Summary record of the topical session of 17th Meeting of the IGSC

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Role of Geo-Scientific arguments in the siting process

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Introduction and scope of the topical session

The topical session was an exchange of experiences from the siting process, as performed, or planned to be performed, in the different member countries of the IGSC. The focus was on the role and use of geoscientific arguments within the whole siting process. In particular, the objectives were to:

(i) explore how members are planning or have used geoscientific arguments to identify suitable sites for geological disposal facilities;
(ii) compile what geoscientific safety arguments have been used or are planned for use;
(iii) explore how particular geoscientific safety arguments were received by stakeholders (both technical and non-technical) in countries where the siting process is advanced; and
(iv) evaluate regulatory views / experience on using geoscientific safety arguments for siting.

The following presentations were given and can be found at https://www.oecd-nea.org/download/igsc/igsc-17/index.html.:

- The role of the geology in site selection in the US. *Abraham Van Luik, Carlsbad Field Office, US Department of Energy*
- Nomination of scientifically suitable areas within the revised site selection process in Japan. *Hiroyushi Ueda, NUMO, Japan*
- The UK national geological screening exercise. *Glenda Crockett, RWM, UK*
- Geoscientific arguments in the early stage of siting. *Sona Konopásková, SURAO, Czech Republic*
- The Use of Geoscience Data in the Early Phases of Canada's Siting Program for a Used Fuel DGR. *Ben Belfadel, NWMO, Canada*
- The new siting procedure in Germany and the role of geoscientific information. *Jürgen Wollrath, BfS, Germany*
- Geosciences within the siting process: the French experience. *Emilia Huret and Guillaume Pépin, Andra, France*
- Role of geoscientific arguments in the on-going siting process in Switzerland. *Jürg Schneider, Nagra, Switzerland*
- Using geoscientific argumentation for the siting process and in the construction licensing phase– experiences from Finland. *Barbara Pastina, Posiva, Finland*
- Role of geoscientific arguments in siting an SNF repository in Sweden. *Allan Hedin, SKB, Sweden*

Regulatory aspects

In some countries the siting process is very clearly described, e.g. in Switzerland. In the Sectoral Plan for Deep Geological Repositories a three stage process is formulated and the regulator prescribes in detail the calculation endpoints, namely the indicators to be calculated and used for each stage. The whole process is strongly based on geoscientific arguments.

The regulatory requirements on the use of geoscientific arguments in the siting process or generally in a safety case differ for each country. Some national regulations explicitly formulate high-level geoscientific requirements, as was for example the case of the Final Disposal Act in Japan. In Germany, the Working Group on a Site Selection Procedure for Repository Sites, AKEnd, proposed to apply exclusion criteria, minimum requirements and weighting criteria derived from requirements for a favourable overall geological setting. However, the regulations in both countries are currently under revision and these requirements are not in force.

In other national regulations, for example in Sweden, no specific emphasis is placed on geoscientific arguments, but rather the focus is on the functioning of the whole system. In the US the disposal system is required to have at least one natural and one engineered barrier, but there are no natural subsystem requirements stated in current US regulations. In the UK the national policy was revised in 2014, setting out a Government-led staged process, in which information on geology is provided early in the siting process to assist stakeholder consultation.

Most national regulations, however, do not specify which geological arguments are to be considered in safety cases. Rather, it is left to the implementer to ensure that the safety case is sufficiently comprehensive, taking into account all relevant geoscientific data.

General aspects of the site selection process

In nearly all programmes the site selection procedure is a multi-stage process, which roughly consists of (i) an initial study, consisting of desktop work with a comprehensive literature/data survey, (ii) a second step with preliminary site investigations such as geophysical surveys and a limited number of boreholes and (iii) detailed investigations including, e.g. airborne surveys, further boreholes, excavation of test tunnels, or construction of and research in underground research laboratories (URLs). The siting process starts with a higher number of sites and during each step the number of sites taken forward is narrowed down. The detailed investigation step needs extensive and costly work and is typically carried out only for a maximum of one or two sites.

In the first step it was stated (e.g. in Japan) that literature/datasets need to be (i) quality assured in terms of credibility, (ii) publicly available in terms of transparency/traceability and (iii) be nationwide to avoid regional inequality. For example, in France data from previous exploratory wells for oil and gas industry were used, and previous seismic profile data were re-interpreted. At the second step with a preliminary site investigation, geological surveys, 2D seismic profiles and a selected number of boreholes may be used to identify global properties of potential host rock, such as thickness, permeability or diffusibility (e.g. Andra). Subsequently, a more detailed site investigation with e.g. 3D seismic surveys, high resolution airborne surveys, additional and maybe deeper boreholes, and investigations in URLs and laboratories would greatly increase the geoscientific knowledge and form the basis for the application of THMC models and comprehensive safety assessments. These are rough commonalities and might vary to some extent for each national programme.

Differences concerning the abundance of host rock types in different countries have an impact on how the siting process is shaped and criteria are applied. For example, crystalline rock, rock salt, and sedimentary clays and clayey shales are all available in the USA. In the case of WIPP the choice of the host rock was the product of a general recommendation for the use of salt rock by the National Academy of Sciences. The general location of the WIPP site was selected based on previous exploratory work in and around the Delaware basin. The choice of the specific site was then the product of the subsequent volunteering of the town of Carlsbad and based on drilling for site characterization and the features found. In the case of Sweden and Finland, where clay or salt sites are not available, crystalline sites were studied and geoscientific arguments were developed specifically for this rock type. As such, relatively many sites could be considered potentially suitable at the beginning of siting. Thus, both geoscientific arguments and acceptance by the local community were sought at different stages of the siting process.

The role of voluntarism in the siting process and the stage of the process in which voluntarism – if any – comes into play differ widely. In several countries voluntarism plays a key role, e.g. local acceptance is a prerequisite in both the Swedish and UK siting processes. Another example of voluntarism in the early stages of siting is the 'Adaptive Phased Management approach', as applied in Canada, where technical and social aspects are advanced in parallel to find an informed and willing community.

In some other countries no voluntarism at all is foreseen in the siting process. In the Czech Republic a voluntarism approach failed and the responsibility was shifted from the municipalities back to the government. In Switzerland, the 'Sectoral Plan' is being conducted to identify the most suitable site, with local communities then being consulted regarding the implementation. In Japan and Germany the role of socio-economic aspects in the siting process are currently being discussed intensively as the siting process in these countries is under revision.

Evaluation factors and criteria

Several countries stated that geoscientific arguments played a key role in the siting process. Frequently, geoscientific arguments flow into criteria or evaluation factors, which are used to control the individual steps of the siting procedure. Such criteria might be exclusion criteria, minimum requirements, or criteria used for ranking. In Japan, three kind of classifications were discussed, namely areas to be avoided, areas to be preferably avoided and preferable areas. Typical exclusion criteria concern the occurrence of large area vertical movements or active fault zones in the area. The use of such criteria is however dependent on the geological situation in each country. For example, the Japanese programme cannot avoid operating within tectonically active regions, and showing that extreme geological events will not compromise repository safety is thus an essential component of the safety case. The Japanese programme has therefore developed advanced methods for the identification of volcanic and tectonic hazards at potential repository sites in Japan in terms of their likelihood and scale, which can provide a basis for site comparison (cf. Topical Session of extreme geological events, IGSC-16).

Many countries formulated minimum requirements, which have to be fulfilled, e.g. a 100m thick host rock, a minimum and maximum depth of 300m and 1500m, respectively, as for example proposed by the German Working Group AKEnd. Nearly all countries formulated arguments as a prerequisite that any suitable site must ultimately satisfy. The following are frequently regarded as attributes of a stable geological system:

- low seismicity,
- low earthquake, fault, and igneous activities,
- low uplift and erosion rates,
- no occurrence of unconsolidated Quaternary deposits.

During the discussion it was mentioned that it is important not only to consider the current situation, but to evaluate these aspects for the whole assessment time frame. A system which is considered stable today, might evolve in the future to a less stable system, e.g. seismic events or uplift rates might significantly increase in the future. A second group of attributes concerns favourable properties in the host rock, formulated as:

- low permeability or low groundwater flow in the host rock,
- favourable rock-mechanical conditions,
- good thermal and mechanical properties,
- favourable geochemical properties to limit radionuclide migration.

The role of each individual attribute is, of course, to some extent dependent on the host formation. A general agreement was observed in the robustness of the geoscientific safety arguments related to these attributes. In this context the ease of characterisation, the homogeneity and predictability were emphasised.

It is a current trend that these arguments are directly related to safety functions, for example containment, isolation and retention. In some countries the arguments for the geological formation on its own are most relevant, e.g. in the UK, where a guidance has been developed on proposals to present geological information in an accessible form to stakeholders. In other countries, the arguments are embedded in the view on the whole repository system. In this context additional safety functions such as protection of the engineered barrier system (EBS) or criteria such as engineering suitability or stability were mentioned.

Some differences also exist in the role of other than geoscientific factors. In Finland in the step “Selection of the Preliminary Investigation Areas” further comparisons of the proposed sites were based also on other environmental factors, including population density, transport infrastructure, land ownership, protected areas and national resources. In addition, in Japan, for example, so-called ‘nomination factors’ for scientifically suitable areas under discussion, include pre-closure safety and the safety of the waste transport. Similarly, in the Canadian approach the safe construction, operation and closure of the repository as well as safe and secure transportation were included as two of six safety functions, which have to be fulfilled by any suitable site during the geoscientific site evaluation process.

Although there is agreement that water resource areas should be avoided, there are different views with regard to areas with mineral resources which might play a role with regard to past and present uses (resulting e.g. in avoiding locations of existing deep mines or of intensely deep-drilled areas), but also considering potential future uses. In some countries, absence of potential mineral resources represents an important argument in the site selection, whereas in others this argument does not play a role. This is particularly the case for countries that intend to use rock salt as the host formation, which is at least today an important mineral resource. Also, salt formations might function as a trap for hydrocarbons, a fact which might encourage investigation drillings even in the factual absence of such hydrocarbons. On the other hand, it is hard to tell which minerals will indeed represent a resource for future generations or which other site features (e.g. geothermal heat extraction, storage of hydrocarbons) might be of interest to future generations. The consequences of human activities, such as exploitation of the mineral, need to be evaluated and addressed in the Safety Case. In addition the repository concept might be optimised to reduce potential consequences of future human actions. It was also mentioned that credit is taken from the NEA project "Preservation of Records, Knowledge and Memory (RK&M) across Generations", which evaluates ways to keep oversight of the repository as long as possible to minimise inadvertent human action (e.g. NEA, 2013).

Role of geoscientific information in different stages of the repository programme

As the repository programme evolves the (geoscientific) knowledge increases. Challenges in the early phase of the process are due to a limited availability of data and therewith large differences might exist in the resolution of data for different areas. In this case a workable approach might be the restriction to a subset of data, where a comparable range of information is available (cf. the Canadian approach). It is recommended to avoid defining criteria too early and / or too strictly in the process, prior to at least some substantial geoscientific knowledge being available. On the other hand, if criteria are defined in a late stage of the process, which increases flexibility, it might be perceived that requirements are tailored to the needs of the implementer, rather than being scientifically based. Further it was mentioned that in the early phase the use of verbal arguments is more valuable than quantitative comparisons. Uncertainties need to be acknowledged and appropriately accounted for when making comparisons. In a generic state, prior to site characterisation it is difficult to use safety assessment results for discrimination between sites, because it is likely to be just discrimination between assumptions.

In the early stage a generic safety assessment, however, can be useful for developing system and process understanding and identifying where further work is needed, but should not be applied for numerical comparisons. There is a need to manage the expectations for preliminary safety assessments and to explain to the stakeholders that these are not full safety cases and are likely to be based on qualitative or semi-quantitative arguments. Nevertheless, generic safety cases can give local communities and regulators confidence in the implementer's ability to make a safety case. Safety needs to be considered from the very start of the process. It is what stakeholders want to know about, but it will be assessed in different ways at different stages.

In this context the importance of a stepwise approach was mentioned, to narrow down siting regions until a full site characterisation is possible. Such an effort can only be performed for a limited number of sites and a detailed set of site data is the basis for a comprehensive safety case. So in general, as the programme moves forward data and knowledge will increase and therewith confidence in modelling and results, i.e. geoscientific indicators become more meaningful. In this process the dialogue between implementer and regulator is seen to be important to define the targets for each step. This gives further confidence in the process.

The difficulty of making quantitative comparisons across different host rock formations (e.g. salt, clay and granite host rock) was discussed. Firstly, there is a need to adapt the geoscientific investigation programme to the respective host rock. As shown for the Canadian approach, different investigation methods have to be used for granite rocks and sedimentary rocks. Secondly, the comparison of sites in different host rocks is hindered by the facts that to some extent different processes have to be considered, those processes might act in different ways and the safety concepts are different for different host rocks. For direct numerical comparison, additional problems arise e.g. from the fact that for a repository in rock salt no radionuclide release may occur under the normal evolution scenario, whereas in other formations this is usually not the case.

An approach developed in Germany which is a combination of a (i) so-called Verbal-Argumentative-Method (VAM) based on a comparison of the safety function "robustness" of the repository system in a verbal-argumentative stepwise approach and (ii) Probabilistic-Calculations-based-Method (PCM) based directly on quantitative analyses and model calculations. For application of both methods sufficient geoscientific knowledge of the sites is needed.

Geological versus societal criteria

Part of the discussion was directed to the role of socioeconomic aspects in the siting process. Firstly, it was stated that there is a need to fulfil both geoscientific and societal criteria for a successful siting process. The judgement of the quality of a site with respect to safety is strongly based on geoscientific criteria but societal criteria frame the process.

There is a danger in trying to select the 'best site' from a geoscientific point of view even in the ranking of sites. Firstly, it might be hard to define the 'best site' and to find it, particularly if different host rocks are considered. Secondly, it might turn out that the 'best site' is not socially acceptable and this will then cause problems in gaining confidence in another site, which is seen as only 'second best'. It was proposed, instead, to talk in terms of an 'optimal site', since optimisation includes other factors, including societal factors. However, there is a general tendency to avoid ranking sites. Instead, it is proposed not to differentiate between sites, distinguishing only between those sites that can provide the required safety and those that cannot.

In an optimisation process economics should not be overlooked. If the quality of a site is limited, engineering measures might still be applied to achieve an acceptable safety case. However the costs of implementation may be very high in such a case. There should be a preference for a site that has the natural ability to contain radionuclides with respect to safety, but it is, of course, the whole system performance what matters.

One observation from the Swiss case is that geoscientific criteria play a key role in the siting process and this fact is strongly supported by the public increasing their confidence in the process. In addition, consultations aimed at gaining stakeholder support for the whole process including the role of the involved organisations and for establishing siting criteria are very important, as shown from experiences in the UK and Switzerland (Swiss Sectoral Plan). Generally, the whole siting project should favour a community's well-being. In the Canadian process a strong interaction between the public stakeholders and the implementer has been established including joint field visits with a detailed explanation and discussion of the next steps to the public as well as participation of implementer staff in ritual ceremonies of the aborigines, to demonstrate respect of local community values.

In general, advanced programmes show that a systematic, stepwise process with open communication of progress and discussion of remaining safety issues is one factor of success. This includes empowerment of local people and might go as far to provide the right of veto up to certain stages. However the latter is not valid for every country. Also support to local communities in matters of expertise and some joint development/outreach/support programme is part of the fair play with the local community.

A good balance between siting studies and concept development can help clarify safety functions. Requirements can be developed from the safety functions. In particular at early stages, assessments of safety must not necessarily involve dose calculations, but rather the evaluation of barriers using other indicators. This, however, would not lead to a full safety case, but basically every stage of the process involves assessing safety in some way (see discussion above). It was mentioned that the NEA status report "indicators in the safety case" can be of help, as it discusses several examples of barrier-related indicators to be used with respect to the safety functions (NEA, 2012).

References

NEA (2012): Indicators in the Safety Case: A Report of the Integrated Group on the Safety Case (IGSC), NEA/RWM/R(2012)7, OECD/NEA, Paris.

NEA (2013): Preservation of Records, Knowledge and Memory across Generations (RK&M). A Literature Survey on Markers and Memory. Preservation for Deep Geological Repositories. NEA/RWM/R(2013)5, OECD/NEA, Paris.