Appendix I: Evaluation Questionnaires for Roer-to-Rhine case study

WP5 - T5.3 Learning from the case studies

Important information

The questionnaire will be based from each case study's lessons learnt report. Please read the selected report thoroughly before completing this questionnaire. The questionnaire should take approximately 2 hours to complete. The questions which are labelled with an (*) are required fields.

Due to the variation in methodological approaches and lessons learnt reports, some questions might be more suited to one case study than others, and some questions may not apply to certain case studies. If a question does not apply to a case study, please explain why.

*Name:	Fabian Jähne-Klingberg
*Organisation:	BGR (federal institute for geosciences and natural resources)
*Date:	14.09.2021
*Case study evaluating *(please highlight)*:	R2R

Structural Framework

Do you agree with the following statements? :

1. * *In this case study, the structural framework has been successful in making the geology of the area more understandable.*

☐ Strongly disagree | ☐ Somewhat disagree | ☒ Somewhat agree | ☐ Strongly agree

> The structural domains "Paris Basin" and Upper Rhine Graben are not described in detail. But especially for Belgium and the Netherlands the descriptions of the methodology and geology are very understandable and detailed.

2. * *In this case study, the structural framework has been successful in providing a coherent geological context for subsurface applications.*

☐ Strongly disagree | ☐ Somewhat disagree | ☒ Somewhat agree | ☐ Strongly agree

The structural domains "Paris Basin" and Upper Rhine Graben are not described in detail.

But the detailed discussion on SF should be helpful to a potential user

3. *In this case study, the structural framework can aid in identifying and/or resolving subsurface management issues? E.g direct/indirect conflicts of use; zones of influence; areas of potential reuse and synergies; potential hazards etc… (please discuss multiple options if necessary).*

☐ Strongly disagree | ☐ Somewhat disagree | ☒ Somewhat agree | ☐ Strongly agree

A specific use case related to a usage was not further explained. But the different scales of the SF within the study area is well explained.

4. * In this case study, what issues/barriers do you identify in applying the structural framework methodology? e.g large scale, large amounts of geological data, time consuming etc…*

- Heterogeneity in data distribution & access, data uncertainty
- The structural framework here presented show the today's structural pattern. For a systematic analysis of relations between specific deformation structures or structural directions to specific geomanifestation time period structural maps could be helpful. But if I remember exactly this point is also discussed in the report.

5. *In this case study, have you identified any fundamental issues / show stoppers / limitations regarding the application of the structural framework?*

- Time to carry out a framework which is applicable for multiple-scales.
- It is difficult to create a product that is equally well adapted to all applications. Therefore, specific or generic use cases would be good as exemplary examples.
- But no big show stopper

6. *Do you have any further recommendations / suggestions which would benefit the application of the Structural Framework in this case study?*

Exist for every drawn element in every scale a Reference and estimation of the representation error. This could support a subsequent application (is needed for statistical risk assessments)

- scale-dependent uncertainty analysis
- It seems that deeper crustal effects and gravimetric anomalies have only been incorporated in a subordinate way?

Geomanifestations

Do you agree with the following statements :

7. * *In this case study, geomanifestations have been successful as specific expressions that identify ongoing or past geological processes:*

☐ Strongly disagree | ☐ Somewhat disagree | ☒ Somewhat agree | ☐ Strongly agree

> For the Belgian and the Dutch part of the study area the mapped geomanifestations and the presented detail cases show very well the potential of this methodical approach. The URG and the outer parts of the Paris Basin domain were only marginally dealt with in the study.

8. * *In this case study, geomanifestations have been successful in improving/completing the geological understanding:*

☐ Strongly disagree | ☒ Somewhat disagree | ☒ Somewhat agree | ☐ Strongly agree

> Most of the structural patterns were already sufficiently known and the here presented geomanifestations should be seen more as additional confirmations of certain structures in the subsurface.
>
> Again, several other examples showed that lineations or clusters of geomanifestations can also indicate structures that are not yet more precisely known, or can concretize the geometry of larger structures that are not precisely determined.

9. *In this case study, was the incorporation of Geomanifestations successful in helping identifying specific/potential management issues in the subsurface? E.g direct/indirect conflicts of use; zones of influence; areas of potential reuse and synergies; potential hazards etc… (please discuss multiple options if necessary).*

Application examples have only been presented by way of example.

However, it was evident that the selection of geomanifestations presented was designed for specific applications or geohazard considerations.

Geothermal energy, mineral waters, mineral resources, volcanic and seismic risks,

10. *In this case study, what are the issues/barriers concerning the application of Geomanifestations? e.g large scale, large amounts of geological data, time consuming etc…*

- heterogeneity of data distribution and quality
- Time to carry out a systematic analysis of all possible links between structural patterns and geomanifestations.

11. *In this case study, have you identified any fundamental issues / show stoppers regarding the application of the Geomanifestations?*

- Depending on the particular geomanifestation and geologic cause, other geologic phenomena may mask the linkage between the geomanifestation and the trigger.
- Before the method is applied on a large scale in a time-intensive manner, predictions of success for the analyses of specific geomanifestations should be made on the basis of exemplary small-scale studies.

No obvious show stopper!

Maybe the creation of a consistent cross-border database & how to establish the maintenance and reduce user thresholds.

The potentials of the presented methodologies are obvious. However, a vision of how a long-lasting implementation on a regional scale and pan-European scale could be realized is still missing.

12. *Do you have any further recommendations / suggestions which would benefit the application of the Geomanifestations in this case study?*

- A list of geomanifestations - Which ones were excluded and why?
- An overview of which analyses of geomanifestations could be performed similarly/comparably across Europe and which, due to regional/local specificities, can only be analyzed by incorporating background knowledge.
- Relations not only between the SF and geomanifestations, but also between several geomanifestations among themselves.
- Showing how to underlay the methods to also allow for interpreter-independent automatic statistical analysis.

Structural Framework and Geomanifestations integration

Do you agree with the following statements :

13. * *The structural framework model annotated with geomanifestations enhances our understanding of the subsurface*

☐ Strongly disagree | ☐ Somewhat disagree | ☒ Somewhat agree | ☐ Strongly agree

It is not always an extension of knowledge but rather a further circumstantial evidence that often additionally confirms already existing theses or studies.

14. * *The Structural Framework benefits from the incorporation of Geomanifestations into the model*

☐ Strongly disagree | ☒ Somewhat disagree | ☐ Somewhat agree | ☐ Strongly agree

This depends on what the structural framework should ultimately represent. A comprehensible scalable representation of today's tectonic pattern of a region or the representation of elements that somehow manifest today. But that does not necessarily make these structures equally important for characterizing the structural framework.

Some Geomanifestations like mantle HE have a more closer relation to important deep reaching structures as other Geomanifestations. Perhaps the Structural framework actually needs to be customized for different applications or different categories of geomanifestations and there relation to structures of the subsurface must be defined?

15. * *The Geomanifestations benefit from the context of the Structural Framework*

☐ Strongly disagree | ☐ Somewhat disagree | ☒ Somewhat agree | ☐ Strongly agree

Most of the presented geomanifestations can only be meaningfully explained by understanding the structures implemented in the structural framework.

16. *What barriers prevent both methodologies working (efficiently) together?

-The creation and analysis of a structural framework requires a completely different expertise than the analysis of specific phenomena/geomanifestations.

-The challenge is thus to bundle the expertise or replace it with AI.

17. *Overall, has the methodology been applied successfully within the selected area, fulfilling the aims it set out to achieve? Please give a rating out of 10 and offer a brief explication in the box below.

'The prime aim of GeoConnect³d is the conversion of geological data into subsurface information and critical parameters that can be used for various geo-applications, decision-making and subsurface spatial planning.'

☐	☐	☐	☐	☐	☐	☐	☒	☐	☐
1	2	3	4	5	6	7	8	9	10

The potential of the methodic is clearly presented but not in the same level of detail for the whole study area

Other Questions

18. *Does the methodology offer additional benefits which were previously unaccounted for?*

Answer : A systematization of the investigation of the subsurface and that across borders according to the same/comparable standards.

19. *Has the methodology opened up new opportunities for further development, exploration or valorisation?*

Answer : The introduction of standards in analysis and standardization will enable evaluation by new computer-aided AI methods in the future of large amounts of data.

WP5 - T5.3 Learning from the case studies

Important information

The questionnaire will be based from each case study's lessons learnt report. Please read the selected report thoroughly before completing this questionnaire. The questionnaire should take approximately 2 hours to complete. The questions which are labelled with an (*) are required fields.

Due to the variation in methodological approaches and lessons learnt reports, some questions might be more suited to one case study than others, and some questions may not apply to certain case studies. If a question does not apply to a case study, please explain why.

*Name:	Ales Havlin / Vit Hladik
*Organisation:	Czech Geological Survey
*Date:	17/09/2021
*Case study evaluating *(please highlight)*:	Roer-to-Rhine	Pannonian Basin	Ireland	Molasse Basin

Structural Framework

Do you agree with the following statements? :

5. * *In this case study, the structural framework has been successful in making the geology of the area more understandable.*

☐ Strongly disagree | ☐ Somewhat disagree | ☐ Somewhat agree | ☒ Strongly agree

> * Please explain the reason for your choice in a few sentences.
>
> Yes, the study contains carefully selected information in each area from different sources, different scales and 5 countries. Especially the use of the three zoom levels seems to be of particular help in this respect.

6. * *In this case study, the structural framework has been successful in providing a coherent geological context for subsurface applications.*

☐ Strongly disagree | ☐ Somewhat disagree | ☐ Somewhat agree | ☒ Strongly agree

* Please explain the reason for your choice in a few sentences.

Yes, SF has linked the available information appropriately.

7. *In this case study, the structural framework can aid in identifying and/or resolving subsurface management issues? E.g direct/indirect conflicts of use; zones of influence; areas of potential reuse and synergies; potential hazards etc… (please discuss multiple options if necessary).*

☐ Strongly disagree | ☐ Somewhat disagree | ☐ Somewhat agree | ☒ Strongly agree

* Please explain the reason for your choice in a few sentences.

Thanks to the structural framework, the study contains signal information on potential for various kinds of subsurface use, as well as on some issues such as possible risks or conflicts of interest. The use of information from the structural framework indicates areas where more detailed research and studies can be elaborated.

8. * In this case study, what issues/barriers do you identify in applying the structural framework methodology? e.g large scale, large amounts of geological data, time consuming etc…*

* Please explain your answer in a few sentences.

When working on relatively large areas, such as in the present study, one can always expect problems with consistency in the quality of input data, which entails time-consuming processing.

20. *In this case study, have you identified any fundamental issues / show stoppers / limitations regarding the application of the structural framework?*

Please explain your answer in a few sentences.

No.

21. *Do you have any further recommendations / suggestions which would benefit the application of the Structural Framework in this case study?*

Please explain the reason for your answer in a few sentences.

No.

Geomanifestations

Do you agree with the following statements:

22. * *In this case study, geomanifestations have been successful as specific expressions that identify ongoing or past geological processes:*

☐ Strongly disagree | ☐ Somewhat disagree | ☐ Somewhat agree | ☒ Strongly agree

> * Please explain the reason for your choice in a few sentences.
>
> There are good examples of geomanifestations provided; the description of their relationships to geological processes is very clear.

23. * *In this case study, geomanifestations have been successful in improving/completing the geological understanding:*

☐ Strongly disagree | ☐ Somewhat disagree | ☐ Somewhat agree | ☒ Strongly agree

> * Please explain the reason for your choice in a few sentences.
>
> We agree completely; good examples are provided in the study.

24. *In this case study, was the incorporation of Geomanifestations successful in helping identifying specific/potential management issues in the subsurface? E.g direct/indirect conflicts of use; zones of influence; areas of potential reuse and synergies; potential hazards etc… (please discuss multiple options if necessary).*

> * Please explain your answer in a few sentences.
>
> Yes, the inclusion of geomanifestations has shown their interconnectedness, Figure 22 is a nice example.

25. ** In this case study, what are the issues/barriers concerning the application of Geomanifestations? e.g large scale, large amounts of geological data, time consuming etc…*

> * Please explain your answer in a few sentences.
>
> These problems are typical of aggregate studies that work with large areas - different authors = different data quality; various scales of source data; large amounts data, time consuming data processing

26. ** In this case study, have you identified any fundamental issues / show stoppers regarding the application of the Geomanifestations?*

*Please explain your answer in a few sentences.

We could not identify any fundamental issues / show stoppers.

The main issue is apparently the levels of detail used for both the structural framework and geomanifestations that need to correspond to each other. Also, the nature of geomanifestations to be linked to features shown in the framework plays an important role – various types of geomanifestations can have various requirements for linkage.

27. *Do you have any further recommendations / suggestions which would benefit the application of the Geomanifestations in this case study?*

No.

Structural Framework and Geomanifestations integration

Do you agree with the following statements:

28. * *The structural framework model annotated with geomanifestations enhances our understanding of the subsurface*

☐ Strongly disagree | ☐ Somewhat disagree | ☐ Somewhat agree | ☒ Strongly agree

* Please explain the reason for your choice in a few sentences.

Every relevant piece of information increases our understanding of the underground environment. The combination of structural framework and geomanifestations in this study clearly shows advantages of the newly proposed methodology.

29. * *The Structural Framework benefits from the incorporation of Geomanifestations into the model*

☐ Strongly disagree | ☐ Somewhat disagree | ☐ Somewhat agree | ☒ Strongly agree

Please give additional information if necessary.

The study provides good evidence of such benefits.

30. * *The Geomanifestations benefit from the context of the Structural Framework*

☐ Strongly disagree | ☐ Somewhat disagree | ☐ Somewhat agree | ☒ Strongly agree

Please give additional information if necessary.

The study provides good evidence of such benefits.

31. *What barriers prevent both methodologies working (efficiently) together?

* Please explain your answer in a few sentences.

Different approaches of the authors of base studies and input databases that require laborious harmonization; possibly also access to necessary data.

32. *Overall, has the methodology been applied successfully within the selected area, fulfilling the aims it set out to achieve? Please give a rating out of 10 and offer a brief explication in the box below.*

'The prime aim of GeoConnect³d is the conversion of geological data into subsurface information and critical parameters that can be used for various geo-applications, decision-making and subsurface spatial planning.'

☐	☐	☐	☐	☐	☐	☐	☐	☒	☐
1	2	3	4	5	6	7	8	9	10

*Please explain the reason for your answer in a few sentences.

The study successfully tested the applicability of the developed methodology in the selected area. The issues related to implementation of the structural framework and geomanifestations have mostly been successfully solved.

With respect to the objective of proposing improved methods for decision making for subsurface planning and management, the study provides good examples of how the methodology can support these procedures by signalling risky areas and potential "sweet spots" for certain types of subsurface use. Another piece of added value might be the improved possibility of how to communicate geology to policy / decision makers.

Other Questions

33. *Does the methodology offer additional benefits which were previously unaccounted for?*

Answer :

Not identified.

34. *Has the methodology opened up new opportunities for further development, exploration or valorisation?*

Answer :

Yes, but its possible exploitation should be tested on practical cases where concrete subsurface mgmt. issues were observed / studied.

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*Name:	Tanja Petrović Pantić
*Organisation:	Geological survey of Serbia
*Date:	13.09.2021.
*Case study evaluating *(please highlight)*:	**Roer-to-Rhine** | Pannonian Basin | Ireland | Molasse Basin

Structural Framework

Do you agree with the following statements? :

9. * *In this case study, the structural framework has been successful in making the geology of the area more understandable.*

☐ Strongly disagree | ☐ Somewhat disagree | ☐ Somewhat agree | ☒ Strongly agree

* Please explain the reason for your choice in a few sentences.

The structural framework and all the data that are included in it, are useful to better understand the geology of the researched area. This is very useful methodology, especially for the detailed research.

10. * *In this case study, the structural framework has been successful in providing a coherent geological context for subsurface applications.*

☐ Strongly disagree | ☐ Somewhat disagree | ☐ Somewhat agree | ☒ Strongly agree

* Please explain the reason for your choice in a few sentences.

Good knowledge of the structural framework enables better subsurface management. It looks that the goal is achieved. Creating a vocabulary was the first step to overstep possible problems between cross-border countries. But only issue can be nonstandard and unequal interpretation of data from the cross-border countries.

11. *_In this case study, the structural framework can aid in identifying and/or resolving subsurface management issues? E.g direct/indirect conflicts of use; zones of influence; areas of potential reuse and synergies; potential hazards etc… (please discuss multiple options if necessary)._

☐ Strongly disagree | ☐ Somewhat disagree | ☐ Somewhat agree | ☒ Strongly agree

* Please explain the reason for your choice in a few sentences.

The Structural Framework can be the first step on planning to usage of subsurface. Influence of the faults on the movement of groundwater and CO_2, is noticed, and of the Tertiary volcanism on thermal anomalies.

12. * _In this case study, what issues/barriers do you identify in applying the structural framework methodology? e.g large scale, large amounts of geological data, time consuming etc…_

* Please explain your answer in a few sentences.

Barriers are made by limited 3D knowledge, then there is a problem for the harmonization of the geology between five countries, and for the fault model with faults crossing the border.

35. * *In this case study, have you identified any fundamental issues / show stoppers / limitations regarding the application of the structural framework?*

* Please explain your answer in a few sentences.

No

36. *Do you have any further recommendations / suggestions which would benefit the application of the Structural Framework in this case study?*

Please explain the reason for your answer in a few sentences.

It will be good, if it could be possible, to include 3D and timing of historical happening.

Geomanifestations

Do you agree with the following statements :

37. * *In this case study, geomanifestations have been successful as specific expressions that identify ongoing or past geological processes:*

☐ Strongly disagree | ☐ Somewhat disagree | ☐ Somewhat agree | ☒ Strongly agree

> * Please explain the reason for your choice in a few sentences.
>
> In this study, thermal anomalies are consequence of the Paleogene volcanism. Also volcanic phenomenaes, CO_2 seeps, polymetalic veins, He anomalies are indicating the past volcanic activities. Seismicity anomalies are indicating contemporary geological process. So it can be concluded that geomanifestations are successful in identification of ongoing or past geological processes.

38. * *In this case study, geomanifestations have been successful in improving/completing the geological understanding:*

☐ Strongly disagree | ☐ Somewhat disagree | ☐ Somewhat agree | ☒ Strongly agree

> * Please explain the reason for your choice in a few sentences.
>
> Geomanifestations are reflecting the geological features, so I am strongly agree with this claim. In the report, geomanifestations are explained based on the geological history and structural framework.

39. *In this case study, was the incorporation of Geomanifestations successful in helping identifying specific/potential management issues in the subsurface? E.g direct/indirect conflicts of use; zones of influence; areas of potential reuse and synergies; potential hazards etc… (please discuss multiple options if necessary).*

* Please explain your answer in a few sentences.

It is identifying influences between geomanifestations and subsurface, as well as influence of the groundwater on CO_2 migration, and also their connection with faults. That is good results of this project and can help in future investigation.

40. * In this case study, what are the issues/barriers concerning the application of Geomanifestations? e.g large scale, large amounts of geological data, time consuming etc…*

* Please explain your answer in a few sentences.

Lack of some information about the geomanifestations (from literature or databases) opens space for biased data-availability. Also database does not contain all available date for all countries, so it is necessary to update it for better results and better management.

41. * In this case study, have you identified any fundamental issues / show stoppers regarding the application of the Geomanifestations?*

*Please explain your answer in a few sentences.

No

42. *Do you have any further recommendations / suggestions which would benefit the application of the Geomanifestations in this case study?*

Please explain the reason for your answer in a few sentences.

Database of geomanifestations needs to be upgraded and updated

Structural Framework and Geomanifestations integration

Do you agree with the following statements :

43. * *The structural framework model annotated with geomanifestations enhances our understanding of the subsurface*

☐ Strongly disagree | ☐ Somewhat disagree | ☐ Somewhat agree | ☒ Strongly agree

* Please explain the reason for your choice in a few sentences.

It emphasizes the intense relationship between geomanifestations and structural framework. In that case, I am strongly agree with statement above.

44. * *The Structural Framework benefits from the incorporation of Geomanifestations into the model*

☐ Strongly disagree | ☐ Somewhat disagree | ☒ Somewhat agree | ☐ Strongly agree

Please give additional information if necessary.

It is good way for better understanding of the all geology, surface and subsurface and to notice possible conflict on the subsurface.

45. * *The Geomanifestations benefit from the context of the Structural Framework*

☐ Strongly disagree | ☐ Somewhat disagree | ☐ Somewhat agree | ☒ Strongly agree

Please give additional information if necessary.

In the report, there are numerous examples that are providing better explanations for the appearing of specific geomanifestations based on the knowledge of structural framework.

46. *What barriers prevent both methodologies working (efficiently) together?*

* Please explain your answer in a few sentences.

Better results can be expected in a case that both of the methodologies are harmonized from the beginning of the project.

Since the methodology is applied cross borders, there were not the same scopes of researches in neighboring countries. So it was not possible to have data of the same density, in the same scale and of same quality. Limited domain of previous geological investigations (for a particular research discipline) is also barrier to efficiently applying both methodologies.

Barrier is also lack of 3D for all research area.

47. *Overall, has the methodology been applied successfully within the selected area, fulfilling the aims it set out to achieve? Please give a rating out of 10 and offer a brief explication in the box below.*

'The prime aim of GeoConnect³d is the conversion of geological data into subsurface information and critical parameters that can be used for various geo-applications, decision-making and subsurface spatial planning.'

☐	☐	☐	☐	☐	☐	☐	☐	☐	☒
1	2	3	4	5	6	7	8	9	10

*Please explain the reason for your answer in a few sentence

Methodology is very good, concise and systematic applied, which gave a good result.

It is obvious that structural framework with geomanifestations allows better knowledge and understanding of geology. This model facilitates decision-making and subsurface spatial planning.

Other Questions

48. *Does the methodology offer additional benefits which were previously unaccounted for?*

Answer :

Yes. It gives better overview of geological history, tectonic and better geological understanding. It facilitates future research, to minimize or avoid expensive exploration.

49. *Has the methodology opened up new opportunities for further development, exploration or valorisation?*

Answer :

It is expected to give better results if the database of geomanifestations will be created after the structural framework.

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*Name:	Andrej Lapanje
*Organisation:	Geological Survey of Slovenia
*Date:	17.8.2021
*Case study evaluating *(please highlight)*:	**Roer-to-Rhine** | Pannonian Basin | Ireland | Molasse Basin

Structural Framework

Do you agree with the following statements? :

13. * *In this case study, the structural framework has been successful in making the geology of the area more understandable.*

☐ Strongly disagree | ☐ Somewhat disagree | ☐ Somewhat agree | ☒ Strongly agree

> As a geologist previously unfamiliar with the structural framework of R2R region, I got good impression on the geological history and structure of elaborated area. The SF provide me also a hint on structural relation between different spatial structures and their main characteristics.

14. * *In this case study, the structural framework has been successful in providing a coherent geological context for subsurface applications.*

☐ Strongly disagree | ☐ Somewhat disagree | ☒ Somewhat agree | ☐ Strongly agree

> The SF provides good starting point for subsurface application. If one is interested in research of geopotentials somewhere within R2R area, the necessary information on geotectonic units and faulting is available. I would say that the scale is still a little to general, but the SF is prepared in that way, that details could be added in further step.

15. *In this case study, the structural framework can aid in identifying and/or resolving subsurface management issues? E.g direct/indirect conflicts of use; zones of influence; areas of potential reuse and synergies; potential hazards etc… (please discuss multiple options if necessary).*

☐ Strongly disagree | ☐ Somewhat disagree | ☒ Somewhat agree | ☐ Strongly agree

> From presented SF you could easily distinct different geotectonic units, so you could define the zones of influence (within the same geotectonic unit) or zones without influence (adjacent geotectonic units), but for more reliable identifying and resolving subsurface management issues you need to check geomanifestations simultaneously. SF can aid in preparation of subsurface management plan, as it is obviously that the recommendations/restrictions on use of geopotentials could be made for each geotectonic unit, or even for subunit.

16. * *In this case study, what issues/barriers do you identify in applying the structural framework methodology? e.g large scale, large amounts of geological data, time consuming etc…*

> The scale is too general to be immediately applicable for star of geopotential applications projects. The preparation (classification, harmonization, unification of concepts) of data is time consuming, but if the progress will go on, the result will be worth every effort.

50. * *In this case study, have you identified any fundamental issues / show stoppers / limitations regarding the application of the structural framework?*

> Data availability and involvement of geologist/geoscientist is not the same for the whole area.

51. *Do you have any further recommendations / suggestions which would benefit the application of the Structural Framework in this case study?*

> I like the idea of allowing the presentation and aggregation of geological information from neighboring countries, which is possible at different levels of knowledge, on one platform. This allows us to quickly identify data gaps (directing future research work), or different interpretations of the same geological phenomena (harmonization).

Geomanifestations

Do you agree with the following statements :

52. * *In this case study, geomanifestations have been successful as specific expressions that identify ongoing or past geological processes:*

☐ Strongly disagree | ☐ Somewhat disagree | ☐ Somewhat agree | ☒ Strongly agree

> Geomanifestations are the result of past/recent geological processes below the surface. With the knowledge of their existence and location we have very good insight in the geological history and geodynamics.

53. * *In this case study, geomanifestations have been successful in improving/completing the geological understanding:*

☐ Strongly disagree | ☐ Somewhat disagree | ☐ Somewhat agree | ☒ Strongly agree

> Geomanifestations are the result of geological processes below the surface. These can tell us the most about what is happening below the surface, while SF only gives us a spatial extend in which these processes take place.

54. *In this case study, was the incorporation of Geomanifestations successful in helping identifying specific/potential management issues in the subsurface? E.g direct/indirect conflicts of use; zones of influence; areas of potential reuse and synergies; potential hazards etc… (please discuss multiple options if necessary).*

> For the study of geopotentials just SF is not enough. Knowledge on geomanifestation gives as key additional info for management and utilisation of geopotentials (analog reasoning).

55. * *In this case study, what are the issues/barriers concerning the application of Geomanifestations? e.g large scale, large amounts of geological data, time consuming etc…*

> Inhomogeneous distribution of geomanifestations data (due to inaccessibility of data or lack of data) across the R2R area reduce to some extend usability and intercomparison of geomanifestation (except for areas which were elaborated, but geomanifestations are absent).

56. * *In this case study, have you identified any fundamental issues / show stoppers regarding the application of the Geomanifestations?*

> Data availability and involvement of geologist/geoscientist is not the same for the whole area.

57. *Do you have any further recommendations / suggestions which would benefit the application of the Geomanifestations in this case study?*

Adding of new types of geomanifestation would be desirable as well as proceeding of entering geoinformation data on areas not yet covered.

Structural Framework and Geomanifestations integration

Do you agree with the following statements :

58. * *The structural framework model annotated with geomanifestations enhances our understanding of the subsurface*

☐ Strongly disagree | ☐ Somewhat disagree | ☐ Somewhat agree | ☒ Strongly agree

it is obvious that the presence of geomanifestations gives an insight into geological processes and structure and can give an indication of the existence of structural elements unknown to us. Geo manifestations can also be used to delimit geological spatial structures more precisely.

59. * *The Structural Framework benefits from the incorporation of Geomanifestations into the model*

☐ Strongly disagree | ☐ Somewhat disagree | ☐ Somewhat agree | ☒ Strongly agree

Some geomanifestation clearly gives indices for active faulting, some geomanifestations or absence of them clearly limit the spatial structures within SF.

60. * *The Geomanifestations benefit from the context of the Structural Framework*

☐ Strongly disagree | ☐ Somewhat disagree | ☒ Somewhat agree | ☐ Strongly agree

If you investigate one existing geomanifestation, you could look for potential (hidden) ones in the same spatial structure within SF.

61. **What barriers prevent both methodologies working (efficiently) together?*

Lack of data.

62. **Overall, has the methodology been applied successfully within the selected area, fulfilling the aims it set out to achieve? Please give a rating out of 10 and offer a brief explication in the box below.*

'The prime aim of GeoConnect³d is the conversion of geological data into subsurface information and critical parameters that can be used for various geo-applications, decision-making and subsurface spatial planning.'

☐	☐	☐	☐	☐	☐	☐	☐	☒	☐
1	2	3	4	5	6	7	8	9	10

It is a very good start. It need to be maintained further, more data should be include and an upgrade with parametrisation of different geological properties (like porosity, permeability, density, etc….).

Other Questions

63. *Does the methodology offer additional benefits which were previously unaccounted for?*

/

64. *Has the methodology opened up new opportunities for further development, exploration or valorisation?*

A methodology where data is hierarchically arranged requires quite a bit of work on their organization, but this is later rewarded with the ability to upgrade it and improve resolution. Insofar as upgrading continues, this will encourage new research and integration and provide an environment for subsurface management.

WP5 - T5.3 Learning from the case studies

Important information

The questionnaire will be based from each case study's lessons learnt report. Please read the selected report thoroughly before completing this questionnaire. The questionnaire should take approximately 2 hours to complete. The questions which are labelled with an (*) are required fields.

Due to the variation in methodological approaches and lessons learnt reports, some questions might be more suited to one case study than others, and some questions may not apply to certain case studies. If a question does not apply to a case study, please explain why.

*Name:	Russell Rogers
*Organisation:	GSI
*Date:	20/08/21
*Case study evaluating *(please highlight)*:	==Roer-to-Rhine== | Pannonian Basin | Ireland | Molasse Basin

Structural Framework

Do you agree with the following statements? :

17. * *In this case study, the structural framework has been successful in making the geology of the area more understandable.*

☐ Strongly disagree | ☐ Somewhat disagree | ☒ Somewhat agree | ☐ Strongly agree

> * Please explain the reason for your choice in a few sentences.
>
> The very complex geology has certainly been synthesized and presented well, but the variety of approached taken regionally and the different emphasis this inherently applies will not be apparent to a lay user.

18. * *In this case study, the structural framework has been successful in providing a coherent geological context for subsurface applications.*

☐ Strongly disagree | ☐ Somewhat disagree | ☒ Somewhat agree | ☐ Strongly agree

* Please explain the reason for your choice in a few sentences.

As a broad tool to put other data in context this is a very successful product, however some regions emphasizing subsurface data and others surface expressions will need to be well communicated to users.

19. *In this case study, the structural framework can aid in identifying and/or resolving subsurface management issues? E.g direct/indirect conflicts of use; zones of influence; areas of potential reuse and synergies; potential hazards etc… (please discuss multiple options if necessary).*

☐ Strongly disagree | ☐ Somewhat disagree | ☐ Somewhat agree | ☒ Strongly agree

* Please explain the reason for your choice in a few sentences.

As a first pass overview product the structural framework is a valuable tool for identifying subsurface issues

20. * In this case study, what issues/barriers do you identify in applying the structural framework methodology? e.g large scale, large amounts of geological data, time consuming etc…*

* Please explain your answer in a few sentences.

The heterogeneity of the data types and coverage. A problem everywhere, but especially for this particular region

65. *In this case study, have you identified any fundamental issues / show stoppers / limitations regarding the application of the structural framework?*

* Please explain your answer in a few sentences.

No

66. *Do you have any further recommendations / suggestions which would benefit the application of the Structural Framework in this case study?*

Please explain the reason for your answer in a few sentences.

Given a lot of time and resources, I would construct an SF using the same method everywhere, so us only the data types and features available in Wollonia for all areas. Then in later iterations include SF created using methods applicable to more data-rich regions, thus producing a variety of SF products

Geomanifestations

Do you agree with the following statements :

67. * *In this case study, geomanifestations have been successful as specific expressions that identify ongoing or past geological processes:*

☐ Strongly disagree | ☐ Somewhat disagree | ☐ Somewhat agree | ☒ Strongly agree

> * Please explain the reason for your choice in a few sentences.
>
> Yes, the geomanifestations are providing insight into geological processes as well as providing areas for further stdy

68. * *In this case study, geomanifestations have been successful in improving/completing the geological understanding:*

☐ Strongly disagree | ☐ Somewhat disagree | ☐ Somewhat agree | ☒ Strongly agree

> * Please explain the reason for your choice in a few sentences.
>
> The insight provided by the thermal anomalies and CO2 seep data further the geological understanding significantly

69. *In this case study, was the incorporation of Geomanifestations successful in helping identifying specific/potential management issues in the subsurface? E.g direct/indirect conflicts of use; zones of influence; areas of potential reuse and synergies; potential hazards etc… (please discuss multiple options if necessary).*

> * Please explain your answer in a few sentences.
>
> In this case study the geomanifestations can be used to emphasize which features of the structural framework need to be given the most consideration during resolution of subsurface management issues.

70. * In this case study, what are the issues/barriers concerning the application of Geomanifestations? e.g large scale, large amounts of geological data, time consuming etc…*

> * Please explain your answer in a few sentences.
>
> The variability in data coverage and type present a very heterogenous application

71. * In this case study, have you identified any fundamental issues / show stoppers regarding the application of the Geomanifestations?*

*Please explain your answer in a few sentences.

No

72. *Do you have any further recommendations / suggestions which would benefit the application of the Geomanifestations in this case study?*

Please explain the reason for your answer in a few sentences.

As the authors note themselves, the bias introduced through different partners taking different approaches to documenting geomanifestations would need to be addressed.

Structural Framework and Geomanifestations integration

Do you agree with the following statements :

73. * *The structural framework model annotated with geomanifestations enhances our understanding of the subsurface*

☐ Strongly disagree | ☐ Somewhat disagree | ☐ Somewhat agree | ☒ Strongly agree

* Please explain the reason for your choice in a few sentences.

As well as confirming and refining the spatial features of the SF, the geomanifestation provide further information about the features themselves, e.g. which faults are permeable or not, which are downwelling cold water and which have uprising warm water etc

74. * *The Structural Framework benefits from the incorporation of Geomanifestations into the model*

☐ Strongly disagree | ☐ Somewhat disagree | ☐ Somewhat agree | ☒ Strongly agree

Please give additional information if necessary.

75. * *The Geomanifestations benefit from the context of the Structural Framework*

☐ Strongly disagree | ☐ Somewhat disagree | ☐ Somewhat agree | ☒ Strongly agree

Please give additional information if necessary.

GeoManifestations in isolation are of no use without the context of the SF

76. *What barriers prevent both methodologies working (efficiently) together?*

* Please explain your answer in a few sentences.

The different ways that the SF and GeoManifestations were developed in different parts of the case study area are a barrier to interpretation. The first step when finding a trend in this data is to determine if it is a data bias or natural.

77. *Overall, has the methodology been applied successfully within the selected area, fulfilling the aims it set out to achieve? Please give a rating out of 10 and offer a brief explication in the box below.*

'The prime aim of GeoConnect³d is the conversion of geological data into subsurface information and critical parameters that can be used for various geo-applications, decision-making and subsurface spatial planning.'

☐	☐	☐	☐	☐	☐	☐	☐	☒	☐
1	2	3	4	5	6	7	8	9	10

*Please explain the reason for your answer in a few sentences.

 I think this area is a great proof of concept for the combination of geomanifestations and SF. This is a good first pass, providing plenty of opportunity for refining the techniques of developing SF and GeoManifestations data bases and for interpreting them.

Other Questions

78. *Does the methodology offer additional benefits which were previously unaccounted for?*

Answer :

No

79. *Has the methodology opened up new opportunities for further development, exploration or valorisation?*

Answer :

The areas highlighted for further research and exploration, particularly in fluid flow for geothermal applications.

WP5 - T5.3 Learning from the case studies

Important information

The questionnaire will be based from each case study's lessons learnt report. Please read the selected report thoroughly before completing this questionnaire. The questionnaire should take approximately 2 hours to complete. The questions which are labelled with an (*) are required fields.

Due to the variation in methodological approaches and lessons learnt reports, some questions might be more suited to one case study than others, and some questions may not apply to certain case studies. If a question does not apply to a case study, please explain why.

*Name:	Monika Konieczyńska, Joanna Fajfer
*Organisation:	PIG-PIB
*Date:	15.09.2021
*Case study evaluating *(please highlight)*:	**Roer-to-Rhine** | Pannonian Basin | Ireland | Molasse Basin

Structural Framework

Do you agree with the following statements? :

21. * *In this case study, the structural framework has been successful in making the geology of the area more understandable.*

☐ Strongly disagree | ☐ Somewhat disagree | ☒ Somewhat agree | ☐ Strongly agree

> * Please explain the reason for your choice in a few sentences.
>
> Yes, the SF contributed to a better understanding of the geology of R2R in cross-border area of 5 countries. Based on aggregated data, one can get a general overview of the geological structure of the case study region and focus on the range of the main units. And then, after using the zoom up option - get more detailed view of R2R regions of interest. The analyzed geological data in the area of each country differed significantly in the degree of detail, data processing, and also their availability. Besides, they were developed for each country separately and originally the geological maps and models finished at the border of the country. At present, however, the obtained effect in the form of SF allows to visualize the range of the existing geological structures of the entire area and to enter into details.

22. * *In this case study, the structural framework has been successful in providing a coherent geological context for subsurface applications.*

☐ Strongly disagree | ☒ Somewhat disagree | ☐ Somewhat agree | ☐ Strongly agree

> * Please explain the reason for your choice in a few sentences.
>
> It looks like the first step only, giving the idea of geological structures across several countries sharing them, but the SF itself is not sufficient to provide the information of possible subsurface application - it does not provide the 3D models of subsurface, not allowing for assessment of space available. Yet GMs provide in this case some ideas on possible applications and their limitations.

23. *In this case study, the structural framework can aid in identifying and/or resolving subsurface management issues? E.g direct/indirect conflicts of use; zones of influence; areas of potential reuse and synergies; potential hazards etc… (please discuss multiple options if necessary).*

☐ Strongly disagree | ☒ Somewhat disagree | ☐ Somewhat agree | ☐ Strongly agree

> * Please explain the reason for your choice in a few sentences.
>
> Structural Framework presented in the case studies may be somewhat helpful in identifying problems related to the use of subsurface. In particular, information on faults and their occurrence in the geological units of the analyzed area. But the lack of 3D visualisation, little information on limits and units properties and not clear instruction how to use SF together with vocabulary file, where hierarchical and non-hierarchical relations are defined and where more data are possibly accessible does not give the strong knowledge to identify and solve possible management issues.

24. * *In this case study, what issues/barriers do you identify in applying the structural framework methodology? e.g large scale, large amounts of geological data, time consuming etc…*

> * Please explain your answer in a few sentences.
>
> − heterogeneous scale of source data - problem with data interpretation within SF;
> − lack of availability of 3D data models for all case study stakeholders, which directly affects data interpretation;
> − diffusion of information in key areas of the case study (Walloon area);
> − individual approach to distributed data in order to aggregate them into a form that can be used in SF;
> − diversified geological structure of individual regions providing large amounts of data for analysis with varying degrees of detail, eg. Wallonia, Nordrhein-Westfalen and Luxembourg area;
> − a large amount of geological data for interpretation;
> − difficulties in identifying concepts known from historical publications, cross-borders linking and harmonization;
> − difficulties in linking seismicity with possible faults' activities;

80. * *In this case study, have you identified any fundamental issues / show stoppers / limitations regarding the application of the structural framework?*

> * Please explain your answer in a few sentences.
>
> Difficulties in interpretation of tectonic history and actual role of tectonic phases.
> Data with varying degrees of detail, which may affect the image of the geological structure of the entire R2R and difficulties in presenting data in a spatial manner. The lack of 3D visualisation of SF features in many parts of the R2R area - depending on the country archives and data interpretation models available.

81. *Do you have any further recommendations / suggestions which would benefit the application of the Structural Framework in this case study?*

> Please explain the reason for your answer in a few sentences.
>
> It is still not clear how the SF is supposed to work with the vocabulary and most of the SF features' attributes and relations between them, which can give broader view on e.g. depth and thickness aspects, are defined in the vocabulary (we believe as haven't found in the GIS package). Maybe as long as 3D is not implemented, some attributes addressing especially units' properties might be added to GIS files directly.

Geomanifestations

Do you agree with the following statements :

82. * *In this case study, geomanifestations have been successful as specific expressions that identify ongoing or past geological processes:*

☐ Strongly disagree | ☐ Somewhat disagree | ☐ Somewhat agree | ☒ Strongly agree

> *** Please explain the reason for your choice in a few sentences.
>
> Yes, in this case study, it was a good idea to use the chosen set of GM for better understanding of SF features history and properties. The implementation showed the value added and the Deliverable expressed how the SF and GM may work together for better understanding of subsurface.

83. * *In this case study, geomanifestations have been successful in improving/completing the geological understanding:*

☐ Strongly disagree | ☐ Somewhat disagree | ☒ Somewhat agree | ☐ Strongly agree

> * Please explain the reason for your choice in a few sentences.
>
> Yes, in some cases implementation of GMs into the SF helped in identification of past geological processes, especially in terms of conductive pathways in the subsurface (CO2 seeps, He content). Also connection between veins of polymetallic mineralization and SF features appeared helpful in understanding the systematics of the mineralization system and enabled new mineral discovery. But in many cases the actual correlation between e.g. seismic activity and fault activation could not be found.

84. *In this case study, was the incorporation of Geomanifestations successful in helping identifying specific/potential management issues in the subsurface? E.g direct/indirect conflicts of use; zones of influence; areas of potential reuse and synergies; potential hazards etc… (please discuss multiple options if necessary).*

> * Please explain your answer in a few sentences.
>
> Yes, e.g. they allowed for new metal ore resources possibilities identification which may cause conflicts with other potential use of the area of N Luxembourg. The analysis related some phenomena to SF features, but, on the other hand, in some cases actual connections were hard to find.

85. * *In this case study, what are the issues/barriers concerning the application of Geomanifestations? e.g large scale, large amounts of geological data, time consuming etc…*

> * Please explain your answer in a few sentences.
>
> The problem is the reliability of the existing GMs inventories in the studied area. Proper interpretation seems to be time-consuming and requires a decent geological knowledge. Interests of countries of the region are normally focused on different things and spatial coverage of existing data repositories differs between them.

86. * *In this case study, have you identified any fundamental issues / show stoppers regarding the application of the Geomanifestations?*

> *Please explain your answer in a few sentences.
>
> Although GMs look informative placed on the SF scheme, the proper interpretation of them still needs experts involvement and in many cases statistical and spatial analysis not only on a particular underground project scale, but broader. Incorrect interpretation may lead to erroneous conclusions, e.g. presence of He indicates one processes but yet it's isotopic ratio is related to something else; ground subsidence may be caused by tectonic or karst processes, but also can be caused by former human activities. Some of those factors may be acceptable in case of one projects but completely not for other applications.
>
> Some problems may be also seen in the quality of data and reliability of them.

87. *Do you have any further recommendations / suggestions which would benefit the application of the Geomanifestations in this case study?*

Please explain the reason for your answer in a few sentences.

If the tool is to be used by non-experts, it is recommended to prepare some kind of guidelines how to use the GMs knowledge for subsurface conditions interpretation. E.g. the fact that presence of He indicates something else than specific isotopic ratio in places of its occurence is a kind of wisdom not necessarily apparent even for geologists. Relation of earthquakes to activity of faults has been also considered like not always obvious.

Structural Framework and Geomanifestations integration

Do you agree with the following statements :

88. * *The structural framework model annotated with geomanifestations enhances our understanding of the subsurface*

☐ Strongly disagree | ☐ Somewhat disagree | ☐ Somewhat agree | ☒ Strongly agree

* Please explain the reason for your choice in a few sentences.

The Geomanifestations are a specific indicator of geological phenomena taking place in the earth's crust. The correlation of the processes of geomanifestations with Structural Framework leads to a broader view of the geological structure of the R2R area, which translates into wider interpretation possibilities. The use of a model from regions with a well-recognized geological structure can be transferred to regions with a less recognized structure, where they can help to better assess it in terms of the use of subsurface. The advantage of this model is that it does not incur high costs, as would be the case with full geological exploration using drilling.

89. * *The Structural Framework benefits from the incorporation of Geomanifestations into the model*

☐ Strongly disagree | ☐ Somewhat disagree | ☐ Somewhat agree | ☒ Strongly agree

Please give additional information if necessary.

90. * *The Geomanifestations benefit from the context of the Structural Framework*

☐ Strongly disagree | ☐ Somewhat disagree | ☐ Somewhat agree | ☒ Strongly agree

Please give additional information if necessary.

Spatial analysis of gathered GMs with reference to SF features definitely gave new views on their origin, performance and enable their use as an indicators for geological and other processes and in the future can be probably used also as conflict/synergies indicators too.

91. *What barriers prevent both methodologies working (efficiently) together?*

* Please explain your answer in a few sentences.

The reliability of data especially acquired in the past

92. *Overall, has the methodology been applied successfully within the selected area, fulfilling the aims it set out to achieve? Please give a rating out of 10 and offer a brief explication in the box below.*

'The prime aim of GeoConnect³d is the conversion of geological data into subsurface information and critical parameters that can be used for various geo-applications, decision-making and subsurface spatial planning.'

☐   ☐   ☐   ☐   ☐   ☐   ☒   ☐   ☐   ☐
1   2   3   4   5   6   7   8   9   10

*Please explain the reason for your answer in a few sentences.

The R2R exercise showed which kind of data is needed for proper preparation for subsurface space management and tried to put this data together in a manner that one type of data can contribute to the knowledge the other types bring. This was supposed to create easy to read picture benefitting from all kind of information available. The unknowns about linking the vocabulary sheets with the SF and GMs spatial features make it hard to say if really all that has been described in the report really CAN be deduced from the system (which still is not in operation). The shortages of the 3D presentation, which results in lack of knowledge of depth and thickness of presented SF elements in our opinion is the main disadvantage which hinder the use of the SF in subsurface planning process.

The innovation of use of a broad range of GMs in relation to SF features seems to be very promising, but needs still a lot of work to enable its use in a unequivocal manner, which really would allow for beneficial contribution in subsurface management at least at some stages of planning.

Other Questions

93. *Does the methodology offer additional benefits which were previously unaccounted for?*

Answer :

Not really, but the case study showed how much is still to be done in the future.

94. *Has the methodology opened up new opportunities for further development, exploration or valorisation?*

Answer :

Yes, in our opinion, the proposed approach, in contrary to traditional, emphasize the features important in subsurface use planning and risk management. Connecting a tectonic history with phenomena observed on the surface or in boreholes, understanding their interactions can contribute definitely to the better picture of the whole system behaviour and consequently may enable predictions of the induced behaviour changes. But the whole thing must be completed with the 3D aspects visualisation/presentation in order to have an idea about the actually available volume of space. GM introduction needs to be better defined with a kind of cataloque of its possible use - meaning 'which shows what'. It may appear that this GMs indicative role can be area specific, which will even more comlicate the SF tool population.