Performance assessment of plugs and seals

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This presentation gives an overview on the work in work package 5 on "Performance assessment of the plugs and seals systems" of the DOPAS project. The aims of WP5 were to support the experimental work and the construction of the large-scale sealings by predictive process modelling and to understand the implications of the plugs and seal performance on the overall safety for the whole reference period of a final waste repository of one million years. An important element of this work was to develop justification of model simplifications for long-term safety assessment simulations. This includes the objective to improve the state-of-the-art in process modelling and its abstraction in integrated performance assessment.

1 Introduction

The aim of work package 5 on "Performance assessment of the plugs and seals systems" of DOPAS was mainly twofold. The first aim was the support the planning, construction and experimental work of the large-scale demonstrators by predictive process modelling. Another aim of WP5 was to understand the implications of the plugs and seal performance on the overall safety for the whole reference period of a final waste repository of one million years. An important element of this work was to develop justification of model simplifications for long-term safety assessment simulations. This includes the objective to improve the state-of-the-art in process modelling and its abstraction in integrated performance assessment. More specifically the objectives can be defined as follows:

- simulation of processes and their evolution within individual sealing components,
- predictive modelling to support the design and the construction of the large-scale seals,
- modelling of small and mid-scale experiments performed in WP3 to gain process under-standing,
- identification of the main processes that are relevant and thus to be considered for predicting the short and long-term behaviour of the plug and sealing systems,
- identification of remaining uncertainties and their influence on performance assessment,
- development and justification of conceptual models of plugs and seals for the different disposal concepts and geological environments and
- development and application of the PA methodology and integrated PA models to analyse the system behaviour.

Work-package 5 was divided into the following four different tasks which have a different focus. The task 5.1 is mainly on process understanding and has a very strong link to the experimental work performed in work-package 3 and the other work-packages of the project. The task describes the process on a phenomenological basis and its evolution on different time scales. Suitable process models were identified and improved if necessary to perform process models. The large part of the work performed in this task supported the planning and construction of the experimental work. The first task was the largest part of WP5 regarding work and budget. In the task 5.2, conceptual models

were developed striving for abstraction of the process level-work performed in the first. The second task is therefore the link to the third task which finally focused on integrated long-term performance assessment modelling. Integrated models were finally developed and applied in task 5.3 with regard to demonstrate long-term safety and to determine remaining uncertainties and open questions. The task 5.4 was devoted to work package management and reporting.

2 Work performed

This presentation is to summarise the work performed in WP5 and to link to other presentations and posters of the DOPAS seminar were the results are presented in higher detail. Not performed in WP5, but closely related is the work of SKB on predictive modelling for the DOMPLU plug which was performed already prior to DOPAS. The following eight pieces of work have been performed by the organisations participating in WP5 and the related presentations and posters are given in parenthesis.

1. A review performed jointly by Radioactive Waste Management Limited (RWM) and Galson Sciences Limited (GSL) on the state of the art of the treatment of sealing systems in Totals System Performance Assessment (See presentation by D. Galson).

2. The assessment of the water tightness and mechanical integrity of the POPLU experiment by Posiva Oy (POSIVA) to serve as input in the POPLU experiment construction.

3. Predictive process modelling performed by Agence nationale pour la gestion des déchets radio-actifs (ANDRA) of the expected behaviour of the REM experiment, which serves as a metric scale demonstrator of the FSS experiment (See presentation by A. Pasteau et al.).

4. Process modelling performed by DBE TECHNOLOGY GmbH (DBETEC) on the compaction behaviour of sealing materials to be used in the ELSA experiment (See poster by M. Jobmannn et al.).

5. Process modelling of laboratory experiments related to the ELSA experiment to test the mechanical and chemical behaviour of sealing materials by Gesellschaft für Anlagen und Reaktorsicherheit gGmbh (GRS) (See presentation by O. Czaikowski et al. and three posters by K. Jantschik et al., O. Czaikowski et al. and Chun-Liang Zhang).

6. Integration of the processes identified to affect the sealing elements of the ELSA experiment into the integrated performance assessment model by Gesellschaft für Anlagen und Reaktorsicherheit gGmbh (GRS).

7. Process modelling performed by ÚJV Řež a. s. (UJV) for the results from the physical hydraulic model carried out under laboratory conditions as part of the EPSP experiment (See poster by D. Trpkošová et al.).

8. An investigation on options to link demonstrator activities with performance assessment by the use of suitable indicators, performed by Nuclear Research and Consultancy Group (NRG) (See presentation by E. Rosca-Bocancea et al.).

3 Conclusions

Geological disposal of radioactive waste involves isolation and containment of the waste from the biosphere. Containment and isolation can be provided through a series of complementary barriers, e.g. the waste form itself, waste containers, buffer and backfill materials, and the host geology, each of which will be effective over different timescales. As part of the backfilling and closure of a repository, specific parts will have to be closed and sealed. The purpose of plugs and seals will depend on the disposal concept, the nature of the geological environment and the inventory to be disposed. Plugs and seals e.g. may be required to

- isolate emplaced waste from the rest of the underground excavations during the operating phase to limit radiological exposure to the workers,
- support other EBS components until the repository has evolved to its desired state,
- limit groundwater flow and radionuclide migration,
- prevent inadvertent or unauthorized human access.

A variety of modelling tasks has been performed within the work package 5 of the DOPAS project and has been reported in WP5 and WP3 deliverables. The report at hand shortly summarises this work and provide links to all the underlying reports that give more detailed information.

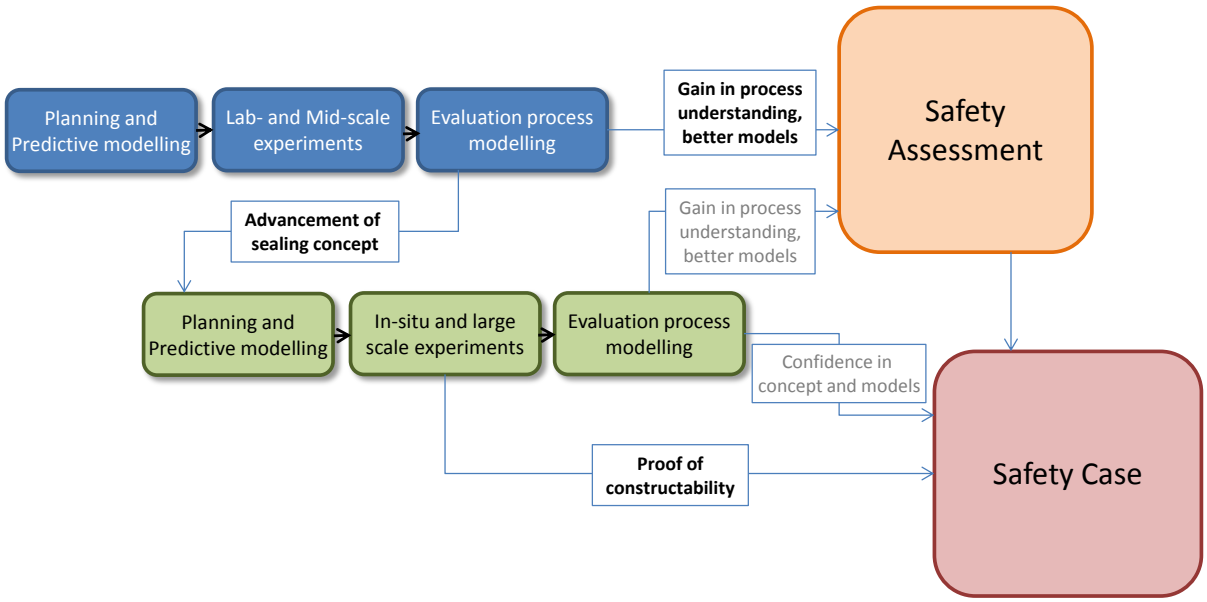

Figure 1: Contribution of work package 5 to safety assessment and the development of the safety case

The DOPAS project and work package 5 contribute significantly to the further development of the safety cases for radioactive waste repositories by bringing forward the plug and sealing concepts in three main host rock types considered in Europe: crystalline rock, clay rock and salt rock. The role of the work package 5 in this contribution is shown in figure 1 and results from predictive and evaluation process modelling of laboratory (blue boxes) as well as in-situ and large-scale experiments (green boxes). The different aspects of the achievements are (white boxes):

- **Gain in process understanding and improvement of models for safety assessment by evaluation process modelling of laboratory experiments:** Process modelling performed of laboratory experiments (work-list number 5 and 7) in work package 5 was able to predict and

interpret the results from laboratory experiments enhancing the confidence in the suitability of the used models to describe the observed processes. The process models were party converted to abstract models that could be included in integrated safety assessment models to achieve a better process representation in future total system performance assessments. Future comparison of the performed predictive modelling on mid-scale experiments (work-list number 3) with experimental results will contribute in the confidence of the validity of the up-scaling of process modelling results from small scale to metric scale.

- **Advancement of the sealing concept:** The process modelling of laboratory and mid-scale in-situ experiments (work-list number 4 and 5) contributed update of the sealing concept and the choice of sealing materials. The predictive process modelling of the in-situ experiment (work-list number 2) directly supported and influenced the layout and construction of the experiment.
- **Confidence in concept and models:** Future comparison of the predictive modelling with experimental results will contribute in the confidence of the validity of the up-scaling of process modelling results from small scale to large scale.
- **Proof of constructability:** All aspects given before jointly contribute to the confidence in the fact that the plugging and sealing systems will develop as planned and will be able to meet their designed function in the overall repository concept.

The high-level design basis of a sealing system (reported in the DOPAS WP2 work) describes the principal safety functions that plugs and seals have to fulfil as part of the overall safety objective of a repository system, typically in a qualitative fashion. The safety functions and performance requirements of the seal which are tested in the DOPAS modelling work of work package 5 are:

- the mechanical stability and
- the hydraulic conductivity, i.e. water tightness of the seal.

The latter is investigated regarding two aspects, either the initial hydraulic conductivity at the time of construction, or its long-term development.

The aim of the process modelling work reported was twofold; the large part of the modelling work was predictive modelling and only a small part was to evaluate experiments. The main use of the predictive WP5 process modelling was to

- design the seals,
- to support construction,
- to predict experiment evolution,
- to predict material behaviour and
- to test models.

The input data which was used in this type of modelling was derived only to a minor part from experiments from WP3 of DOPAS, but mainly from existing data obtained in laboratory experiments of the participating organisations prior to the DOPAS project, and from existing literature. No input was used from the mid and large-scale experiments which are performed within DOPAS. The reason for this is that the main results from the larger scale experiments were not available within the project duration of DOPAS. Even for the mid- or small-scale laboratory experiments, only a minor part of the modelling work was performed to evaluate results of experiments. A large amount of experiments that have been started in DOPAS will be continued beyond the end of the DOPAS project. Therefore, more modelling work is expected to be performed in the future to interpret the results. This work will be reported in company reports of the organisations performing the experiments.

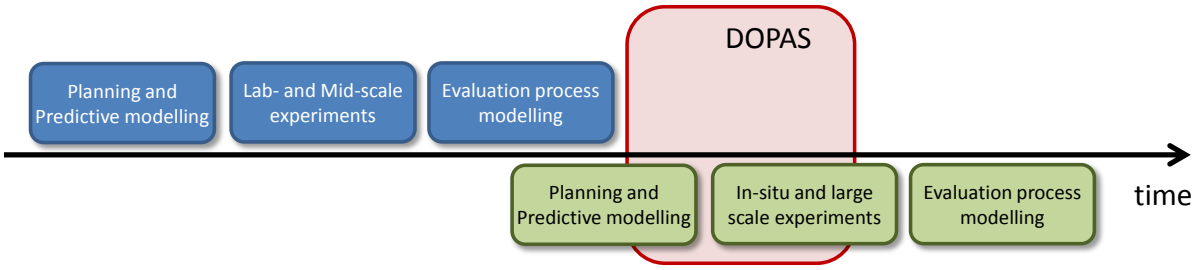

Figure 2: DOPAS in the life-time of the experimental program to investigate plug and seal behaviour

The aspect of DOPAS in the life-time of the experimental program to investigate plug and seal behaviour is further illustrated in figure 2. Even for DOPAS, with 48 months of duration being one of the longest running EU projects, this project can only represent a short section of the long time-span for the iterative process of preparative laboratory work, planning of a large-scale experiment, executing the experiment and finally investigating the results by process modelling. For example, even for the metric scale experiment (REM) by ANDRA (see also work-list number 3), which only acts as a small scale model for the full scale experiment, the full resaturation time was estimated to be about 30 years. Due to the different stages the different experiments were in at the beginning of DOPAS, mostly all parts of the experimental cycle were covered by DOPAS, except the evaluation process modelling of a large-scale experiment. While on the one hand, the ELSA experiment still was in an early stage of laboratory and mid-scale experiments, on the other hand the installation of the DOMPLU experiment was already ongoing. Due to this temporal shift, different stages of the experimental process were investigated in DOPAS.

Finally it can be concluded that the process modelling work performed in work package 5 of DOPAS has significantly contributed to the preparation and execution of the experiments and has helped to interpret the obtained results of some of the experiments. Since many of the experiments are not finished at the end of DOPAS, more updated process modelling is expected in the future to investigate the experimental results and to confirm predictive modelling. This work will be reported in company reports of the organisations which performed the work listed above.