Appendix II: Evaluation Questionnaires for Pannonian Basin 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:**	**Ales Havlin / Vit Hladik**
***Organisation:**	**Czech Geological Survey**
***Date:**	**23/09/2021**
Case study evaluating** ***(please highlight):	Roer-to-Rhine | Pannonian Basin | Ireland | Molasse Basin

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

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

This has been successful for the Pre-Tertiary basement where the use of four levels of detail proved helpful for general understanding of the geology of the area. The approach apparently did not work for the basin fill as such.

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

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

The subsurface applications are mostly related to the basin sediments, so the SF applied to the bedrock can only have a limited role in providing the needed geological context.

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

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

Similarly to point 2, the subsurface mgmt. issues are mostly related to the basin fill while the SF was applied to the bedrock, so the support of the SF itself to identifying and resolving these issues is limited.

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…*

* Please explain your answer in a few sentences.

According to the authors, the main issues were data accessibility and harmonization, time consuming processes to compile large amounts of data and information and methodological issues related to different approaches of different authors (the study area covered territories of 9 countries). We do not see any reason to question these statements of the authors.

5. * *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. SF was found unsuitable for the thick sedimentary sequences of the basin fill (similar finding to the Molasse Basin in Bavaria).

6. *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. The main question is if the SF is or is not applicable to the sedimentary sequences of the basin fill (even if in a limited extent). The idea to use the individual sub-basins as a basis for the SF has been rejected by the authors for reasons explained in the study, which we find impossible to challenge without good regional geological knowledge. On the other hand, if the SF is not applied to the basin fill sequences, its utilization potential is strongly limited in our opinion.

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

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

Yes, good cases are identified in this case study in all pilot areas (e.g. mineral waters, thermal waters, mofettes, coal, seismic events).

8. * *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.

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).*

* Please explain your answer in a few sentences. Yes, there are good examples of this identified in the report, including hazards, zones of influence and potential conflicts of use.

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…*

* Please explain your answer in a few sentences: In our opinion, successful implementation and utilization of individual geomanifestations deserve a detailed scale of processing, which is demanding not only in terms of time but also in terms of the volume of data processed.

11. * *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.

12. *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.

No.

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

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

Every relevant piece of information increases our understanding of the underground environment. The study, however, rather gives the impression that current knowledge and understanding of the subsurface was used to apply the structural framework and interpret geomanifestations. Added value of the new methodology is indicated in a rather general way, and concrete examples are rather scarce.

14. * *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 approach of the authors was rather to explain / interpret geomanifestations as "manifestations" of the structural framework. A few examples of benefits that geomanifestations might provide to the SF are indicated but not described in more detail.

15. * *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, especially for geomanifestations that are directly linked to the bedrock-related SF.

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

* Please explain your answer in a few sentences.

The main barrier is related to the absence of the SF for the basin fill, which does not allow for efficient linking of some types of geomanifestations to the SF.

In addition, other barriers are the time required, the large volume of diverse data to be processed and the need for a broad team of geologists of different specializations, as knowledge across geology is processed (geology, structural geology, hydrogeology, geophysics, geochemistry and many others).

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

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

The pilot case study areas were well selected and thus provided a strong case for further development of this approach as a suitable tool for decision-making and subsurface spatial planning. On the other hand, the authors were able to apply the structural framework only to the Pre-Tertiary basement, and not to the basin fill itself. This, in our opinion, represents a significant limitation of application of the methodology to the Pannonian Basin area, and probably also to other areas with similar geology.

Other Questions

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

Answer:

Not identified.

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

Answer :

Yes, but the issue of its applicability to deep sedimentary basins needs to be solved. Moreover, its possible exploitation should be tested on practical cases where concrete subsurface mgmt. issues were observed / studied.

WP5 - T5.3 Learning from the case studies

Important information

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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:**	**14/09/21**
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. The selection of the pre-Cenozoic as the reference horizon allows the deeper geology to be displayed in a clear and understandable way that only a structural framework could achieve

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.

Providing the subsurface applications are targeting the pre-Cenozoic, then the structural framework is an excellent tool for putting disparate national systems into context

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.

The single unified nomenclature that the structural framework provides are the first step in the discussions needed to resolve conflicts

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.

The framework as derived here relied on deep geophysics, which had a patchy availability.

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, although with the framework relying so heavily on geophysics rather than established historical mapping, it would be nice if some kind of confidence could be communicated e.g. a data density map

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. As stated in 5., I would like to see a data availability map.

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.

Even at the most simplistic level related in the report, dividing the geomanifestations into those directly linked to the structure and those indirectly linked to the structure in valuable.

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.

The identification of convection cells using the geomanifestations is a great success of the method

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. I believe that this report shows that potential subsurface management issues are already evident and somewhat understood in the region, and that this work focused on providing a greater understanding to solve these issues rather than identifying new ones.

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. Lack of density of data as well as heterogeneity in data availability

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.

No, the methodology has been well applied

27. *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.

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.

The ability to clearly distinguish between geomanifestations directly linked to the structure and those indirectly linked is a great success for the combined 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 combined product as a whole is improved by the incorporation of geomanifestations, but I do not believe that the geomanifestations were used to improve the SF

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.

Interpreting some of the geomanifestations without the context of the structural framework is impossible

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

* Please explain your answer in a few sentences.

Lack of data density

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.

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

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

Answer :

The clear presentation of the Pre-Cenozoic geology is a tremendous tool that was not previously available

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

Answer :

I think areas for further study have presented themselves, and the SF provides something that can be confirmed or disproved with further geophysics.

WP5 - T5.3 Learning from the case studies

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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:**	**23.09.2021**
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. As the introduction shows, the geology of PB basement is very complicated due to tectonic history of the region. We are not sure if the implementation of SF makes the geology more understandable, but for sure it brings the simplification which makes the subsurface area manageable. It also enabled harmonization of ideas and concepts between countries and institutions involved which brings the opportunity for better mutual assessment in the future of possible impacts and synergies of activities and planned activities in subsurface, which is which is undoubtedly essential especially in near borders regions. A general multiscale hierarchy system of the structural framework in our opinion in the Pannonian basin case works the best out of all cases (maybe it's thanks to geology but authors really implemented this tool in a very smart way).

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.

The presented SF image is legible and described according to the available state of knowledge and interpretation of the collected data and materials. However, the geological structure of basement formations in this region is very complicated and of substantially varying depth and for subsurface management purposes presentation of the 3D aspects is crucial.

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.

Pannonian Basin SF presented as the case study result harmonised the multi-country view of big area, which will already help in identifying issues relevant to particular subsurface uses and their interactions. The exercise done showed that interdisciplinary approach for interpretations of data is helpful not only when one focuses on something but also in simplifying complex issues, when such simplification must take into account different aspects.

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.

- the hugely alternating level of knowledge of the subsurface at different parts of the basin;
- different and unharmonised geological nomenclature;
- varying data policies (public geoscientific data rarely available, many subsurface data confidential);
- thick Neogene cover of the subsided basement Units which are supposed to build the SF
- limits studied mostly by geophysics which makes them disputable
- some problems with no-name limits, which got names only after appearing in the FDB of HIKE(?)
- combining dataset of different level of resolution;

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.

The lack of 3D visualization of SF features in many parts of the Pannonia Basin area and problems with formations nomenclatures between countries and availability of public data (some of data confidential).

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.

Definitely 3D aspect implementation like in every other case.

Maybe also presentation issued related to activity/non-activity of faults (e.g. a kind of pre-assessment of a possible impact on different applications)?

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.

The set of GMs chosen in this case study seems to well contribute to the understanding of processes, especially in connection with the SF. Due to the lack of sufficient data not in all cases this identification is 100% apparent, which requires constructing several possible scenarios, but it still brings one closer to the geological system understanding.

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.

According to authors, this was the first exercise of this kind, it required interdisciplinary interpretation of observed phenomena which definitely enabled better understanding of geological history and contemporary processes.

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.

Analysis done by the authors clearly show that studying and understanding the GMs can definitely help I better subsurface management - in terms of stability of resources (like in case of CO2 content in commercially used mineral water), possible conflicts of use (when two or more assets are present in the same region, like mineral water and hydrocarbons) and natural hazards (when e.g natural seismicity may indicate a threat of possible induced events in case of underground injection projects). However the SF+GM tool still cannot replace detailed recognition targeted to particular type of subsurface use, it can only show necessary areas to be further investigated.

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. Only part of identified GMs can be linked directly to SF, the rest is associated with thick Neogene cover. There is the limited access to archival data (especially the deep geophysical datasets created in hydrocarbons exploration) and lack of 3D models. Difficulties in assigning GMs to particular faults as faults zones themselves are not sufficiently defined because of scarce data. Also different resolution of available datasets makes it necessary to be very careful in interpreting and creating hypothesis. Large area and transboundary aspects create problems with harmonisation of datasets.

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. It seemed that the main difficulties in this case was correct interpretation of different geological datasets (in terms of scope and resolution) as well as harmonization of nomenclature between different countries

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. We agree with the authors that in future it is essential to extend the information to 3D – to regionally link the geomanifestations and extent of fault zones to the elevation and geological formation in which they occur or in which they originate from. Also, as everywhere, furher data aquisition and analysis are needed.

<u>Structural Framework and Geomanifestations integration</u>

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's clearly stated that only joined SF/GM data revealed clear interconnection of some geological processes (of which most were already assumed, but not so much interpreted in the past), e.g. active fault zones and deep fluid emissions, regional convection in fault zones, etc.

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. Yes, it's been proven that some GMs presence can indicate the actual features of subsurface structures that cannot be assessed based on e.g. geophysical data - e.g. noble gases and deep CO2 presence in groundwater suggest lack of fault sealing, conductivity of some non-fault structures. The later can be also evidenced by the unusual temperature gradient, etc.

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 this case combining some of the GMs, these of positive economic value, like thermal and mineral water or mofettes, with the SF will help in better understanding of their origin and character as well as mutual dependences thus will enable more correct management and use of resources.

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

* Please explain your answer in a few sentences. As in other cases - the lack of sufficient data which makes necessary to create several theories/models of GM/SF interaction.

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 sentences.

The Pannonian Basin case study showed that despite complicated geological structure, the developed SF framework and the identified GMs can be a source of information for the analysis of potential conflicts and synergies in the use of subterranean formation. The problem is - how much of the interpretations presented in the report can be done based of the SF+GM+vocabulary tool, that will be presented by the GIP-P and how much is additional expertise of the authors?

Whatever the answer is, further development covering 3D visualisation of the SF features is necessary. Noteworthy is also the proposal to extend the research to include additional studies of noble gas fumes from groundwater wells.

Other Questions

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

Answer :

Also this example shows that not all of the occurring GMs may be directly related to the SF features and that careful study is needed while choosing a set of GMs to support interpretations of geology in a certain region.

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

Answer :

The exercise showed a need for multi-aspects analysis while interpreting geological system in order to use it for big scale applications. Traditionally, applied geology research was limited to mineral resources prospection, exploration and production. New challenges related to resource exploitation understood not only as mineral extraction make it absolutely necessary to study the whole system with regard to all the assets it contains and its vulnerability to different kinds of pressure. Combining of structural features with GMs which are symptoms of processes active in a system in a SF+GM two stage approach tool does not answer all possible questions (at least at a present stage) but can show proper directions for further investigations and assessments.

WP5 - T5.3 Learning from the case studies

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***Name:**	**Johanna Van Daele**
***Organisation:**	**VPO**
***Date:**	**20-09-2021**
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

The Structural Framework (SF) of the Pannonian Basin represents a new and unique of visualizing the basement of this complex sedimentary basin, which certainly will aid in the geological understanding of the area. A lot of previously unknown faults ("latent limits") were identified and named during the construction of the SF. Also the result of a uniform, cross-border nomenclature is extremely useful for discussions and straightforward information sharing between different countries.

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 has been constructed for the whole Pannonian Basin, on multiple zoom levels and using a consistent methodology. This results in one coherent framework in which (future) subsurface applications can be implemented, or from which information regarding the potential of different subsurface applications can be inferred. The relevant zoom levels play a key role in this.

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

The Structural Framework provides a coherent and high-quality framework of all faults, subbasins, … in the Pannonian Basin. This provides relevant background knowledge when a particular problem would be observed and to be solved. However, I cannot see the SF itself (stand-alone) having an important, immediate support in realistically identifying subsurface management issues on beforehand. Of course, the combination of SF + GM does (see below).

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 SF of the Pannonian Basin seems of excellent quality, not showing any major barriers to be applied. As mentioned by the authors, the fact that it concerns a SF for the *basement* of the Pannonian basement, implies that it had to be built with the limited reliable and good-quality information that is (freely) available.

Another minor drawback could be the difference in data quality/resolution of the literature sources, maps, datasets, … that were used to construct the SF. It is not clear how successful the harmonization was on that regard, and what implications this has on its usability & interpretability. In any case, it is difficult to assess the importance of this aspect, as not much information is been given on the data sources and how data was extracted from these.

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

No.

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

As mentioned in the report, additional information from the deep subsurface (additional seismic lines, boreholes, …) could improve the overall quality and resolution of the SF, especially in areas that have less data-coverage. Also incorporation of the 3D aspect would be beneficial for its applicability.

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

All Geomanifestation (GM) types that have been collected for the three pilot study areas in the Pannonian Basin, identify one or more subsurface process(es) in the basement that influence the occurrence of these Geomanifestations. Often, the Neogene sedimentary cover was observed to play a role as well.

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

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

Certainly. For example, fundamental processes like convection cells and the numerical modelling of temperature variation with depth could be identified/realized based on the inventory of thermal water occurrences. Also, general water geochemistry data (e.g., in Bosnia and Herzegovina) provide valuable hydrogeological information. The collected Geomanifestations are a great help for predicting geological potential more accurately.

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).*

Yes! The Geomanifestations (in combination with the Structural Framework) can be useful for safety matters (e.g., necessity blowout preventers, risk for induced seismicity, …) and defining optimal operation parameters (e.g., preventing scaling or overexploitation), for evaluating potential conflicts of use between different subsurface exploitation activities, and for sustainable management of subsurface resources, particularly in cross-border cases.

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…*

Some Geomanifestation types were only inventoried for a part or some of the pilot study areas. This potentially can lead to mis-interpretations if not documented well (as blank spots on the map do not necessarily correspond with an absence of Geomanifestations).

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

No.

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

In this case study, Geomanifestations were only inventoried for three sub-areas of the Pannonian Basin. This implies that subsurface management issues can be tackled/investigated only for a limited area with the aid of the Geomanifestations approach. Expansion towards the whole Pannonian Basin might increase the impact and applicability of the GeoConnect³d databases significantly. Of course, that is a quite time-consuming task.

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

The combination of the SF and GM databases is particularly helpful in this case study to identify processes (and the interplay between processes) in the subsurface.

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

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

The Structural Framework was designed completely independent of the Geomanifestations. The earthquake hypocenter dataset potentially would become more useful to refine the SF once a 3D-aspect is incorporated.

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

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

The Structural Framework is the main aspect that is taken into account for the interpretation of the Geomanifestations. The occurrence of most Geomanifestation types is linked to regional fault zones, although for some of them, the Neogene sedimentary cover (which is not included in the SF) is also of importance.

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

In general, the connection between the two methodologies works really well. In the areas without clear spatial/causal link between SF and GM (or none at all), this usually is due to a geological barrier, i.e. the thick Neogene cover. A solution would be to expand the SF with this Neogene part. However, it is mentioned in the report that it is difficult to adopt the methodology of the Structural Framework for this geological situation because of its specific and rather homogeneous characteristics.

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

The Structural Framework and Geomanifestation databases of the Pannonian Basin are a very nice example of how geological data of multiple sources can be harmonized and put together in a functional, coherent framework, that can lead to new knowledge on the subsurface. Additionally, this new fundamental knowledge is extremely relevant for assessing the overall subsurface potential of the Pannonian Basin, identifying potentially upcoming issues, which all facilitates a more safe and sustainable exploitation of the subsurface.

Other Questions

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

Answer : /

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

Answer : In my opinion, no immediate development opportunities other than those mentioned above concerning subsurface management (issues) can be detected