Application of a novel geological risk mitigation scheme in the Danube Region

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ABSTRACT

During the completion of DARLINGe project a novel geological risk mitigation scheme is under development. The creation of the scheme started with the identification of possible damages occurring at given project's phases (during drilling, testing or operation) and a retrospective evaluation of risk events through follow on event(s) that might result the given damage. When a risk event is known, the connected risk avoiding, and mitigating measures can be described including conditions, timing and proposed monitoring activity. The result is a comprehensive listing of mitigation measures according to project phases. The list of each phase includes (1) the damage to be avoided, (2) the risk event and follow on events, (3) mitigation measures to be used, (4) conditions of mitigating and (5) possible amending activities to be applied at a later phase. The application of Danube-GRSM is tested at 3 cross-border pilot areas in the DARLINGe project, which includes definition of a theoretical project, data collection, comprehensive geological evaluation, reservoir assessment, geological prognosis of the future doublet(s) as well as hydrogeological modelling.

1. INTRODUCTION

The main aim of the DARLINGe project (Nádor et al., 2019) is to support the enhanced and efficient use of geothermal energy in the Danube Region, at the southern part of the Pannonian Basin. One of the project objectives is to establish a market-replicable tool-box for sustainable geothermal reservoir management, especially in transboundary settings. One module of the tool-box is the Geological Risk Mitigation Scheme tailored to the needs and to geological as well as socio-economic conditions of the Danube Region (Danube-GRMS).

Danube-GRMS deals with subsurface uncertainties on a transparent and efficient way during a geothermal project development. Due to the wide complexity of geothermal projects, certain simplification was applied promoting the easier understanding of the scheme. The Danube-GRMS deals only with geological risks (both short and long-term), which are connected to subsurface properties and are evaluated primarily by geoscientific experts. The scheme is focussing on conventional use of geothermal energy, so artificial reservoir creation, like EGS (Engineered Geothermal System) is not part of the discussion. Further consideration, that risk transfer and sharing are not discussed, because these are not mitigating activities.

2. RISK MITIGATING ACTIVITES OF GEOTHERMAL DEVELOPEMENTS

Risk mitigation is a type of risk treatment, that deals with the avoidance of negative consequences. In general, everyone thinks in first instance that the aim of risk treatment is risk mitigation. Which is seemingly true, because the active steps of risk treatment are mostly mitigating activities, and the risk increasing activities are less pronounced, because these are kind of "harmful" activities, which are not the most advertised deeds in geothermal. For example, the decisions initiated by cost and time constraints one way or another are used to decrease the original technical content of a project, which will result higher uncertainties, and thus higher likelihood of damages.

All risk mitigation activity is costly measure. While the actual cost of an activity could be defined by tolerable accuracy, because it consists of some services and of use of some devices and materials, the evaluation of real contribution of a mitigating measure to the success of a project is problematic. And this is quite difficult task during geothermal exploratory activities, because on one side the confirmation of success is available quite late, after performing numerous costly construction activities, on the other side the limited access to the subsurface hardly ensures obvious verifications. Due to complexity of measures and deficient visibility of subsurface it is way too difficult to decide what is the exclusive role of a mitigation measure in the success of the project. In addition to there are numerous mitigating measures, which's usefulness could be decided adequately after long term operation. Beside the cost the mitigation activities have effect on project timeline too, in addition to the application of a given measure might call for special conditions and might have adverse effect on the success of other activities, including risk avoiding measures.

Concerning activities like estimation, evaluation and design, which are based on geological data, a request for second independent opinion is always an available tool for increasing the reliability of geological knowledge, which will decrease the risk stem from the uncertainty of subsurface data.

The application of a given risk mitigation measure is result of a decision. The development of a geothermal project is full of opportunities, when these actions could be made. The risk owner is responsible for the decisions, which has effect on the project development, and thus on the success of the project. The risk owner should make an informed decision, which might contain risk acceptance or risk mitigation measures. The decisions should be documented and contain reasoning, which helps later what was the conditions and considerations when the decision was made. The latter will provide indispensable information to evaluate what kind of lessons were learnt after the completion of the project. When a mitigation measure is applied, the monitoring of completion of the measure and its consequences is strongly recommended.

Decisions during the project development might have such a consequence, which is narrowing down future opportunities and thus reducing the freedom of choice later. The risk owner should be aware of irreversible, or quasi irreversible character of consequences to accept them and to arrive on a decision accordingly.

3. METHODOLOGY

Danube-GRMS's methodology is based on the identification and description of a series of mitigation measures to avoid possible damages during the completion of an idealised, conventional deep geothermal project in Danube Region both in porous and fractured reservoirs. The scheme is dealing with one idealised project, which consists of planning and drilling of a doublet (one production and one injection well), connecting the wells and circulating the fluid via heat exchangers for heat and/or electricity production. Most of the measures are identical for the porous and fractured reservoirs, but there are several, which are different, and these are indicated accordingly.

After the setting of above-described conditions, the first step of creation of the scheme was the identification of damages (see Figure 1). The damage is defined as a result, which differs from the expected results, and creates increase in original project costs or decrease in future, planned income of the project. A damage could be observed during drilling process, during production testing, or during operation. The declaration of a damage is based on the observation of some proofs, which verifies the presence of it. One damage could be verified based on different proofs of different project phases.

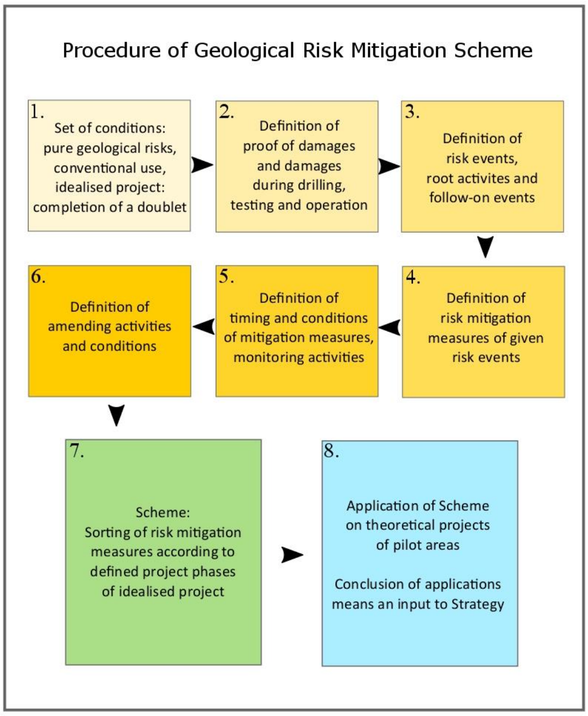

Figure 1: Procedure of creating of Geological Risk Mitigation Scheme in DARLINGe project.

The next step was the retrospective identification of risk events and theirs follow on events from the direction of a given damage. There are numerous risk events, which might result the same damage, and there are risk events, which might result different damages. The risk events were defined as pair of "if" and "then" relation. The most frequent events are connected to unforeseen subsurface condition, poor exploratory data and inaccurate evaluation of subsurface data. All these conclude different damages via different set of follow-on events. The location of wells of doublet might be improper due to inaccurate modelling or inaccurate verification of reservoir model or inadequate testing. The precondition of a given risk event, like a root activity is defined as well.

When a risk event is known, then the connected risk mitigation measure(s) could be defined. For the design of a measure the timing of application and the conditions was indicated as well. In case of a damage is result of chain of events, the mitigation measure should avoid the evolvement of the chain by the breaking the chain at the most critical and most managable link. Sometimes a risk event directly results the damage, so the mitigation should focus on the risk event itself. The mitigation measures could be grouped into different activities like (1) interpretation of geoscientific data, (2) collection of new geoscientific information, (3) technical activity, (4) hydrogeological modelling and (5) monitoring activity.

Taking into consideration of the gravest damage, the loss of well, the mitigation measures are almost exclusively focussing on proper data collection, interpretation and on procurement of new geoscientific data by new measurements in case of poor exploratory data. The reliability of exploratory data and its interpretation is quite relative, but the use of second opinion gives an opportunity for the risk owner to decide the need of further analysis and measurements. The avoidance of the situation, when the proven amount of energy is lower what previously was expected, calls for numerous mitigation measures of different kind. Besides the increase of reliability of data and its interpretation, there are numerous technical considerations, which's application decreases the likelihood of having risk events. The temporary damage, the pending of operation might be avoided proper hydrogeological modelling, which is based on sound data collection, especially during the production test of well(s). The cost increase in operation might be avoided mostly by technical measures and accurate data collection and interpretation.

There are kind of amending activities which might cure given damages. In geothermal the lack of water-bearing layers in the already drilled production section might be amended by drilling on deeper, if conditions allow this opportunity. The underperformance of wells might be amended by use of stimulation methods, like thermal, chemical or hydraulic stimulations. These activities are not part of risk mitigating measures, because these are performed after the damage has been observed. But these activities could be performed if certain conditions have been fulfilled previously. So, the integration of conditions of amending measures during the completion, as precautionary activity is indispensable prerequisite to decrease the size of negative consequence after it was observed. The amending activities are quite limited opportunities compared to mitigation measures, in addition to many of them could be completed only when certain conditions are fulfilled previously. The application of further drilling, stimulation and coil tubing have technical preconditions, while other measures, like decrease of production or compensation of receptor(s) have no such. Of course, all the amending activity has financial consequences.

When the list of mitigation measures by damages was available, then the restructuring of the risk mitigation measures could be made according to project phases. This form of the Scheme would give a guideline for a project developer to identify what kind of mitigation measure could be made in due time at given project phase to avoid different possibly appearing damages.

Figure 2 presents the defined phases of an idealised project. The indicated project phases are not exactly subsequent phases. Most of them are running parallel, but at given periods, these have definite roles. So, the actual work of each phase might start earlier, or last later compared to the period, when the actual, responsible work is performed. The figure indicates the responsible partner of advice or service at each phase.

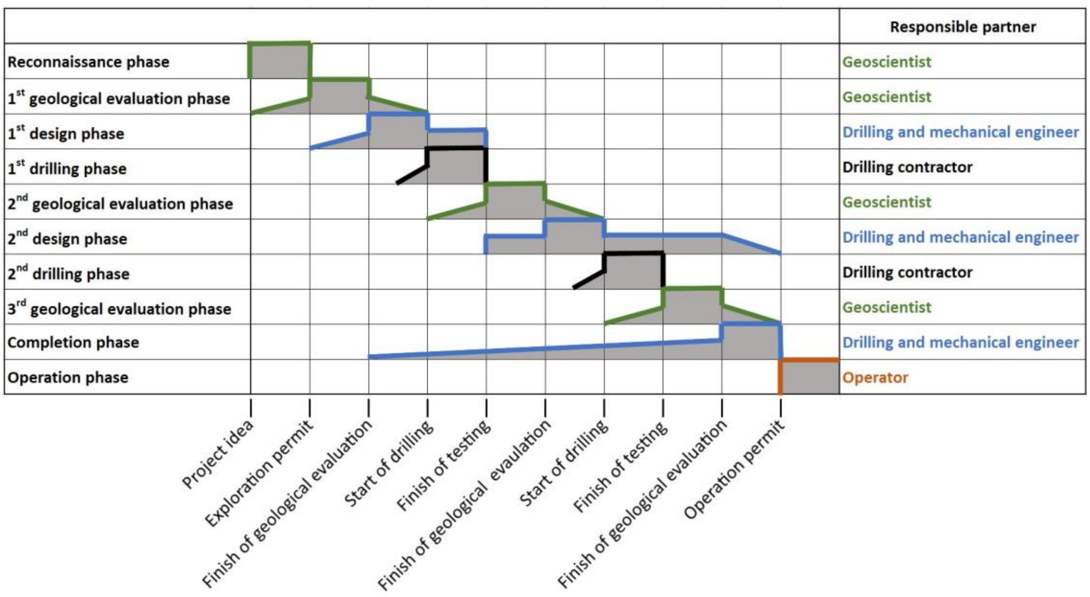

Figure 2: Phases of idealised project.

4. RESULTS OF THE SCHEME

The result of the Scheme is the listing of mitigation measures according to project phases instead of damages.

4.1 Reconnaissance phase

The reconnaissance phase is the earliest phase of development, which starts from the project idea and lasts until the decision to obtain an exploration permit or not. During this period the collection of easily procurable existing data, maps, literature, reports and performance of quick and cheap chemical analysis are part of data gathering. Based on above-mentioned data and site visit an evaluation is made about the features of a resource and profitability of a theoretical development. The evaluation might include proposal concerning further steps and exploration activity. The risk owner can use the result of reconnaissance study to justify her decision on securing exploration permit by further investment. As the main challenge of this phase is to accept the financial risk of exploration permit based on available data, the mitigation measures have very limited role during this time, thus these measures are not described here. If a risk owner is not satisfied with the outcome of the study, she can ask for an independent second opinion.

4.2 1st geological evaluation phase

This phase covers data gathering and interpretation activities made exclusively by geoscientists. This phase theoretically starts in the reconnaissance phase and last until the drilling, but the main activity is made between the approved exploration permit and the start of the design phase. The main challenge of geological evaluation during this period is to provide reliable data for the design of first drilling and of surface systems. In this phase all mitigating activity is connected to data. On one side the access to available data could be improved or new data could be collected.

4.3 1st design phase

The design phase is after the geological evaluation, in which the drilling engineers and mechanical engineers have the leading role. The most important outcome of this phase is the plan of drilling or drilling program. The measures are focussing on yield predictions, hydrogeological modelling and design of production section. It is necessary to bear in mind that most of the mitigation measures to be completed in the next drilling phase(s) should be designed in advance, in the relevant design phase.

4.4 1st drilling phase

The drilling phase is when the active onsite work of drilling is running. It starts from the mobilization of the rig and lasts until the finish of operation of end of drilling (OED), which period (OED) covers the testing activities in general. During the operation the drilling contractor has the highest responsibility to secure the safe and professional work, while the risk owner has the right to supervise the activity of drilling company. This way the risk owner can check the compliance of planned and performed activities, and she can act in due time, when decision is needed to deviate from the planned activities triggered by the appearance of a new information. The mitigation measures of this phase are technical activities, like adequate chemical sampling and analysis, or clay mineral-free drilling, or drilling long enough production section, or avoiding cementing of production section etc., of which should be designed and/or procured prior to the actual application.

4.5 2nd geological evaluation phase

The 2nd geological evaluation is based on the data collected during the completion of first drilling. The responsible person of the evaluation is geoscientist. The result will be used in the planning of next drilling and surface facilities. The mitigation measures of this phase are connected to hydrogeological modelling including data collection and interpretation, and adequate evaluation of corrosion and scaling potential.

4.6 2nd design phase

The second design phase is based on the data of 2nd geological evaluation. There is no explicit mitigation measure identified for the idealised project, which might be performed during this phase. Meanwhile, the design of technical measures of subsequent drilling phase should be done in this phase.

4.7 2nd drilling phase

The period of 2nd drilling is like 1st drilling’s one, it starts from the mobilization of the rig and lasts until the finish of OED. Besides the general technical measures of the 1st drilling phase, there are two additional measures (1) in case of porous aquifer the production section of the injection well should not contain fine grained sediments, (2) performing adequate interference or tracer test for securing information for verification of hydrogeological model.

4.8 3rd geological evaluation phase

The 3rd geological evaluation is based on the data collected during the completion of second drilling. The only one and most important mitigation measure of this phase is the update of hydrogeological model by the help of data procured during the interference and tracer tests.

4.9 Completion phase

The completion phase covers the activities of surface works excluding drilling activities. During this phase only one mitigation measure, the adequate filtering of produced water could be made.

4.10 Operation phase

The operation phase is when the construction is finished, and the plant is working continuously according to the approved operational permit. The mitigation measures of this phase are technical activities connected to regular control and maintenance, like adequate filtering of reinjected water, regular checking and maintenance of the wells, monitoring of different properties of produced fluid.

5. APPLICATION OF THE SCHEME

During the implementation of DARLINGe project, the above described Geological Risk Mitigation Scheme is being tested on pilot areas. The completion of testing includes the below listed activities:

1. Definition of a theoretical geothermal project, including production parameters, expected damages, type of aquifer etc.
2. Definition of needed data and data collection
3. Geological evaluation
4. Reservoir estimate
5. Geological prognosis for drilling of a well
6. Conceptual and hydrogeological model
7. Definition of risk mitigating activities according to the time line of a project

The first six activities provide information about the subsurface to evaluate, what kind mitigation measures of the scheme are recommended for supporting the theoretical development.

The scheme was tested on three cross border pilot areas: (1) Hungary-Romania-Serbia, (2) Croatia-Hungary-Slovenia, and (3) Bosnia and Herzegovina-Serbia.

Based on the performed testing on the pilot areas the amount of available data has the strongest effect on the selection of mitigation measures. When the amount of available data low and/or poor quality, the recommended mitigation measures are rather connected to data interpretation and procurement of new data to increase the predictability of circumstances of subsurface. When the amount of availability data is significant, and the parameters of the subsurface is known with high likelihood, the mitigation measures are rather connected to the proper use of hydrogeological modelling to avoid the conflict of existing thermal water use, which are the source of above-mentioned enough data for evaluation. The flow of a development is also recognisable amongst the identified measures, because in early phase the data collection, analysis and procurement are dominating, during drilling mostly technical measures could be made, while in the phase of operation the monitoring measures are characteristic.

6. CONCLUSIONS

In the frame of DARLINGe project a geological risk mitigation scheme is under development, which is focussing on pure geological risks. The outcome of the scheme is a set of measures to be made on a given project phase to avoid identified risk events. Taking into consideration of available knowledge of an area the user of the scheme could narrow down relevant measures to be used to increase the success rate an idealised project. There is an opportunity for further development of the scheme by the integration of legislative (permitting), financial and market-related risk mitigating measures, by which an overall risk mitigating tool might be established.

REFERENCES

Nádor, A. et al.: Danube Region Geothermal Strategy and Information System to support the decarbonisation of the heating sector, *Proceedings of the European Geothermal Congress 2019*, Hague, Netherlands, (2019), ID 179, Policy.

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