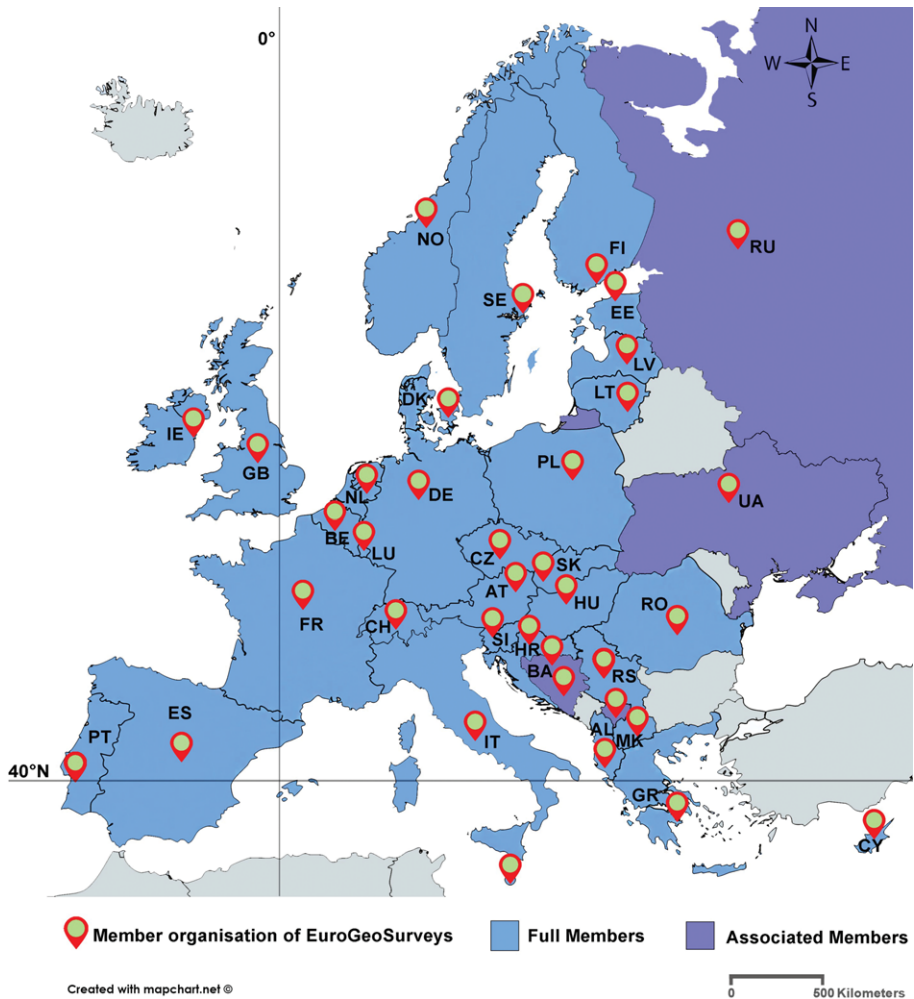


Fig. 1. The 37 member organizations of EuroGeoSurveys: Albania (AL) – Albanian Geological Survey (AGS); Austria (AT) – Geological Survey of Austria (GBA); Belgium (BE) – Geological Survey of Belgium (GSB); Bosnia Herzegovina (BA) – Geological Survey of Federation of Bosnia and Herzegovina FZZG, Geological Survey of Republic of Srpska (RZGRS-GSRS); Croatia (HR) – Croatian Geological Survey (HGI-CGS); Cyprus (CY) – Ministry of Agriculture, Natural Resources and Environment, Geological Survey Department (GSD); Czech Republic (CZ) – Czech Geological Survey (CGS); Denmark (DK) – Geological Survey of Denmark and Greenland (GEUS); Estonia (EE) – Geological Survey of Estonia (EGK); Finland (FI) – Geological Survey of Finland (GTK); France (FR) – French Geological Survey (BRGM); North Macedonia (MK) – Geological Survey of Macedonia (GSNM); Germany (DE) – Institute for Geosciences and Natural Resources (BGR); Greece (GR) – Hellenic Survey of Geology and Mineral Exploration (HSGME); Hungary (HU) – Geological and Geophysical Institute of Hungary (MBFSZ); Ireland (IE) – Geological Survey Ireland (GSI); Italy (IT) – Italian Institute for Environmental Protection and Research (ISPRA); Kosovo (XK) – Kosovo Geological Survey (KGS); Latvia (LT) – Geological Survey of Latvia (LVGMC); Lithuania – Geological Survey of Lithuania (LGT); Luxembourg (LU) – Geological Survey of Luxembourg (SGL); Malta (MT) – Continental Shelf Department (OPM); The Netherlands (NL) – Geological Survey of the Netherlands (TNO); Norway (NO) – Norwegian Geological Survey (NGU); Poland (PL) – Polish Geological Institute – National Research Institute (PGI); Portugal (PT) – Geological Survey of Portugal (LNEG); Romania (RO) – Geological Institute of Romania (GIR); Russian Federation (RU) – A. P. Karpinsky All Russia Geological Research Institute (VSEGEI); Serbia (RS) – Geological Survey of Serbia (GZS); Slovak Republic (SK) – State Geological Institute of Dionyz Stur (SGUDS); Slovenia (SI) – Geological Survey of Slovenia (GeoZS); Spain (ES) – Geological and Mining Institute of Spain (IGME); Sweden (SE) – Geological Survey of Sweden (SGU); Switzerland (CH) – Swiss Geological Survey (swisstopo); Ukraine (UA) – State Research and Development Enterprise ‘Geoinform of Ukraine’ (GeoInform); UK (GB) – British Geological Survey (BGS).

subsurface, including (ground)water, soils, and the ocean floor; and (3) enhancing society's resilience to natural (geological) hazards (e.g. landslides, climate change), thus reducing the loss of human life and environmental and economic damage. The data includes that provided by satellite or airborne Earth observation from Europe's flagship Copernicus programme on Earth observation.

In its strategic vision from 2014, EGS members stated their commitment to establish by 2020 a common European geological knowledge base and to jointly provide a geological service for Europe (EGS 2014). The vision was based on three main pillars of the EGS: (1) joint research with impact on EU policy level; (2) harmonizing and sharing pan-European geological data; and (3) sharing knowledge, capacities and infrastructure. The main objective of such a vision was to provide the EU with access to objective, coherent and harmonized data, information and knowledge on Europe's subsurface structure, resources and risks.

The first pillar aims to develop a co-ordinated 7–10-year common programme of geological research with a focus on tackling societal challenges and needs that require knowledge of subsurface properties and conditions. This research programme strengthens and supports: (1) innovation, industrial development and competitive growth; (2) European policymaking in improving quality of life and safety for European citizens; (3) sustainability of exploration, exploitation and management of the subsurface and its natural resources; and (4) the capacities of the geoscientific community, with a greater focus on pan-European issues.

The second pillar addresses the need for pan-European, long-term, interoperable geoscientific information and focuses on building a European Geological Data Infrastructure (EGDI) that would be the foundation for the common EU geological knowledge base. Such infrastructure is increasingly forming the backbone for delivering multinational, distributed, derived spatial and temporal datasets, in line with the EU INSPIRE Directive and other international standards.

The third pillar addresses capacity building through training and participation in multinational and multidisciplinary research, multinational exchange of researchers and best practices, and sharing of laboratories, facilities and infrastructures. It addresses the different starting points and capabilities of member states which currently seriously hamper some states and regions from unlocking their scientific and innovative potential. It also identifies the need for sufficient professionals in the field and the need for optimization of the European applied-geoscience research area.

The three pillars form the basis for creating a sustainable European geological service. This service

would be developed, maintained and delivered by the national geological surveys. The aim is to take existing collaboration to the next level and work towards integration of national programmes in the field of applied geology. The EGS aims to make a significant contribution to the EU 2020 Strategy objectives of Smart, Sustainable and Inclusive Growth and the EU flagship initiatives of 'Innovation Union', 'Resources Efficient Europe' and 'An industry policy for the globalization area'. It will contribute to the Raw Materials Initiative objective of securing reliable and unimpeded access to raw materials for Europe's industries, and to the '20-20-20' reduction targets of the EU's Climate and Energy Package. The latter aims to reduce emissions of greenhouse gases by 20% compared to 1990 levels, to increase EU energy efficiency by 20% and to achieve a share of 20% of renewables in the total EU energy production by 2020 (EGS 2014).

The EGS vision also aligns with the aims of the Strategic Implementation Plan (SIP) of the European Innovation Partnership on Raw Materials (EIP) (EC 2012, 2013). The EGS's research, innovation, knowledge sharing and international co-operation makes it a core organization for co-realization of the SIP.

The Geological Service for Europe (GSE) supports the collaborative management and protection of subsurface resources and capacities. The GSE will only be relevant if it can continuously provide complete, up-to-date and harmonized subsurface information. Continued involvement of local (e.g. regional surveys) and international stakeholders (surveys and associations outside Europe) will assist in the delivery of the GSE so that it will become an effective instrument for national and European end-users as well as a reliable information source for the public.

European co-operation is imperative for national and regional geological surveys to continue to play their central role in geoscience for society and the economy, while also guaranteeing that the geo-ethical principles of sustainability, transparency, verification and objectivity are fully respected (Van Gessel *et al.* 2017).

Ongoing activities

The first pillar of the EGS strategy is being implemented by the 45 national and regional geological surveys from 33 European countries. They have joined forces to develop a European Research Area Network (ERA-NET) co-funded action: Establishing the European Geological Surveys Research Area to deliver a Geological Service for Europe (GeoERA). GeoERA (<http://geoera.eu/>) deals with four different scientific themes: geo-energy, groundwater, raw materials and information platform.

The geo-energy, groundwater and raw material themes share the common objective to provide and disseminate spatial information on their respective resources and underpin geological data. As the cross-thematic integration of information is an important aspect of GeoERA, a specific information platform theme that effectively integrates all information and communications technology-related and technical issues (database and dissemination) has been introduced.

‘Secure, clean and efficient energy’ is at the heart of the H2020’s Societal Challenge 3 as Europe transitions to a reliable, sustainable and competitive energy system. The geo-energy theme aims to develop transparent, harmonized and science-based pan-European information and data on subsurface energy (fossil fuels, geothermal energy and energy storage) potential and CO₂ storage capacities, potential hazards and environmental impacts associated with subsurface energy exploitation and/or storage, and relevant cross-thematic links to groundwater and mineral resources.

The objective of the GeoERA groundwater theme is to provide data, information and decision-support tools for the long-term protection, sustainable management and improvement of groundwater resources across Europe. Innovative methodologies will be required to tackle the diversity of hydrogeological settings and the range of scales – regional to pan-European. By jointly developing effective tools and methodologies for monitoring, modelling, data management and visualization, in close collaboration with the other GeoERA themes, this work will improve understanding of groundwater systems and their interaction with surface water and ecosystems.

Raw materials are essential to the EU economy, either for the manufacturing of goods or the provision of services, and form the third theme. The European Commission recognizes the importance of Raw materials through its Raw Materials Initiative (RMI), the EIP and H2020 funding, specifically through Societal Challenge 5 – Climate Action, Environment, Resource Efficiency and Raw Materials. These initiatives aim to help secure and sustain primary and secondary mineral raw materials within the EU while minimizing potential negative environmental, health and societal impacts associated with their production. GeoERA will consider all raw materials (metals, industrial minerals, construction materials and those produced through recycling) from both on- and off-shore in the context of the circular economy. This requires the development of mineral intelligence, including products such as European Minerals Yearbook and European Mineral Resources Inventory, as well as improvements in European regional geological and metallogenic knowledge, such as the map of critical raw-material deposits in Europe (Bertrand *et al.* 2016). The map

was updated in January 2018 (Version 4.1.) based on the European Commission’s list of critical raw materials (EC 2017). More basic areas such as development of genetic and exploration models for different resources and the creation of 3D modelling and predictive targeting systems are also required. The overall objective of this theme is to develop more efficient and effective exploration tools and technologies for the subsurface so that Europe can domestically source more of its raw materials.

The second pillar of the EGS strategy is the focus of the information platform which addresses the development of a common geoscience information platform capable of integrating up-to date data, interpretations and models from distributed sources, both within and across the three main geoscientific themes of the GeoERA project.

Although EGS members collaborated in the past to develop harmonization and interoperability of geoscientific data across Europe, such initiatives were difficult to sustain due to a lack of funding. Between 2012 and 2014 an EU co-funded project (European Geological Data Infrastructure (EGDI)-Scope) established an implementation plan. An EGS Spatial Information Expert Group developed a Version 1 of EGDI that was launched in June 2016 (<http://europe-geology.eu/>) and has since been extended to include more data sets. It provides access to pan-European and national geological datasets and services from the geological survey organizations of Europe and to the European Plate Observing System (EPOS). This infrastructure forms the backbone for delivering multinational, distributed, derived spatial and temporal datasets, in line with the EU INSPIRE Directive and other international standards. It is the foundation for the common EU geological knowledge base.

In May 2017, a core group of five surveys from the EGS Spatial Information Expert Group wrote a strategy paper on EGDI, including a vision for the infrastructure, a list of strategic goals in a five-year perspective, a number of success criteria, a description of a governance structure and a work plan and budget for a one-year period. After presenting this paper at the EGS General Meeting, EGS members agreed to ensure funding for the operation and maintenance of EGDI in the first stage for a two-year period. The group of five surveys formed the EGDI Consortium to operate and maintain EGDI.

In addition to the four themes, GeoERA also addresses cross-cutting issues including multiple uses of subsurface space. Information on subsurface use will enable policy decisions that support safe and responsible exploitation of subsurface resources and capacities. Such data can also increase public awareness of the potential contributions that the subsurface has to help meet Europe’s energy and climate challenges.

The third pillar of the EGS strategy concerns sharing knowledge, capacities and infrastructure. This is currently addressed through projects in Africa and Latin America. The PanAfGeo project supports the technical and scientific capacity development of geoscientific staff from African geological surveys through an innovative training programme in relation to mineral exploitation and related infrastructures, as well as natural disaster prevention and mitigation. PanAfGeo covers the entirety of the African continent with a specific focus on those countries that are rich in mineral resources. The project focuses on the Organization of African Geological Surveys (OAGS) and its member organizations as well as on relevant governmental bodies such as mining authorities and geological research bodies (e.g. universities, research centres).

In 2015 the EGS and the Association of Iberoamerican Geological and Mining Surveys (ASGMI), a not-for-profit organization representing 22 national geological surveys in Latin America, including Portugal, Spain and a regional geological survey in Spain, signed an agreement initiating continental-scale long-term co-operation, support and development, which set out the terms for the collaboration. Both parties agreed to proceed with the identification of founding sources for a co-operation support in two phases: a feasibility study and a joint project, with the main objective to strengthen relations and capacity building between Latin American and European geological surveys.

Specific objectives of this joint project would be: (1) the harmonization, interoperability and standardization of the geoscientific data and information in participating countries as an effective way of disseminate geological and mining information, (2) to support the preparation of normative, methodologies and operational procedures according to international standards that foster the interoperability and exchange of geoscience information (e.g. EU Inspire Directive, Commission for the Management and Application of Geoscience Information (CGI)-developed data standards and Open Geospatial Consortium (OGC) data standards) for the implementation of national programmes of geological and geothematic mapping at proper scales, (3) to support the setup of trained teams for the management of abandoned mine sites and of conflicts related to informal mining, (4) to strengthen the EU–Latin America Earth science co-operation through EGS–ASGMI on topics of common interest and finally, (5) to foster innovation. So far, both associations participate together in two projects funded under H2020 programme: Towards a World Forum on Raw Materials (FORAM, <http://foramproject.net/>) and International Network of Raw Materials Trainings Centres (INTERMIN, <http://interminproject.org/>).

EGS strategy – moving forward

Supporting the EU in reaching the Sustainable Development Goals (SDGs) through policy advice and data provision remains the primary goal of the EGS. The EGS also fosters the use of geological knowledge by society in key public policy domains: climate, energy, electromobility, agriculture. It is accomplishing this through the development of regional/geographical representations; the definition of data policy on international, national, regional and local levels; and ensuring digital geodata is used to support sustainable urban planning/development.

A fundamental question for the future is how can EGS governance optimally converge with GSE strategy? In order to accomplish co-ordinated responses to European-wide issues in a timely manner, GSE would require a defined structure that involves the Secretariat, experts, directors using mandates to pass on requests to the members.

The basic idea of the first pillar of the EGS strategy, driven by global change, demographic growth and technological development is still valid, that is funding joint research programmes, driving survey collaboration and sustaining results. The main objective is to develop a strategic research agenda, to contribute to the formulation of The Horizon Europe Framework Programme, to produce policy position papers and to focus on outreach and marketing. Sustainability of projects is of great importance and are based on three to five-year jointly funded projects.

The second pillar needs further scientific harmonization, more expert involvement and a permanent source of funding. By 2025, the EGS would like to have established the international geological information system, with EPOS and the European Commission's Joint Research Centre (JRC) as users and customers with the EGS providing raw data and metadata. The next steps include establishing a task force for industry, defining work plans, flows and services and establishing a designated body. Challenges of the second pillar include overcoming differences between data priorities and different legal frameworks between the member states, lack of raw data available, defining approach to fund providers and establishing/revising data policy. The sustainability of the second pillar requires close collaboration with EPOS, with a view of inclusion in the broader geoscientific datasets.

The third pillar represents the capacity of excellence to answer specific societal needs and has the ambition to enable exchange of expertise and experts and map the available knowledge and needs by 2025. The value of the third pillar lies in the support coming from the geological surveys and the EU (e.g. funding PanAfGeo project) in exchanging information and contributing to the development of regulation about the use of the subsurface. The third

pillar creates a system for sharing infrastructure in order to be more efficient. In the coming years the third pillar will start with mapping of capacities, infrastructure, laboratory services and contribution of expert groups, including the members' available commercial services.

Ways forward: the EGS within a more sustainable Europe by 2030

On 25 September 2015, the United Nations (UN) adopted the 2030 Agenda for Sustainable Development and its 17 SDGs, agreeing to end poverty, protect the planet and ensure prosperity for all. With the SDGs, together with the Paris Agreement on Climate Change, there is now a roadmap to a better world and the global framework for international co-operation on sustainable development and its economic, social, environmental and governance dimensions (EC 2019).

The EU was one of the leading forces behind the UN 2030 Agenda and has also fully committed to be a frontrunner in its implementation, both within the EU and by supporting implementation efforts in other countries, in particular those most in need, through its external policies. Furthermore, the EU has already embarked on the transition to a low-carbon, climate neutral, resource-efficient and biodiverse economy in full compliance with the UN 2030 Agenda and the 17 SDGs (EC 2019).

The EGS actively contributes to meeting several SDGs, starting with its major contribution to SDG 17 ('Partnerships for the goals') by ensuring a strong network among geological surveys that commonly tackle several societal challenges that relate to the subsurface. Through collaboration with several western Balkan countries (Kosovo, Albania, North Macedonia) and an ongoing international project on capacity building (PanAfGeo), the EGS contributes to the target 17.9 ('Enhance international support for implementing effective and targeted capacity-building in developing countries to support national plans to implement all the sustainable development goals, including through North–South, South–South and triangular co-operation'). Furthermore, with its collaboration agreement with JRC, the EGS contributes to target 17.6 ('Enhance North–South, South–South and triangular regional and international co-operation on and access to science, technology and innovation and enhance knowledge sharing on mutually agreed terms, including through improved co-ordination among existing mechanisms, in particular at the UN level, and through a global technology facilitation mechanism').

Within its GeoERA programme and related projects, the EGS also contributes to SDG 13 ('Climate action'), especially to Target 13.1 ('Strengthen

resilience and adaptive capacity to climate-related hazards and natural disasters in all countries'). In particular, the TACTIC project (Tools for Assessment of Climate Change Impact on Groundwater and Adaptation Strategies) aims to develop research infrastructure for the advancement and harmonization of climate change assessments using knowledge and data on the groundwater system, while the HIKE project (Hazard and Impact Knowledge for Europe) carries out research and assessments of hazards related to the exploitation of subsurface resources and capacities throughout Europe. As a part of their national mandates, geological surveys have a primary role in advising the government, while through the EGS they aid each other in supporting national advice, addressing in this way target 13.2 ('Integrate climate change measures into national policies, strategies and planning').

Through numerous projects and activities related to facilitating access to raw materials (e.g. proSUM, FORAM, MICA), the EGS contributes to SDG 12 ('Responsible consumption and production'), in particular target 12.2 ('By 2030, achieve the sustainable management and efficient use of natural resources'), and to SDG 7 ('Affordable and clean energy'), more precisely to target 7.a ('By 2030, enhance international co-operation to facilitate access to clean energy research and technology, including renewable energy, energy efficiency and advanced and cleaner fossil-fuel technology, and promote investment in energy infrastructure and clean energy technology').

Several GeoERA projects address subsurface potential to deliver energy resources and storage capacities and as such contribute to SDG 7 ('Affordable and clean energy'): MUSE (Managing urban shallow geothermal energy) and HotLime project (Mapping and assessment of geothermal plays in deep carbonate rocks).

Finally, with a number of GeoERA projects working on providing data, information and decision-support tools for the protection, sustainable management and improvement of groundwater resources, the EGS also contributes to SDG 6 ('Clean water and sanitation'), for example HOVER (Hydrological processes and geological settings over Europe controlling dissolved geogenic and anthropogenic elements in groundwater of relevance to human health and the status of dependent ecosystems) and RESOURCE (Resources of groundwater harmonized at cross-border and pan-European scale) projects. The EGS will continue to support the EU in its transition to a low-carbon, climate-neutral, resource-efficient and biodiverse economy by offering a unique gateway to unbiased geoscientific data at a European level, establish a common European geological knowledge base and jointly provide a geological service for Europe. Furthermore, the EGS' long-term vision includes harmonizing national programmes at EU

level, relating its topics to the EU policies and agenda pursuing its co-operation with EPOS. Special attention will be given to information technology developments and other technological developments, for instance in geophysics, related to the description and the modelling of the EU subsurface. EGS will continue to contribute to the development of subsurface related data, information, knowledge and sustainable management integrating geo-resources (energy, water, raw materials) and environmental conditions (natural hazards, anthropogenic impacts), fostering the contribution of public geosciences to a circular economy through pan-European geoscientific knowledge and contributing towards the overall science-based EU response to the Paris Agreement and to the UN SDGs.

Acknowledgements The authors wish to thank the two reviewers, Patrice Christmann and Larry Meinert, whose suggestions helped us improve the manuscript. We are grateful to the Editor, Murray Hitzman and to the Associate Editor for their constructive suggestions and proposed corrections. Our thanks also go to Krishnan Subramani Ramakrishnan for his technical support in the production of Figure 1 and to Anthea Sutherland for proofreading the manuscript.

Funding This research received no specific grant from any funding agency in the public, commercial, or not-for-profit sectors.

Author contributions **JV**: conceptualization (supporting), data curation (lead), formal analysis (lead), project administration (supporting), visualization (lead), writing – original draft (lead); **YS**: conceptualization (equal), funding acquisition (lead), project administration (lead), writing – review & editing (equal); **TW**: project administration (lead), supervision (lead), writing – review & editing (supporting); **JT**: conceptualization (equal), funding acquisition (lead), project administration (lead), resources (lead), supervision (lead), writing – review & editing (supporting); **SVG**: conceptualization (equal), project administration (equal), supervision (equal), writing – review & editing (equal); **KP**: conceptualization (equal), project administration (equal), supervision (equal), writing – review & editing (equal); **SS**: conceptualization (lead), project administration (lead), resources (lead), supervision (lead), validation (lead), writing – review & editing (lead).

Appendix A: List of Acronyms with full titles

AEGOS –	African-European Georesources Observation System
ASGMI –	Association of Iberoamerican Geological and Mining Surveys

CGI –	Commission for the Management and Application of Geoscience information
EGDI –	European Geological Database Infrastructure
EGS –	EuroGeoSurveys
EIP –	European Innovation Partnership on Raw Materials
EPOS –	European Plate Observing System
ERA-NET –	European Research Area Network
FORAM –	Towards a World Forum on Raw Materials
FOREGS –	Forum of European Geological Surveys
GeoERA –	Establishing the European Geological Surveys Research Area to deliver a Geological Service for Europe
GSE –	Geological Service for Europe
HIKE –	Hazard and Impact Knowledge for Europe
HotLime –	Mapping and Assessment of Geothermal Plays in Deep Carbonate Rocks
HOVER –	Hydrological processes and Geological settings over Europe controlling dissolved geogenic and anthropogenic elements in groundwater of relevance to human health and the status of dependent ecosystems
H2020 –	Horizon 2020 programme
INSPIRE –	Infrastructure for Spatial Information in the European Community ((EU directive)
INTERMIN –	International Network of Raw Materials Trainings Centres
JRC –	Joint Research Centre
MICA –	Mineral Intelligence Capacity Analysis
MUSE –	Managing Urban Shallow Geothermal Energy
OAGS –	Organization of African Geological Surveys
OGC –	Open Geospatial Consortium
PanAfGeo –	Pan-African Support to the EuroGeoSurveys-Organisation of African Geological Surveys (EGS-OAGS) Partnership
ProSUM –	Prospecting Secondary raw materials from the Urban Mine and Mining waste
RESOURCE –	Resources of groundwater harmonized at cross-border and pan-European scale
RMI –	Raw Materials Initiative
SDGs –	Sustainable Development Goals
SIP –	Strategic Implementation Plan of the European Innovation Partnership on Raw Materials
TACTIC –	Tools for Assessment of Climate change Impact on Groundwater and Adaptation Strategies
WEGS –	Western European Geological Surveys

References

- ANNELLS, R. 1996. EuroGeoSurveys: The national geological surveys combine to map a way forward for the total environment of the European Union. *Episodes*,

GEOLOGICAL SERVICE FOR EUROPE

- 19, 61–65, <https://doi.org/10.18814/epiugs/1996/v19i3/003>
- BERTRAND, G., CASSARD, D.G., ARVANITIDIS, N. & STANLEY, G. 2016. Map of critical raw material deposits in Europe. *Energy Procedia*, **97**, 44–50, <https://doi.org/10.1016/j.egypro.2016.10.016>
- CHRISTMANN, P. 2007. EuroGeoSurveys, the Austrian Geological Survey and the European Construction. *Jahrbuch der Geologischen Bundesanstalt*, **147**, 47–52.
- EC. 2000a. *Establishing a Framework for Community Action in the Field of Water Policy*. Official Journal of the European Communities L 327, European Commission (EC), Brussels.
- EC. 2000b. *Integrated Coastal Zone Management: A Strategy for Europe*. European Commission (EC), Brussels.
- EC. 2005. *Thematic Strategy on the Sustainable use of Natural Resources*. European Commission (EC), Brussels.
- EC. 2006a. *Management of Waste from Extractive Industries and Amending DIRECTIVE 2004/35/EC*. Official Journal of the European Union L 102, Brussels.
- EC. 2006b. *Thematic Strategy for Soil Protection*. European Commission (EC), Brussels.
- EC. 2007. *Establishing an Infrastructure for Spatial Information in the European Community (INSPIRE)*. Official Journal of the European Union L 108, Brussels.
- EC. 2008. *The Raw Materials Initiative – Meeting our Critical Needs for Growth and Jobs in Europe*. European Commission (EC), Brussels.
- EC. 2009a. *Directive on the Geological Storage of Carbon Dioxide and Amending Council Directive 85/337/EEC, European Parliament and Council Directives 2000/60/EC, 2001/80/EC, 2004/35/EC, 2006/12/EC, 2008/1/EC and Regulation (EC) No 1013/2006*. Official Journal of the European Union L140, Brussels.
- EC. 2009b. *Developing the International Dimension of the Integrated Maritime Policy of the European Union*. European Commission (EC), Brussels.
- EC. 2011. *Roadmap to a Resource Efficient Europe*. European Commission (EC), Brussels.
- EC. 2012. *Making Raw Materials Available for Europe's Future Wellbeing: Proposal for a European Innovation Partnership on Raw Materials*. European Commission (EC), Brussels.
- EC. 2013. *Report from the Commission on the implementation of the Raw Materials Initiative on the implementation of the Raw Materials Initiative*. European Commission (EC), Brussels.
- EC. 2017. *On the 2017 list of Critical Raw Materials for the EU*. European Commission (EC), Brussels.
- EC. 2019. *Reflection Paper towards a Sustainable Europe by 2030*. European Commission (EC), Brussels.
- EGS. 2014. *The Geological Surveys of Europe, for Europe: The EuroGeoSurveys vision towards a Geological Service for Europe*. EuroGeoSurveys (EGS) Strategy Task Force, Brussels.
- LUMSDEN, G.I. (ed.). 1992. *Geology and Environment in Western Europe. A Coordinated Statement by the Western European Geological Surveys*. Clarendon Press, Oxford.
- VAN GESSEL, S., HINSBY, K., STANLEY, G., TULSTRUP, J., SCHAVEMAKER, Y., PIESSENS, K. & BOGAARD, P.J.F. 2017. Geological services towards a sustainable use and management of the subsurface: a geoethical imperative. *Annals of Geophysics*, **60**, 1–8, <https://doi.org/10.4401/ag-7500>
- VIDOVIC, J. & SOLAR, S. 2018. Recent developments in raw materials policy in European Union: EuroGeoSurveys as data supplier perspective. *Biuletyn – Panstwowego Instytutu Geologicznego*, **472**, 11–20, <https://doi.org/10.5604/01.3001.0012.6902>