

**FSC THEME: THE LINK BETWEEN RESEARCH, DEVELOPMENT & DEMONSTRATION  
(RD&D) AND STAKEHOLDER CONFIDENCE**

**TOPICAL SESSION ON THE USE OF ANALOGUES FOR CONFIDENCE BUILDING**

**SUMMARY OF PRESENTATIONS AND DISCUSSIONS**

**Background**

In December 2007, the Forum on Stakeholder Confidence discussed its theme entitled “Link between research, development & demonstration (RD&D) and stakeholder confidence”. It was remarked that regulators need a technical demonstration to aid in evaluating the safety case. Local stakeholders appreciate the opportunity to visualise technological arrangements. In both cases, demonstration adds to confidence in the feasibility of solutions. Some believe there is an important role for analogues in communication with stakeholders, if handled with integrity. To explore and benchmark current practices, it was decided to hold a topical session at the 9<sup>th</sup> regular meeting of the FSC on 4 June 2008 regarding the use of analogues for confidence building.

The session opened with an introductory presentation by the session rapporteur. This incorporated input provided for the purpose by FSC members in cooperation with their country’s representative to the NEA RWMC “Integration Group on the Safety Case”. Three speakers then presented the various uses of analogues by implementers, regulators and scientists to build their own confidence; a fourth speaker dealt with the experience of using natural analogues in public information. The presentations addressed the use of analogues in the field of geological disposal of high-level waste (HLW) and long-lived intermediate level (ILW-LL) radioactive waste. Then the FSC participants split into two working groups for discussion. The outcome of these discussions was reported in plenary on 6 June 2008 and it was agreed to publish proceedings of the session.

The present summary, prepared by the session rapporteur with input from the NEA Secretariat, captures the main points heard in the course of the event. It combines data from the formal presentations and remarks made in discussion. The latter represent viewpoints expressed by a group whose primary focus is not natural analogues but rather stakeholder interests. The summary and viewpoints do not represent an official position of the FSC, but a simple benchmark of current reflection that a wide range of stakeholders may use.

**Introduction**

*To begin with, it is important to understand what is meant by natural or anthropogenic (archaeological and contemporaneous) analogues in the specific framework of radioactive waste geological disposal. The following understanding is typical:*

- Natural analogues refer to natural materials or situations whose evolution was not influenced by human intervention.

- Anthropogenic (archaeological or contemporaneous<sup>1</sup>) analogues refer to engineered materials, whose evolution was influenced by human actions, engineered conditions and natural environments.

For both the cases above, however, there exist various degrees of similarity to possible situations within a geological repository for radioactive waste or its environment. **According to the degree of similarity to the repository and its environment, the situation or example in question may be considered to be an analogue, an analogy or an anecdote. The FSC used the following definitions to frame its observations:**

When a fairly direct similarity to repository situations exists, the case may be used as an argument to support a phenomenological theory and its modelling: it is an **analogue**. As the degree of similarity decreases (e.g. if relevant chemical or physical conditions do not apply with those of the repository and the consequences of these deviations cannot be quantified; if system boundaries cannot be defined), the case applies more narrowly to the generic feasibility of medium- to long-term safety of geological disposal. When the degree of similarity is quite low, the case may provide a “common sense” rationale supporting the concept of geological disposal as an option that should not be ruled out and could be a relevant solution, providing that adequate research and demonstration are performed to confirm this hypothesis. In the latter cases, the situation is considered an **analogy** or even only an **anecdote**.

The following examples illustrate the FSC definitions of analogue and analogy/anecdote:

- The case of Roman nails found in Scotland can be presented as
  1. An **analogue** for the analysis of corrosion resistance, were it decided to use steels that are viewed to be as corrosion-resistant or more corrosion-resistant than the metal of which the nails were made. Indeed, the evidence of their longevity would contribute to modelling confirmation, despite the related uncertainties.
  2. An **analogy** to illustrate the confinement properties of natural clay over a long time period, as well as their ability to reduce corrosion. We cannot go beyond analogy here because the initial number of nails buried is unknown (we cannot state how many nails corroded away).
  3. An **anecdote**, simply to show that man-made artefacts can last thousands of years underground, if it was used by a programme that is not contemplating the use of steel for containers or clays as a barrier.
- The discovery in a clay formation of a fossilised animal that can be determined to be an herbivore from food remains that were preserved in its stomach over millennia, is an **anecdote**. It illustrates the fact that clay has long-term confinement properties, but as we do not plan to dispose of material similar to vegetarian animals, the degree of similarity is low. Nevertheless, because of the peculiarity of such an example, and because inert materials are much more durable than organic tissue, the anecdote could be used to illustrate the long-term confinement concept.
- With regard to earthquakes, it is possible to compare earthquake damage in a mine with possible damage in a geological repository when affected by a similar event. As such, it is very valuable input for e.g., the design of underground structures and their supports. This situation, which corresponds to a high degree with the modelling and engineering applications expected in a geological repository, serves as a **contemporary analogue**. On the other hand, historical records of earthquakes over a few millennia should not be designated as an analogue. Instead, they would

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1. Archeological analogues are those on the order of a few thousand years old, whereas contemporaneous (or contemporary) analogues are those drawn from a period ranging from a few centuries ago until today.

be labelled simply as important data relevant to assessing geological stability and possibly of use for bounding analyses, i.e., for setting limits on uplift or fracturing.

This report focuses mainly on the use of analogues as a line of evidence and as an instrument for confidence-building in safety assessors, evaluators and members of the public.

### **Analogues: Why, for whom, which ones and how?**

#### ***Why use analogues?***

Timescales relevant to long-term safety of geological disposal (on the order of several centuries, millennia and sometimes more) cannot be attained in experiments. Analogues can provide qualitative or quantitative data in order to illustrate long-term behaviour or conditions and to validate assessment models. They can also provide references and examples, and confirm phenomenological forecasts over long timescales.

Referring to the foregoing definitions, we shall distinguish between natural and anthropogenic analogues. Natural analogues---related to natural materials or situations whose evolution was governed by natural phenomena--- involve very long timescales on the order of geological ones. The conditions of evolution, including the initial state, may not be well known, and we can expect to gain principally qualitative information.

On the other hand, anthropogenic analogues---which involve engineered materials, the evolution of which was governed by both the engineered and natural environments and human intervention---involve smaller timescales, a few thousand years at the most. Such materials are better studied and understood (typically, the more recent the analogue, the better known are the materials and evolution conditions) and are usually more similar to the engineered materials being considered in current repository studies. Therefore, they may very often provide quantitative data. In short, the smaller and more recent the analogue timescale, the more precise and quantitative is likely to be the information it provides.

Apart from the limitations already mentioned---that initial and evolution conditions cannot be always well known and that the materials used may be different from the ones to be considered in a repository---it must also be acknowledged that analogues will never reproduce exactly the possible repository situations such as the coupling of radioactivity, pressure and temperature. Therefore, they can contribute to safety cases as a *line of evidence* in the best case but cannot be relied on as the **sole** line of evidence. For instance, they can provide confirmation, with some associated uncertainty, of particular aspects in broader modelling or can aid in identifying the presence of specific phenomena such as chemical reactions, etc. Overall, it is recognised among the technical community that analogues can not be used as a sole and unique demonstration, but need to stand as one of multiple lines of evidence.

As the degree of similarity with possible repository situations diminishes, examples become analogies or anecdotes and their arguments are more useful in terms of supporting generic and conceptual feasibility of geological disposal.

#### ***Analogues for whom? And which ones? How?***

We must distinguish between two audiences or stakeholder groups which may be targeted:

- Safety assessors and regulators, who comprise a scientific and technical community;
- Political decision makers;
- The public at large.

While geological disposal is found to be generically feasible and safe by the first group, a less confident attitude on this aspect is to be expected from some members of the two latter groups.

*Analogues as line of evidence and confidence-building for safety assessors and regulators*

Analogues are considered by safety assessors to be a useful tool, one of multiple lines of evidence used in the safety case to confirm phenomenology and modelling. Analogies and anecdotes are not as important for this scientific and technical community as they present no direct relationship with the phenomena and materials involved in the safety case under review.

Nevertheless, different regulators (whose role is to evaluate the safety assessment) place varying emphasis and value on the use of analogues in terms of confidence-building arguments. Some do not mention them specifically in their basic safety guidelines, whereas others recommend their use and in some cases make their use mandatory when they correspond to possible situations of the repository. For instance:

- In the USA, natural analogues are recommended by U.S. Nuclear Regulatory Commission (NRC) for the Yucca Mountain safety case and identified as **potential elements** of supporting information for models assessing repository performance.
- In Switzerland, analogues are used as general supporting arguments in the safety case and independent evidence for the plausibility of certain modelling results and the underlying parameters. As such, the Swiss regulator makes their use **mandatory** in the safety case.

Some quite extensive studies, such as the Nanet cooperative project of the EC or the compilation coordinated by the Spanish regulator (CSN) with universities (each of which was presented at the topical session), have inventoried and referenced analogues along with their relationship with the various conditions and situations possible in geological repositories. As such databases are an important resource notably for organisations just initiating safety cases or when use of analogues is recommended by regulators, it would be wise to continue such efforts. Nevertheless, it is not realistic to expect a fully exhaustive match between a set of analogues and all repository situations.

The case of so-called “negative analogues,” meaning analogues describing, for instance, a higher corrosion rate than forecast, must be thoroughly investigated and explained. If left unaddressed, a “negative” analogue becomes a counter-example and will challenge the proposed phenomenological theory and its modelling. Thorough investigations must examine whether (and how) such a case is consistent (or not) with the proposed phenomenology and its modelling, and the causes of the supposed initial discrepancy should be highlighted. In fact, “negative” analogues can provide useful information about situations which must be avoided in a repository or can provide a basis to define degraded evolution scenarios, if it is possible for such situations to occur. Therefore, analogues initially considered “negative” can become “positive” analogues and provide an added value to the safety case.

Finally, the dialogue between the implementer and the evaluator is a scientific and technical one, where a comparable degree of specialisation is found on both sides. In this context, there is more likely to be a common understanding of the uses and limitations of analogues. Indeed, there is agreement in this community that an analogue can never be a fully sufficient demonstration; it is only one of multiple lines of evidence.

*Analogues as line of evidence and confidence-building for the general public*

Although analogues are often described as important confidence-building arguments for the public, most FSC members were not so affirmative in their assessment of this claim. Some typical quotes from the written input by FSC members demonstrate scepticism:

- It is stated that “for **technical specialists, analogues are used** .....” but the statement is not so affirmative related to the public: “towards **the general public analogues can be used** .....
- “We proactively use materials found in Japan to provide our **readers** a sense of familiarity. However, since their effectiveness measurement hasn’t been carried out, we haven’t figured out how much they’ve been helpful for confidence building.”
- On one hand, “their main role for **technical specialists is seen** in their support .....
- On the other hand, “their major role for the **general public is probably to raise interest and increase** understanding of processes by illustration and showing familiarity to many people”.

Nevertheless, most FSC members have the feeling that analogies and anecdotes could help the public to grasp timescale and understand the basic rationale and principles of geological disposal. They represent concrete examples of important functions such as long-term confinement properties to illustrate potential repository situations which might otherwise be seen as “pure theory”.

The careful statement about the “possible” efficiency of analogues in public confidence-building may originate from the lack of demonstrated evidence of this effect. The presentation of analogues and analogies must be adapted to the audience, using understandable language, and their limitations should be clearly stated. The effort and scale of projects related to the use of analogues for scientific assessors has not generally been balanced by corresponding surveys on the use of analogues aimed at the general public---with the exception of the cooperative project “Traces of the future,” funded by the European Commission. Given that public confidence is the Achilles’ heel of geological disposal projects (and especially of siting decisions) and that it is assumed that analogues do contribute to such confidence-building, it could be worthwhile to develop this line of investigation.

Some FSC members suggested that the use of *national* analogues (i.e. drawn from situations within the host country) may be more effective for the general public than extra-national ones, notably when concerning anthropogenic analogues. Given that analogues are concrete representations of possible repository situations, it seems plausible that the public may be more likely to find a national analogue persuasive and comprehensible, since it is geographically and culturally closer to their own experience and likely to be very concrete, especially in the case of anthropogenic analogues. The familiarity with the case facilitates understanding and may itself provide some reassurance to the public. However, other FSC members suggest that stakeholders in some contexts display more confidence in findings and illustrations presented by international parties who are assumed to be more neutral. Neither position has been systematically demonstrated through societal surveys and each must be considered as hypothetical for the moment.

From the various member contributions it appears that the use of analogues as confidence-building arguments for the general public varies with time and with the stage of programme development and therefore depends on the decision making process and its phases. As the project focuses on progressively more specific sites and more defined concepts, an increasingly closer relationship with the repository situations, for instance in terms of geological formations, engineered materials, etc. becomes possible. Later, as the project is accepted in its principle by local public stakeholders, it seems that the need for analogues, analogies and anecdotes for stakeholder confidence dwindles. This latter statement still remains to be proven valid over the long term of a repository development, though, as it was based only on observations in Finland and France, in which geological repository projects are quite ahead of those in other countries but still in relatively early phases compared to the 100 or more years in which they are meant to be an active presence in the host community.

**Possible developments that could be suggested include:**

- Continue efforts to build analogues databases such as Nanet, notably for regulators and assessors, but as well in relation to the two following points.
- Use such database matrices to integrate the so-called “negative” analogues and investigate thoroughly the cause of perceived discrepancies to transform the case into an added-value (“positive”) analogue.
- Translate the scientific and technical analogues, as inventoried in various databases, into convincing arguments for the public at large, with specific consideration for national analogues.
- Measure the effectiveness of analogues and related arguments in terms of public confidence-building, in order to improve the tools and techniques of presentation.
- Looking beyond only analogues, investigate the evolution over time (i.e., through the development of a repository) of the type of confidence-building arguments needed for the general public. A first step would be to study whether any evolution has been observed with existing low- and intermediate-level, short-lived radioactive waste repository projects and, by extension, with other controversial industrial projects.

The application of contemporary analogues as input to the design and choice of materials with a view to reversible disposal was not discussed in the working groups, although this was mentioned in the introduction by the session rapporteur. Perhaps this is because analogues have been typically depicted to describe phenomena over timescales beyond hundreds of years. On the other hand, the relationship between repository situations over a few centuries and contemporary analogues, such as tunnels or mines, is very close. Given the relatively early phase of most disposal projects, these analogues might be useful for discussing the concept of reversibility with wider audiences as well as with technical stakeholders. For instance:

- the regulator may find this to be compelling evidence that reversibility is not achieved at the expense of safety;
- the public may be interested in demonstrations of reversibility in engineered system, which could be provided through analogues.

Finally and still in relationship with the project phases, it was reported from Finland and France that current public issues in these countries tend to be socioeconomic ones. The topic of socioeconomic analogues (probably very contemporary ones involving similar projects in terms of investment, running costs, construction, operating life, footprint, etc.), which was not in this session’s remit, could be a future theme of interest for the FSC.