D8.13

BEACON
Bentonite Mechanical Evolution

First joint evaluation report prepared by the Expert Advisory and Review Board

DELIVERABLE D8.13

Dissemination type: Report

Authors:
Klaus-Jürgen Röhlig
Frédéric Bernier
Jean-Dominique Barnichon
Jinsong Liu
Wilfried Pfingsten

Reporting period: 01/06/17 – 30/11/18

Date of issue: **07/09/2017**

Start date of project: **01/06/17** Duration: 48 Months

This project receives funding from the Euratom research and training programme 2014-2018 under grant agreement No 745 942		
Dissemination Level (choose)		
PU	Public	

DISTRIBUTION LIST

Name	Number of copies	Comments
Athanasios Petridis (EC) Christophe Davies (EC) Beacon partners		

EUROPEAN COMMISSION
DIRECTORATE-GENERAL RESEARCH & INNOVATION
Energy
Fission Energy

First joint evaluation report prepared by the Expert Advisory and Review Board

BEACON
Bentonite Mechanical Evolution

Contract (grant agreement) number: 745942
Author(s):
Klaus-Jürgen Röhlig
Frédéric Bernier
Jean-Dominique Barnichon
Jinsong Liu
Wilfried Pfingsten

Date of issue of this report: 07/09/2017

Project co-funded from the Euratom research and training programme 2014-2018		
Dissemination Level		
PU	Public	
RE	Restricted to a group specified by the partners of the BEACON project RE	**RE**
CO	Confidential	

Start date of project: **01/06/2017**
Duration: 48 Months

1. Scope of the Expert Advisory and Review Board evaluation

The Expert Advisory and Review Board (EARB) consists of experts which are representatives of organisations from outside of the project, and is in charge to advise the Technical Coordinator, and the Executive Board and the commission with critical evaluation concerning research quality and significance of outputs.

This first evaluation report will express the EARB's initial view on the Project and its work plan. Next evaluation reports will focus on progress review in connection with the annual project meetings as well as on the review of selected scientific/technical project deliverables.

2. Sources of information for the first evaluation

The EARB analysed information gathered through the following sources:

- Grant Agreement, in particular the work description in ANNEX 1 (hereinafter: "Technical Annex")
- Kick–off meeting
- Presentations in the frame of the Beacon Initial Workshop, 19 and 20 June 2017, Kaunas, Lithuania

3. EARB comments and advice

1. Table 1 (Technical Annex Part B p. 5-6) is a very good starting point for identifying research needs to be addressed in BEACON. The proposal incorporates the points made in Table 1. From a project management point of view, it might be good to periodically and systematically check BEACON's progress and achievements in the light of Table 1 and of the reports behind the table (half an hour presentation based on input from WPs and discussion at each Annual meeting?).
2. Items A-D in section 1.3(a) (Technical Annex Part B p. 8) are compliant with the philosophy and methodology of state-of-the-art Safety Cases. The EARB appreciates that the project will take the holistic perspective described in this section, which seems to be well reflected in the Work Plan (Figure 8 - Technical Annex Part B p. 23). Establishing all the links and information flows indicated by the arrows in Figure 8 will become a challenge for this type and size of project, though. Therefore, it might be good for WP 1 to soon develop a short document (perhaps a table) indicating how, by which means and by whom these links and information flows will be established. A close link between WPs 1 and 8 will be needed to establish an organisational framework which is also appropriate from such a Safety Case point of view.
3. Moreover, in the opinion of the EARB it will be essential that WP 1 will establish a Performance Assessment and Safety Case perspective on BEACON's laboratory and modelling work in order to manage the project appropriately. So far, the criteria for the definition of the cases as well as for the evaluation of the outcomes of laboratory and modelling work are not very well visible in the proposal, some effort is needed to improve this situation.
   More specifically, it will be important to properly establish the strategy aspects at the very beginning of the project (Technical Annex Part B p. 8 "A: Strategy aspects"). Indeed the

performance targets as well as the manufacturing and installation requirements, as part of the technical basis for the design of the barriers, are key inputs to define the assessment cases (WP1), the lab test programme (WP4) and the modelling work (WP3 & WP5). The EARB advises to consider several achievements of

- the DOPAS project (in particular the Design Basis Workflow illustrating the iterative development of the design basis from conceptual design to detailed design) [1].
- the GEOSAF IAEA project defining the notions of "Safety Envelope", "Design Target", "As Built State"[2]

These achievements could help to define the objectives of the assessment cases and tests in a systematic and transparent way.

4. Safety function indicators have the potential of, inter alia, aiding interdisciplinary communication (as it is needed for BEACON, see above) but are, so far, only used by a limited number of national programmes (e.g. by SKB). The ideas about utilising safety functions and safety function indicators orally presented at the Kaunas workshop by P. Marschall (not well visible in the written abstract but evident from slides 8/9) are worth to be further explored and developed.
5. The description of work for WP 1 (Table 3.1a) appears a bit additive and heterogeneous. The individual components (addressing uncertainties by NAGRA and Andra, case definition to be supported by ENRESA, requirements development by GRS, ISM to developed by POSIVA, stocktaking by RWM, design assessment by SKB, assessment activities by SURAO) all seem to be important and essential, but at the same time very much defined around the needs of the respective national programmes. It is not completely clear to the EARB how these important pieces of work will be brought together in order to serve the overall objectives of WP 1 and of the whole project.
6. The EARB appreciates the stepwise strategy planned for verification and validation (Fig. 10, WP 5). The approach is very promising, synthesis work to be done by Andra will be decisive for success. Further inspiration for systematising the approach could be taken from the invited presentation by A. Gens.
7. From the WP2 description, it is not clear which types of bentonites will be considered (except MX-80). Following the description, each team seems to work separately. The objective of the workshop (task 2.1) was precisely to have an overview of the existing data and experiments. The EARB advises to well define the interactions between the partners and the overlap if any within task 2.2 taking into account the WP2 workshop as input. It will be also important to justify the selection of the relevant data and models against the output of WP1 (see bullet 5).

   WP2 started already before the Kick-off WS. A template had been distributed on "available data and modelling". It might be worthwhile to also generate a criteria catalogue on how these inputs from data, from experiments, and from modelling will be processed. E.g. experimental data might be useful for some issues (specific or complex model description, too many unknowns for model testing etc.); and not useful for others (specific process understanding, transient unsaturated-saturated phase, …). In other words, it would be good to define criteria so that a decision is possible on how certain data from an experiment could be used for specific models. This allows focusing on "best data" for different models with respect to complexity. It is mentioned that the main driver for the project is the limited predictive capability of the current models with respect to conceptual and numerical

approaches. From this point of view it might be appropriate to have more than 10 different models which should be "improved", "extended" or "developed" (as foreseen in WP3) in order to meet the goal of describing "bentonite heterogeneity and mechanical property evolution …." What might be very helpful here could be a catalog of the models available in the consortium as a result of the templates about modelling populated by all project partners. This catalog should include the actual status of the individual models (they range from commercial products to open source codes, are there already more advanced models available elsewhere?), the necessity to bring all models to the same level of detail (or otherwise), and a recommendation on what should be finally included in individual models to meet the defined goal of concerning their predictive capability.

8. The EARB is in agreement with the statement in the Technical Annex Part B p. 9, that the quantitative models that are currently available for modelling the homogenising processes of bentonite are not fully capable to represent all the complexities of the evolution of an installed bentonite and further developments aiming at better conceptual models and at the numerical implementation of such models are necessary. The EARB is of the opinion that, at the very beginning of the project, the detailed shortcomings concerning the conceptual understanding of the homogenising process should be identified and clearly stated, so that the partners involved in WP3 can focus at the early stage of the project on improving the conceptual understanding as well as on developing better conceptual models.
9. Within WP3 different modelling teams are using different codes and different approaches, and focus on different processes. A comparing table could help to better see the commonalities and the differences between the codes as well as the processes they are able or not to model (limitations). This table could be an output of WP2.
   At this moment there is no model considered describing the molecular scale of bentonite swelling and its influence on bentonite mechanical properties, which might lead to new conceptual approaches. Also, there is one model that should be extended with respect to chemo-osmotic effects, but not to general geochemistry. The latter may come into play for geochemically heterogeneous bentonite-cement interfaces with quite different geochemical properties and related pH changes within the bentonite influencing the bentonite mechanical properties as shown at the WS and as included in two of the three foreseen test cases: Andra's tunnel concept (including concrete plugs, Fig. 1 - Technical Annex Part B p. 4) and Nagra's concept (including shotcrete, Fig. 2 - Technical Annex Part B p. 5).
10. The EARB is in agreement with the claims in the Technical Annex Part B that much of the modelling results for the mechanical evolution in general, and the homogenisation in particular, need to be verified against laboratory and field tests. The EARB is of the opinion that the verification efforts should be laid more on the verification of the Barcelona Basic Model (BBM) as well as the extended Barcelona Expansive Model (BExM) for their handling of slightly to strongly swelling clays. These are the models most relevant to the homogenisation processes. Through such verifications, better understanding of the shortcomings of the models can hopefully be revealed and new conceptual models be developed.
11. The EARB is of the opinion that, with the extension of conceptual models to include the chemo-osmotic aspect, focus should be on a better understanding of the process for build-up of swelling pressure in a confined system during the resaturation process. As the process could possibly be extremely non-linear (the electrostatic interaction and van der Waal interactions are non-linear processes), the partners should be well prepared at the early stage of the project to deal with these non-linearities resulting in numerical difficulties.

12. The EARB is of the opinion that the amount of swelling minerals, such as smectite, in bentonite should be included as an important parameter during the development of the conceptual models. The reason is that, for all of the three examples of constructions mentioned in the Technical Annex Part B, i.e., ANDRA's tunnel plug, Nagra's disposal cell and SKB's tunnel backfill, a relative large amount of bentonite will be needed and bentonite with different contents of smectite will unavoidably be used. As the other accessary minerals in bentonite usually do not have the swelling capability, it could be expected that the amount of smectite in bentonite is of great importance for achieving final homogenisation. This point has also been illustrated in Section 1.4 in the Technical Annex Part B when performance of backfill materials in SKB's Prototype Repository test and that in Nagra's Engineered Barrier Emplacement Experiment are compared.
13. WP4 is well described and the interactions between the partners are clear. The output of this WP is key for the success of the project. WP4 needs an early definition of "new experiments" with definition of complete data sets for all models, meaning that it must be clear in advance which experiments could deliver sufficient data for models of different model complexity – a challenging task.
    With respect to development of new conceptual models, the measurement scale has to be taken into account. It has to be defined to set up models on different scales depending on related model approaches.
    As said in the WP4 description, the good control of the conditions of the test is crucial.
14. The EARB is of the opinion that the experimental program in WP4 should also include tests of bentonite having varying amounts of smectite, as well as bentonite/sand or bentonite/crushed rock mixtures. These different types of minerals may have different swelling properties and therefore different homogenisation capabilities. Moreover, all these types of minerals are expected to be used in different repositories for spent fuel or wastes containing long-lived radionuclides. See also comments under Bullets 7 and 13.
15. In WP5 more groups should be involved in Nagra's test case, which is one of three test cases. Also, a very early, simple and maybe idealized or virtual test case should be set up and distributed to have a very early code/model benchmark instead of just waiting for input from other WPs in the beginning.
16. Interactions between WP2, 3, 4 & 5 with WP1 are not always explicitly explained in the WP description but are important to situate the outcome of the WPs within the assessment context.
17. As recognized by national programmes as well as by several international working groups and projects (e. g. FSC, IGSC, INSOTEC, SITEX-II, JOPRAD), interaction with Civil Society is essential for disposal programmes. Therefore, establishing links to Civil Society is also important for research projects: Members of the Civil Society need to be made aware of what implementers, regulators and researches consider the issues at stake and to be given opportunity to provide input about their views and concerns. There is also a need to increase transparency concerning the research work being done, and there is a chance for added value concerning the research by obtaining independent views. Thus, the ideas and efforts described in 1.4(b) about interaction with Civil Society are appreciated. Some challenges remain, though:
    a. Although the broad sealing issue can be easily appreciated, the scientific and technical topics to be addressed in BEACON are very specific ones, thus these topics may not be an easy starting point for establishing links with Civil Society.

b. To overcome the risk of getting lost in technical details, perhaps in the beginning some effort should be undertaken to establish a common understanding about general technical and safety concepts and the role and place of the topics addressed by BEACON in these concepts (e.g. following the DOPAS approach – see bullet 3).
c. Given the problem described above, it is good and necessary (though not necessarily sufficient) that a specialised scientist would be involved in WP 6. The EARB understands this is the role of Prof. R. Pusch, which is expected to be valuable to the project.
d. There are several definitions of the term "Civil Society". The EARB understands that, within BEACON, "Civil Society" is understood to be represented by non-governmental and non-business organisations. In the oral presentation at the Kaunas workshop, a working group of 4 NGO representatives and one expert was named. Given this, WP 6 will probably not be in a position "to give Civil Society [as such] the opportunity to follow, discuss and give feedback" (Technical Annex Part A p. 46, insertion in square brackets by EARB) – the maximum achievable is to do this with a very limited number of organisations.
e. The EARB notes that, except for WP8 (lead), WP6 is the only WP where there is only one beneficiary (MKG). According to the Grant Agreement, "MKG will follow the work in the work package [WP1-5] and coordinate interaction with WP6" but there is no mutual involvement of WP1-5 participants in WP6. Also, communicating WP1-5 results to Civil Society by a single beneficiary could therefore become a challenge.
f. During the WS, the EARB learned about the interaction with Civil Society (including also bentonite specialists) that Civil Society representatives are also concerned about chemistry and microbiology influencing bentonite mechanics, especially at high temperatures. This could appear as an issue as in most of the applied codes/concepts, no chemistry or microbiology is included.

18. The EARB appreciates the approach to involve associated groups in order to include their views in the project's work as well as in order to communicate the project's progress and results and to exchange views on problems to be addressed. The EARB wonders whether there are specific means foreseen to integrate the view of regulators or regulatory TSOs into this exchange.
19. The EARB appreciates the efforts (final workshop, journal publications) foreseen to place the project's work into the scientific context. It also appreciates the aims directed at PhD and post-doctoral research and mobility.
20. In the opinion of the EARB, the initial workshop held in Kaunas achieved its objectives of establishing a network and of gathering the information relevant to the project. The format (mixture of project workshop and scientific conference) served this purpose well.
21. The kick –off meeting gave an excellent opportunity to the EARB to get a first impression on the Beacon project setup, the partners involved and some more details on the WPs as given in the project application. Aside from the project and WP presentations the choice of additional presentations and posters fit very well to the Beacon project. (The presentations given at the WS were partly made available via the Beacon Webpage since 26 June 2017.)

5. References

[1] M. White and S. Doudou. "DOPAS Work Package 2 Deliverable D2.4: WP2 Final Report Design Basis for DOPAS Plugs and Seals", http://www.posiva.fi/files/4370/DOPAS_D2.4_WP2_Final_Report.pdf

[2] IAEA TECDOC, Managing integration of post-closure safety and pre-closure activities in the Safety Case for Geological Disposal, to be published https://www-ns.iaea.org/downloads/rw/projects/geosaf/geosaf-tecdoc-draft.pdf