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Minutes of the workshop subsurface management and planning

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GENERAL INTRODUCTION

This deliverable presents the minutes of the GeoConnect³d workshop that took place on the 10th of June, 10 am – 12 pm CEST as part of the Geoscience, Policy and Society event.

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1 CONTEXT OF THE GEOCONNECT³D WORKSHOP

The GeoConnect³d workshop on subsurface management and planning, which took place online on June 10th, 2021 from 10 am to 12 pm CEST, represents the final stakeholder event of the GeoConnect³d project (M9: subsurface management workshop with pan-European outreach). Its full title is "GeoConnect³d project: Geological information and knowledge for policy support", but in this report, it will be referred to as the "GeoConnect³d workshop". The timeline below (Figure 1) indicates its position within the GeoConnect³d project.

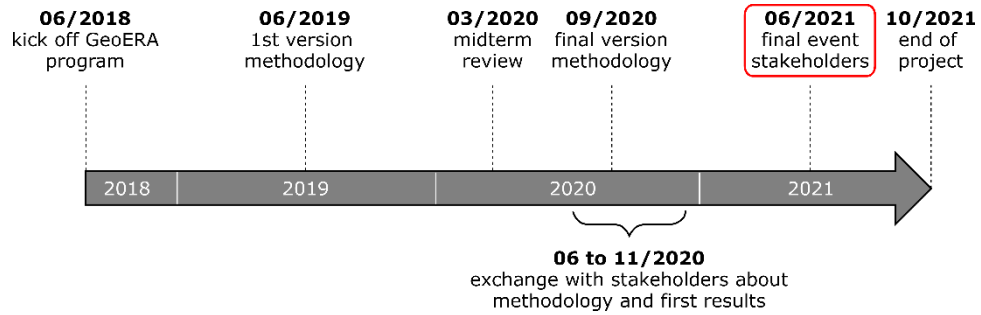

FIGURE 1: TIMELINE OF THE GEOCONNECT³D PROJECT

The main goal of this event, initially foreseen as a presential workshop, was to inform stakeholders about the outcomes of the GeoConnect³d project, both of the Structural Framework and Geomanifestations, and how these can be used as support in subsurface management-related policy challenges. Simultaneously, the opportunity was taken to ask the stakeholders their feedback on the Structural Framework and Geomanifestation approach via live poll questions during the workshop and a follow-up questionnaire send afterwards. A recording of the GeoConnect³d workshop is available at: https://youtu.be/MU-o3gh5Q1E.

The GeoConnect³d workshop was organized as side-event of the Geoscience, Policy and Society (GPS) webinar series, running from 7th to 11th of June and organized by BRGM (French Geological Survey), EGS (EuroGeoSurveys), GBA (Geological Survey of Austria), GSB (Geological Survey of Belgium) and USGS (U.S. Geological Survey). The main event associated to the GeoConnect³d workshop, followed on Thursday June 10th (4 – 6 pm CEST), and had as topic "Managing the multiple uses of the subsurface". In that session, different perspectives (geological survey, operational, European commission) where shared on subsurface management, both from the side of the US and Europe.

The Geoscience, Policy, and Society (GPS) 2021 free online event aimed to discuss the crucial role of the subsurface and its resources in the transition of our society with focus on renewable energy, sustainable use of resources, and low-climate impact. This event was organized by Geological Surveys that all have been engaged in providing the needed science for improved sustainable subsurface management and policy.

The GPS 2021 event addressed policy makers, regulators, interest groups, geoscientists and representatives from industry and the research community dealing with the multiple uses and management of underground resources. The event also welcomed anyone with a broad interest in geoscience or any of the specific topics presented to join the discussions through sessions tailored to a broader public.

Each day of the main event focused on a different aspect of geoscience-related subsurface use, management, planning, and policy, comparing and learning from innovative science and experiences of both sides of the Atlantic Ocean. Side sessions complemented these discussions by addressing more specific topics, which was the case of the GeoConnect³d session. The program is described in more detail below:

Main event	
07 June	GeoStar Challenge finals: Which geosites best represent the potential of the subsurface?
08 June	Bridging geothermal energy to the next level in the United States and the European Union
09 June	Towards Multi-Resource Assessments for Improved Sustainable Natural Resource Management
10 June	Managing the multiple uses of the subsurface
11 June	Final debate – Geoscience, Policy and Societal Challenges
Side events	
07 June	Virtual field trip: The potential hidden in the subsurface
10 June	GeoConnect³d project: Geological information and knowledge for policy support
14 June	MUSE project: Urban Geothermal energy use with special reference to shallow subsurface application

The GPS event welcomed 231 participants of 42 different countries, of which 212 attended multiple sessions throughout the week. The majority of the public attracted by the different sessions of the event came from geological surveys (46%) and universities (20%), but there was a significant interest from the private sector (14%), governmental institutions (7%) and research centers (7%).

2 IMPACT

2.1 GeoConnect³d session performance

In total, 64 persons were registered for the GeoConnect³d workshop, of which 54 actually attended. The workshop was recorded and shared on YouTube afterwards, also featuring the link to an online questionnaire with the same questions that were presented in the polls during the live event. This gave the opportunity for registered participants that could not attend and other interested people to watch the workshop and provide feedback about it at a later time, elevating the reach of the audience. On the 20th of July, 2021, this YouTube video had had an additional 50 views, although it is not possible to determine how many of these views were unique.

2.2 Composition of the audience

The workshop was attended by people from 18 different —mostly European— countries, showing the wide interest in and relevance of the GeoConnect³d project (Figure 2). In most cases, one representative per country was present, with exceptions for Bosnia-Herzegovina and the United Kingdom (2 each), France and Serbia (5 each), Hungary (6) and Belgium (18). The high number of attendances from Belgium can be explained by three main reasons: offices of both EuroGeoSurveys and the European Commision are located in Brussels, the Belgian Geological Survey is one of the main organizers of the GPS-event as well as the project lead of GeoConnect³d, and two other Belgian partners are involved in the GeoConnect³d project (VITO and VPO).

Based on the affiliation details provided with the registration, it could be deduced that the workshop was followed by a very diverse audience regarding sector as well (Figure 3). More than half of the public was composed of people working for a (national) geological survey, and one fifth is associated to a university (both students and academics). The remaining quarter of the audience represents the public/government sector (11%), independent research institutes (7%) and companies (6%). Unfortunately, no geographical or affiliation information is available for the people who viewed the YouTube recording of the workshop afterwards.

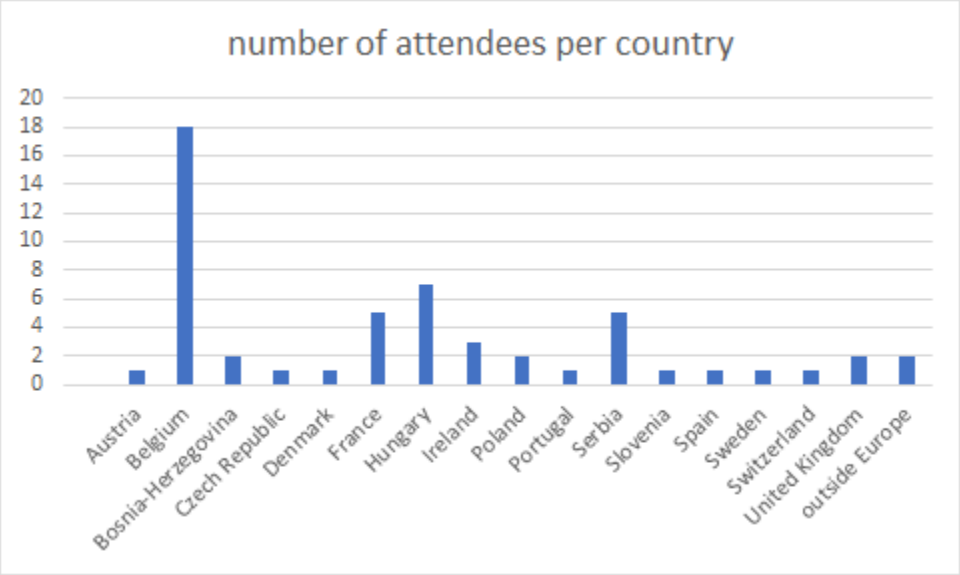

FIGURE 2: NUMBER OF ATTENDEES PER COUNTRY (BASED ON INFORMATION PROVIDED IN THE REGISTRATION FORM)

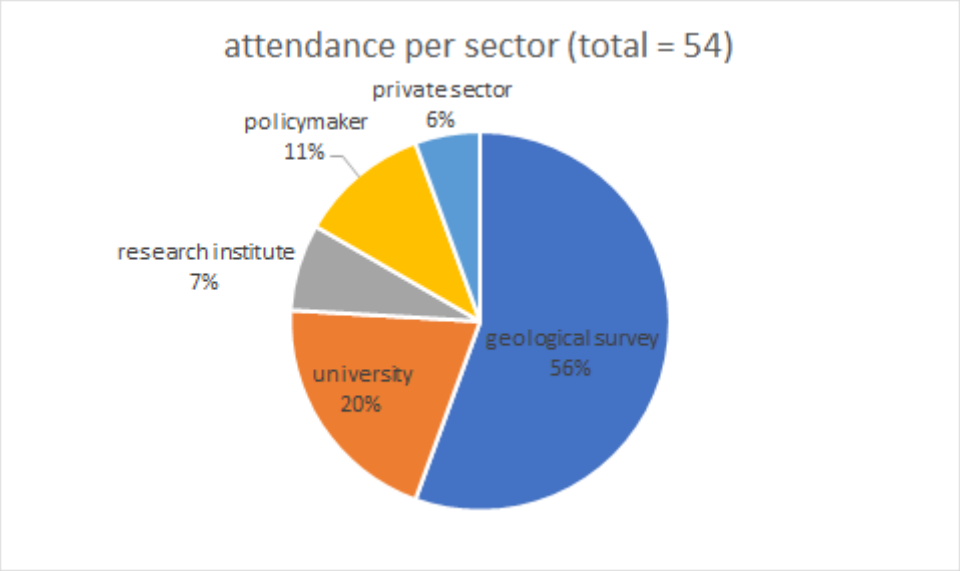

FIGURE 3: ATTENDEES PER SECTOR (BASED ON AFFILIATION GIVEN IN THE REGISTRATION FORM)

3 PROGRAM AND MINUTES OF THE PRESENTATIONS

3.1 Program as published online

Time	Topic	Presenter
10.00 - 10.05 am CEST	Opening, introduction	Renata Barros (GSB)
10.05 - 10.20 am CEST	The Subsurface Management issue	Isaline Gravaud (BRGM) Monika Konieczyńska (PIG-PIB)
10.20 – 11.30 am CEST	Structural Framework and Geomanifestations: new ways to prepare and disclose geological information	
	Introduction to the Structural Framework	Kris Piessens (GSB)
	Implementation of the Structural Framework - Ireland case study	Russell Rogers (GSI)
	Introduction to Geomanifestations	Johanna Van Daele (VPO)
	Answering policy questions in the Roer-to-Rhine area of interest	Helga Ferket (VPO)
	Answering policy questions in the Pannonian Basin	Gyula Maros (MBFSZ) Nina Rman (GeoZS)
11.30 – 11.55 am CEST	Q&A & Panel discussion	Renata Barros (GSB)
11.55 am– 12.00 pm CEST	Concluding remarks	Renata Barros (GSB)

3.2 Minutes of the presentations

10.00 – 10.05 am CEST

Opening, introduction

Renata Barros

Project coordinator, GSB – Geological Survey of Belgium

This presentation gives an overview of the main goal of the GeoConnect³d project, which is to provide a new way to disclose subsurface information, in order to bridge the gap between scientific knowledge and subsurface management. The project contains 16 countries, 2 cross border case areas and 2 one country pilot cases. The Structural Framework model is presented as a three-layer model, including units, limits and Geomanifestations (Figure 4).

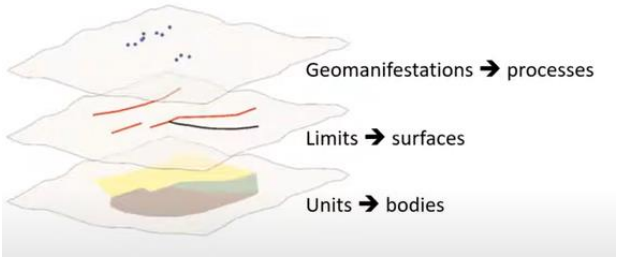

FIGURE 4: THREE-LAYER CONCEPT STRUCTURE OF THE GEOCONNECT³D PROJECT

Each of these layers contains a vocabulary structure, geometry file and database containing geological attributes. The result is an integrated multi-layered, multi-scale informative model.

10.05 – 10.20 am CEST

The Subsurface Management issue

Isaline Gravaud & Monika Konieczyńska
BRGM – French Geological Survey & PIG-PIB – Polish Geological Institute - National Research Institute, Poland

In this presentation it is explained that the subsurface has many uses for functions and resources such as hydrocarbon storage, waste disposal, mineral deposits, oil and gas fields and geothermal energy. These existing functions interact with each other, and in the future new challenges will arise due to new uses of the subsurface that will be introduced as a result of the energy transition (such as the storage of compressed air and H_2).

Given the increased use of the subsurface, two types of interactions are distinguished: (i) conflicts and (ii) reuses and synergies. Conflicts mean that there is a negative interaction between two subsurface uses, during simultaneous operations or when a particular use prevents future utilization of the area for another use. Direct conflicts generally arise due to the fact that many uses target the same type of (generally porous or fractured reservoir) geology. For example, geothermal and CO_2-storage projects both target the same saline aquifers in France. Also, more indirect conflicts are possible, where, for example, the influence radius of one application reaches another subsurface function. Concerning possible positive interactions, reuse (e.g., when depleted hydrocarbon reservoirs are used for storage purposes) is distinguished from synergies (e.g., when heat energy is recovered from production water).

It is concluded that subsurface management needs a proper definition, covering all considerations, planning, decisions and actions to allocate specific uses to appropriate subsurface locations. The management should not only include the targeted space, but also take into consideration the neighborhood of this space and a number of protected compartments to prevent detrimental interactions. Such an approach requires a complex assessment, not only of potential conflicts, but also of possible synergies. Finally, it is important to include the temporality of a subsurface function into the analysis.

Another aspect that was evaluated in this context was the existing regulatory framework among the project partners. It was concluded that a large diversity of authorities has responsibilities related to the management of the subsurface, and that there are large differences in organization between different countries. A legally based strategic vision on subsurface management is currently in place only in the Netherlands and in preparation in Flanders, and the registry of subsurface use is generally not organized in a consistent way. Also, at the level of the European Union, regulation is dispersed in various directives. Finally, the subsurface is generally not considered as a resource itself, but rather approached on a project basis.

As a conclusion, the following points are raised:

- The subsurface should be regarded independently and as a whole
- Sustainable use of the subsurface will require cooperation of authorities on local, regional and international level
- An understandable terminology regarding subsurface management, that is understandable for all stakeholders involved, should be created
- There is a need for new-generation tools such as the Structural Framework providing knowledge to all stakeholders

After this session, a few poll questions were introduced to the audience:

- Can you think of any key words related to subsurface management issues within Europe? (Cloud of words)
- How do you agree with the following statement: Subsurface management is a key issue in the development of the energy transition in Europe?
- Do you have in mind any concrete examples of subsurface management issues (conflicts of interest/ synergies / policy challenges) (open question)

10.20 – 11.30 am CEST

Structural Framework and Geomanifestations: new ways to prepare and disclose geological information

Introduction to the Structural Framework

Kris Piessens

GSB – Geological Survey of Belgium

The goal of this presentation is to illustrate the principles of the Structural Framework on a European scale. The take away message is that if you just put a geological map on the screen, it does not automatically provide insights in the structure of the area. Therefore, the Structural Framework on a European scale distinguishes (1) tectonic plates, (2) collision zones or orogens and (3) rift systems. When those are added to the SF according to their timing, they provide a simple tool to explain the large-scale geology. Within this large-scale framework, the GeoConnect³d cases of R2R, Pannonian Basin, Ireland and Bavaria are situated.

Implementation of the Structural Framework - Ireland case study

Russell Rogers

GSI – Geological Survey Ireland

For this case study, the Structural Framework is thought of as a pre-interpreted geological map because, despite of the rigid Structural Framework model that is behind it, still a large number of expert decisions had to be made when actually creating the model. Three levels of limits are used: unconformities, contacts and faults.

The Structural Framework from Ireland is produced from existing mappings at different scales and includes three different zoom levels. The first zoom level is created from maps at scales of 1: 2 500 000, 1: 1 000 000 and 1: 500 000 and shows the main structural grain of Ireland including the most important inliers. On the second zoom level, more detail appears and the Carboniferous is further subdivided based on the major Visean basins and shelf facies, because this subdivision allows to visualize the structural grain of the country. The decision of making the subdivision based on facies rather than age illustrates how different approaches for constructing a Structural Framework can be followed, and that an expert vision on which aspects of the local geology the Structural Framework should provide insights is important.

The third zoom level is based on 1: 50 000 geological maps and 3D models, for which no national cover exists. Associating the spatial data is performed by a detailed vocabulary structure and attribute table.

Next, a number of examples are shown highlighting the differences between the visual representation of the Structural Framework and traditional geological maps. These examples demonstrate how the Structural Framework can help gaining insight in the geology of an area by visually simplifying the information that is displayed on map-scale and adding insight. It is explained that the Structural Framework was constructed based on the geological maps by (1) selecting specific important information and (2) by combining and interpreting the available information in such a way that the result will visually display the general geological structure of the area.

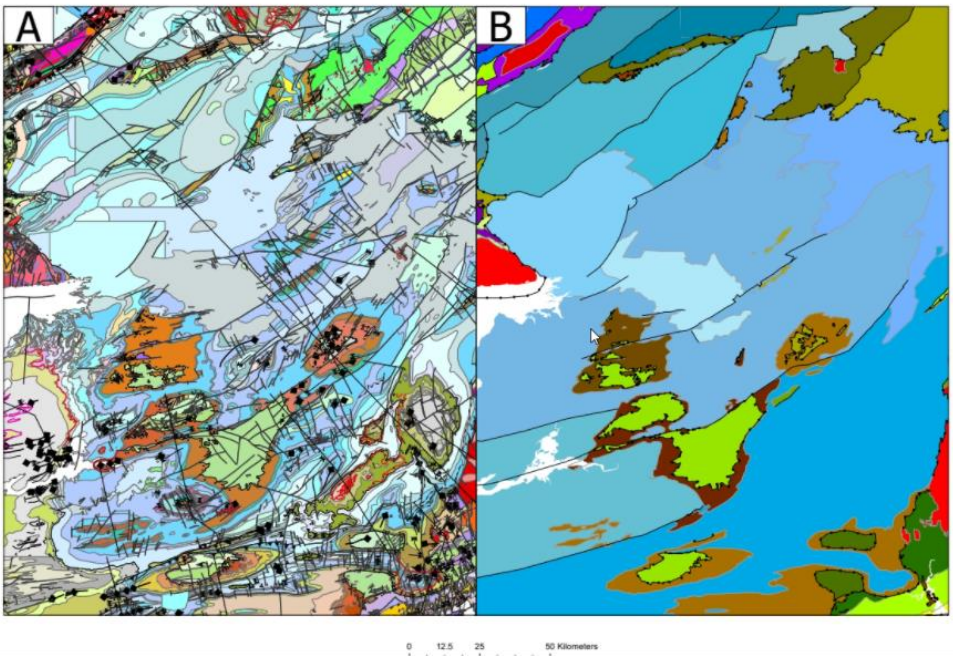

FIGURE 5: EXAMPLE OF IRELAND OF A TRADITIONAL GEOLOGICAL MAP (LEFT) AND STRUCTURAL FRAMEWORK (RIGHT)

As a conclusion, it can be stated that when carefully thinking about the information that the Structural Framework is supposed to give, it can be a really useful tool to communicate geology in a more simplified way.

After this session, a series of poll questions were presented to the participants:

- Is the Structural Framework approach a useful way to constrain sub-surface geology? (yes/no/no opinion)
- Do you think that the Structural Framework has potential application in sub-surface management? (yes/no/no opinion)
- What aspect(s) of the visualization of the Structural Framework would you like to see improved to make it straightforward to use?

Introduction to Geomanifestations

Johanna Van Daele
VPO – Vlaams Planbureau voor Omgeving

The concept of Geomanifestations is explained in a short introductory presentation, using multiple well-known examples that cover the broad range of geodisciplines to which this concept can be applied. Additionally, the added value of Geomanifestations for subsurface exploration and policy support regarding subsurface management issues is briefly highlighted.

Answering policy questions in the Roer-to-Rhine area of interest

Helga Ferket & Bernd Rombaut
VPO – Vlaams Planbureau voor Omgeving & VITO – Vlaamse Instelling voor Technologisch Onderzoek

The goal of this presentation is to illustrate what the Structural Framework and Geomanifestations teach us for tackling different subsurface-related policy challenges, rather than going deep into the geology of the Roer-to-Rhine (R2R) study area.

The presentation starts with an overview of the R2R Structural Framework on multiple zoom levels. Different units can be distinguished on the large-scale, while more detailed and complex fault traces, continuing across the Dutch – Flemish border, appear in a zoomed-in image. Such harmonized database is of great value for subsurface policy matters, e.g., for modeling and evaluating (cross-border) interferences. Another overview picture demonstrates the spatial occurrence of a large variety of Geomanifestations (AVO-anomalies and collapse structures on seismic data, thermal anomalies, CO_2 seeps, volcanism, seismicity and polymetallic veins) that were investigated for the R2R area.

Two main policy challenges are discussed in this talk:

1. <u>Predicting geothermal resource potential</u>

The first policy challenge that is discussed, is the prediction of geothermal resource potential. Key questions are: Can we predict sweet spots? What are the key factors controlling a geothermal play? Can we transpose insights from well explored and successful areas to less evident regions?

An overview of the thermal anomalies on the scale of the whole R2R area, reveals that they dominantly cluster along grabens and large river values, but that there is a modest potential in the Eifel (where one would expect a higher potential thanks to the young volcanism). This shows that large topographic differences are key for creating strong hydraulic gradients, and co-occurring deep groundwater circulation. The example of the west side of the Upper Rhine Graben, where a series of Enhanced Geothermal System projects have been successfully developed, additionally indicates the importance of good transmissivity (by aquifers, faults and fractures). The latter factor is also clearly observed upon zooming in. Linear trends of thermal springs occur along deep-seated Variscan thrust faults, for example in Wiesbaden and Aachen. In Wiesbaden, the temperature of the springs decreases when approaching the nearby intersecting and perpendicularly-oriented graben-related fault. In contrast, spring temperatures increase closer towards such fault intersections in Aachen.

Subsequently, the example of the major Heerlen thermal anomaly, located along the same fault system as in Aachen, and the weaker anomalies west of it, illustrates how those insights might be transposed to other areas. The multiple intersections between the Variscan thrust-fault system and graben-related fault system represent possible sweet spots for geothermal exploration that deserve further investigation.

Amplitude variation with offset (AVO) analyses on seismic data can also be useful to predict spots that are interesting for geothermal purposes. Based on the intercept and gradient of the seismic signature, class I AVO anomalies have been observed in the Campine area in Belgium, often linked to faults. These indicate fluid-bearing or gas-rich intervals in compact sandstone reservoirs, which corresponds to observations from nearby boreholes.

This first part of the presentation ends with a short summary of the following key messages:

- Circulation of large volumes of fluid requires high topographic differences and a good transmissivity along faults, fractures, aquifers;
- Efficient heat transport can occur along faults by advection or convection;
- AVO analyses are a promising, cost-effective technique to lower exploration risks for both hydrocarbon and geothermal energy exploitation.

2. Gas migration through the subsurface

The second policy challenge is about gas migration through the subsurface. The volcanic Eifel and the Ardennes are studied as a natural analogue. For this part, the main processes related to gas migration are discussed for four different zoom levels, from large scale to small scale:

a) On the scale of the R2R study area, a close spatial correlation between the occurrences of CO_2-seeps and He anomalies with those of the Eifel volcanoes can be observed. Combining this information with the mantle signature derived for most seeps suggests degassing from the mantle preferentially through the volcanic pathways.
b) On the regional scale, the occurrence of aligned CO_2-seeps is revealed. Again, the Variscan structural trend can be observed, as well as graben-related faults in some cases. Some lineaments do not correspond to mapped faults.
c) Upon further zooming in, at the semi-local scale, the effect of faults is more obscured. The occurrence of CO_2-seepage is related to groundwater discharge areas (springs, rivers, …). Likely this becomes the dominant transport mechanism for gas when deep-seated faults crosscut aquifers where the gas gets dissolved in the groundwater and further transport is controlled by hydrological factors. Nevertheless, a slight dataset bias is present, as dry CO_2-seeps directly degassing along faults are not visually noticed, and hence can be easily missed.
d) On the in-situ scale, fieldwork, water sampling and characterization can indicate the origin of the CO_2. The example of the CO_2-springs in the Ardennes shows a mixed volcanic-sedimentary origin. Also, alternative mapping methods, e.g., with bio-indicators such as red wood ants that preferentially build there structures at degassing spots, can further help in completing the database and determining the exact processes at play for gas migration.

This second part of the presentation ends with a short summary of the following key messages:

- Natural analogues allow investigating gas migration at different scales
- Important interplay between different processes (CO_2-generation, faults, hydrology)

Answering policy questions in the Pannonian Basin

Gyula Maros, Nina Rman & Annamária Nádor
MBFSZ – Mining and Geological Survey of Hungary and GeoZS – Geological Survey of Slovenia

This presentation takes a closer look to the Structural Framework and Geomanifestations of the Pannonian Basin, and how these can help in solving subsurface-related policy issues.

First, a quick overview is given on the geological situation of the Pannonian Basin, a back-arc basin of the Alpine Orogeny. It is shared by 8 countries, and consists of two main parts; a Paleo- and Mesozoic basement, covered by a Miocene infilling. A Structural Framework was built for the basement, for 3 separate scale ranges with appropriate unit and limit ranges. For the sub-horizontal Miocene fillings, a layer model and associated 3D-viewer was constructed based on seismic data. For the Geomanifestations, the research focused on three study areas, of which two cross-boundary (Mura-Zala basin, Battonya High, and northern Bosnia & Herzegovina). These three study areas cover a wide range and variability in geology and geomanifestation types. In the Mura-Zala basin, thermal and mineral water occurs, as well as seismic events, gas and oil. The Geomanifestations occur mainly along linear trends, which are linked to three major faults. The Geomanifestations of Battonya High, a high flat area, are related to the extreme basement topography and mainly consists of thermal anomalies. For the thermal anomalies of the Mura-Zala basin and Battonya High study areas, 3D forward modelling was successfully performed to investigate the heat and flow characteristics. In northern Bosnia & Herzegovina, water with exceptional geochemistry can be observed. These Geomanifestations are very diverse and still need further investigation.

Secondly, the link to policy was made: How can these scientific results be translated to real subsurface management issues, which policy-makers need to tackle. Often the different applications target the same depth. Interactions between multiple applications are already known for a long time in the Pannonian Basin (e.g., enhanced oil recovery, re-use of abandoned oil wells, …).
At this point, some audio disturbance occurred
A Traffic Light methodology that indicates where competition might arise was constructed to allow a straightforward integrated assessment for multiple uses of subsurface. This approach also includes the indications of possible effects/conflicts per combination of subsurface applications. Even when no competition exists, some overlapping effects can occur. Therefore, this is a complex assessment, requiring careful investigation. Applied to Battonya High, a semi-conceptual 2D-model was established, that indicates which applications (can) take place and may overlap (groundwater, thermal water, oil & gas, storage facility, geothermal energy). A similar exercise was done for the Mura-Zala basin, where certain volumes are suitable for multiple applications. The next step will be to build a real-scale traffic light model, based on the 3D geological models, that actually characterizes 3D volumes of the subsurface.

This presentation was followed by a few poll questions for the public:

- For which application(s) is the Geomanifestations approach most useful? Multiple answers possible.
- What are the pros and cons of the Structural Framework + Geomanifestations approach for discussions about subsurface management issue(s)? (open question)
- What aspects from all case studies presented were most innovative and interesting for you? (open question)
- What changes could improve the utility of the Structural Framework in the subsurface management perspective? (open question)

The answers received on these questions are discussed below.

11.30 – 11.55 am CEST
Q&A & Panel discussion

At the start of the Q&A session, only one question from the public had come in, about the availability of the methodology report. For now, this report is available for internal use only, but it can be shared after the project has ended.

Due to time constraints, there was no panel discussion.

A few concluding poll questions were proposed to the stakeholders to give their feedback on:

- What opportunities or threats do you see for the Structural Framework + Geomanifestations model in view of a European-wide policy on subsurface management?
- Would you be interested in adding data yourself (e.g. on geochemistry) to the database in the future?

11.55 am– 12.00 noon CEST
Concluding remarks

The main conclusions were summarized briefly, and the following events of the GPS webinar series were announced.

4 FEEDBACK FROM THE AUDIENCE

4.1 Answers on poll questions

The first poll question “Which keywords come to your mind related to subsurface management issues within Europe?” breaks into three groups of answers. The majority of keywords relate to subsurface planning avoiding conflicts and developing a long-term vision (e.g., conflicts of interest, vision, competition, inefficiency, planning, border issues, …). A second group of keywords relates to uncertainty of the subsurface potential (e.g., unknown potential, long-term assessment, lack of data, complexity,…). A third group focuses on responsibility and consequences (legacy, responsibility, waste, lobby, inefficiency, …).

The second question “How do you agree with the following statement: subsurface management is a key issue in the development of the energy transition in Europe?” results in a unanimous affirmation (Figure 6).

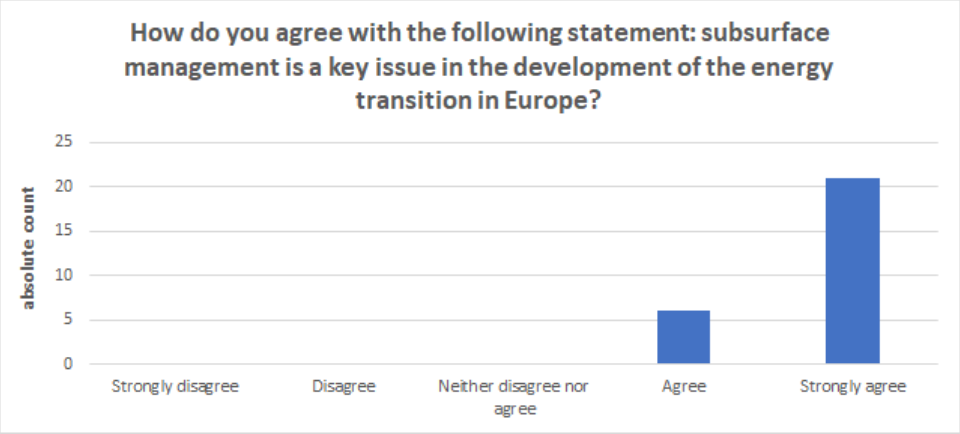

FIGURE 6: ANSWERS ON THE SECOND POLL QUESTION, CONCERNING THE IMPORTANCE OF SUBSURFACE MANAGEMENT IN THE ENERGY TRANSITION

When asking which concrete examples of subsurface management issues our stakeholders know (conflicts of interest / synergies / policy challenges), the answers fall into 4 types. A first group gives combinations of applications that may give rise to conflicts or synergies: e.g., groundwater versus geothermal energy, geothermal versus CCS, hydrocarbon and geothermal, geothermal and storage, … . A second group names the aspects of transboundary georesources. A third group gives legal and policy related barriers such as ownership of heat rights, need of unambiguous monitoring for all activities, disclosure of drillhole information and need of clear policy. A fourth aspect again stresses the need of a long-term vision.

The fourth question “How do you agree with the following statement: the Structural Framework approach is a useful way to constrain subsurface geology?” gives a slightly scattered image (Figure 7). The vast majority (87%) sees advantages in a structured visualization of geology, but one person strongly disagrees and two persons have no strong opinion. Since there was no open answer box, the reason for disagreement cannot be analyzed. It can be related to the cases presented, or depend on the lack of nuance in the question. There can be examples where it can be a pro and others where it can be a con.

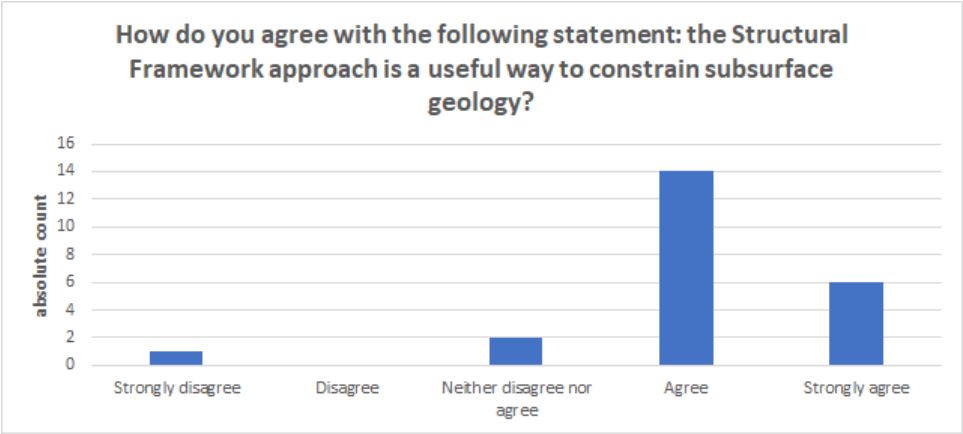

FIGURE 7: ANSWERS ON THE FOURTH POLL QUESTIONS RELATED TO THE USABILITY OF THE STRUCTURAL FRAMEWORK

Nevertheless, when asking whether the Structural Framework has potential application in subsurface management, a clear confirmation comes out (Figure 8). Again, there was no open text box for comments, but the strong reaction might be related to the fact that the Structural Framework gives harmonized cross-border geology and that in the case of the island Ireland, a very logically structured result was presented.

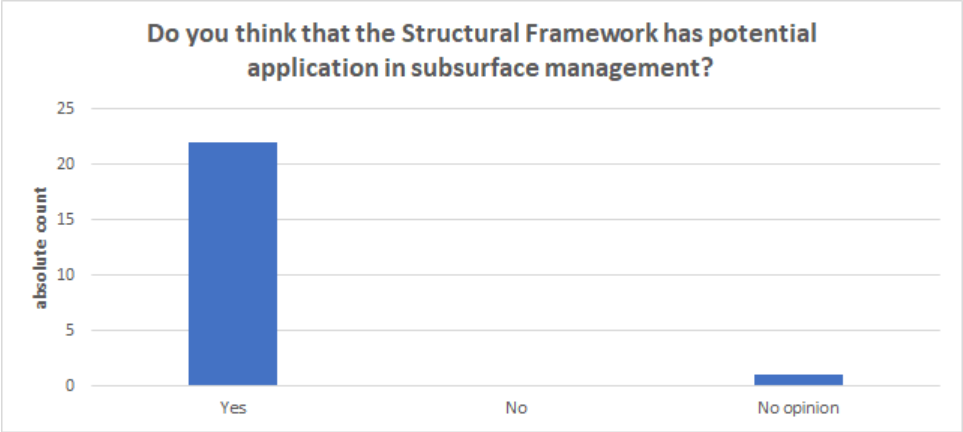

FIGURE 8: ANSWER ON THE FIFTH POLL QUESTIONS, CONCERNING THE APPLICABILITY OF THE STRUCTURAL FRAMEWORK

The sixth question “What aspect(s) of the Structural Framework visualization would you like to see improved to make it straightforward to use?” leads to the suggestion of incorporating the 3rd or even 4th dimension (timing). The request of combining with other type of data, such as environmental or surface infrastructure is not part of the scope of the Structural Framework, but can be combined anyway through a GIS-server.

The seventh question “For which application(s) is the Geomanifestations approach most useful?” led to the following result. Geothermal energy reaches the highest score, probably thanks to the lessons learnt presented on thermal anomalies and the predictive potential of such data. The second score concerns the identification of synergies. The identification of both synergies and conflicts indeed is a good example of the strength of the Geomanifestations methodology, in which integration of multiple disciplines widens the view.

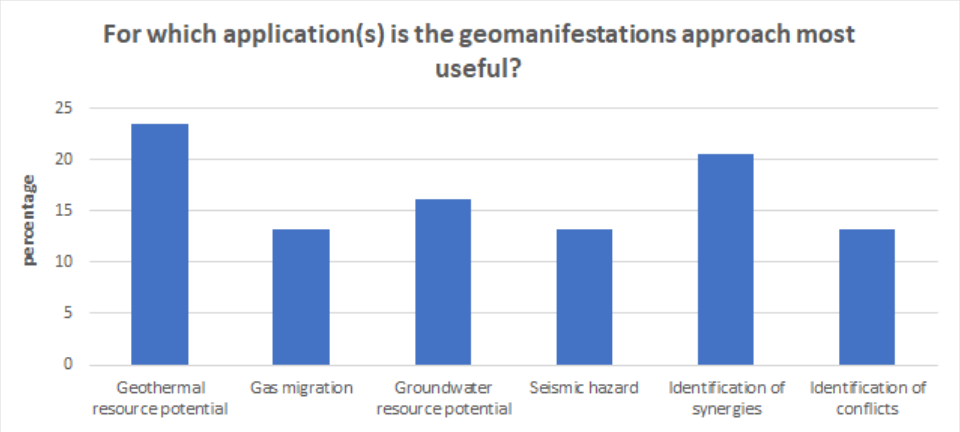

FIGURE 9: ANSWER ON THE SEVENTH POLL QUESTION, CONCERNING THE USABILITY OF THE GEOMANIFESTATIONS APPROACH

For the pros and cons of the Structural Framework and Geomanifestations approach for discussions about subsurface management issue(s), the following pros are indicated: i) it opens the view and facilitates discussions, ii) it makes it easier to harmonize geology across borders, iii) it becomes easier to communicate with experts, iv) it gives a good synthesis and overview of layers, tectonic zones and permeable zones. The single con named is the use of chronological units. However, this is not always the case, as shown by the example of Ireland, where they chose to visualize basin structure instead of chronostratigraphy to give insight.

On the question what aspects from all case studies presented were most interesting there is the concrete examples from different countries, the case studies although more innovative examples would have been welcome, the different controlling factors at different scales and the high quality presentations.

The tenth open question “What opportunities or threats do you see for the Structural Framework + Geomanifestations model in view of a European-wide policy on subsurface management?” resulted in two answers. One person points to establishing international standards related to the geological environment. Another person sees a great opportunity for progressing towards "consilience", i.e., a synthesis of different information sets to provide totally innovative solutions to unsurmountable problems in the sustainable use of the sub-surface.

Finally, on the question whether the respondents would be interested in adding data themself (e.g., on geochemistry) to the database in the future, 4 out of 5 answered yes. That is important for the real impact of the instrument. What was presented is a strategy and methodology with first results and pilot demonstrations. In order to become a powerful tool, more data should be added to fill gaps in data coverage and to fill the wide range of Geomanifestations.

4.2 Discussion

The urgency for developing a sound framework for subsurface management echoes from several inputs from the speakers and from the stakeholders through the surveying.

A specific EU directive or recommendation dealing with subsurface management for all type of subsurface applications and functions would have great value for the actual and future climate, energy and materials challenges Europe is confronted with. If the subsurface potential is not sufficiently explored and if the potential conflicts and synergies are not timely identified, the subsurface resources would be used in a project-driven and suboptimal way on a first-come-first-serve base. A sustainable vision for the subsurface should take into account both actual and future needs and protect vital functions of the subsurface. Member States can already decide to exclude certain areas or even the complete territory for CCS or unconventional fossil fuels making use of high-volume hydraulic fracturing according to Directive 2009/31/EC on the geological storage of carbon dioxide ("CCS Directive"), respectively Recommendation 2014/70/EU. A framework for prioritization or for discriminating between subsurface management choices is currently lacking. Also, the various general EU legislation and specific pieces of EU environmental legislation relevant to subsurface activities lead to a fragmented and increasingly complex operating framework within the EU. An overarching view on sustainable use of the subsurface on the short and long term is needed and generally recognized by the vast majority of the stakeholders that participated to the GeoConnect³d questionnaires. Such vision document should regard the subsurface independently and as a whole, instead of treating potential subsurface applications on a project base.

5 EVALUATION OF THE EVENT

The aim of the event was to demonstrate how the work done in GeoConnect³d can help improve subsurface management and policy questions. First, a general overview of subsurface management issues was given, after which the combined Structural Framework and Geomanifestations methodology followed in GeoConnect³d was introduced. Subsequently, two presentations demonstrated the implementation of the Structural Framework, after which three presentations were focused on the theme of Geomanifestations and how they can help answering policy questions. Organizing the event in this way, building up from a more conceptual level at the start of the event towards very applied examples at the end, allowed for the audience to learn about the GeoConnect³d approach in an accessible way. The poll questions that were asked after some of the presentations allowed for the event to be interactive, although being held completely virtually. Moreover, the answers provided on the questions provided useful stakeholder-input for the project. With respect to attendance, the audience was mainly affiliated to geological surveys (56%) rather than the primary targeted stakeholders (policy makers: 11%). This demonstrates that enough attention needs to be paid to further communicate the results and lessons learned of the project.