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Autor: Gautschi, Andreas

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Deep Geological Disposal of Radioactive Waste – An International Perspective

Andreas Gautschi[1]

This article is a condensed summary of an oral presentation given by the author at the 82nd SASEG annual convention in Baden on 20th June 2015. The presentation was prepared without any review or clearance by the foreign waste management organizations mentioned. For this reason, no details are given and only links to the websites and key reports on which the presentation was based are provided.

Worldwide, there is a large variety of disposal concepts for radioactive waste, ranging from systems with very limited natural barriers or engineered barriers to sophisticated multi-barrier systems (Tab. 1).

Recently investigated or envisaged host rocks with a barrier function (i. e. systems in which rock provides a safety-relevant geological barrier) are:

For high-level waste repositories (HLW):
- Clays/claystones
- Argillaceous limestones
- Crystalline rocks
- Rock salt (currently only salt domes)

For low- and intermediate-level waste (L/ILW) and long-lived intermediate level waste (LL/ILW) repositories:
- The same as for HLW, in addition:
- Marls
- Bedded rock salt [1]

The various host rocks have different advantages and disadvantages and, as a consequence, different design concepts are required in order to optimize repository safety.

In some countries the host rock options are limited, e. g. there are no clay rocks of sufficient thickness in Sweden and Finland and crystalline rocks are therefore the only option. In other countries (France, Switzerland, Canada, Germany), different host rock options have been, or are currently being, evaluated.

The disadvantages of certain host rocks may be minimized by appropriate measures. Crystalline rocks, for example, have a lower efficiency as a transport barrier for radionuclides than clay-rich rocks. Therefore, more weight is placed on the containment of the radionuclides in the engineered barrier system, with the main role of the geological barrier being to protect the engineered barriers against external detrimental processes (e. g. by providing a reducing geochemical system with limited corrosion of the canisters). On the other hand, clay rocks have a lower thermal conductivity and are more sensitive than crystalline rocks to the elevated temperatures induced by high-level waste. In order to mitigate this disadvantage, the spacing of the disposal tunnels may be increased or the waste loading of the canisters may be lowered, which leads to lower temperatures within the repository system.

Disposal of radioactive waste is an issue in many countries. Thus, international collaboration is important and is well established, e. g. in the OECD Nuclear Energy Agency, in the International Atomic Energy Agency IAEA and in numerous EU projects. Extensive scientific collaboration and exchange of experience also occurs within the framework of underground rock laboratory projects in Switzerland (Mont Terri, Grimsel), France (Meuse/Haute Marne, Tournemire) and Sweden (Äspö).

[1] Nagra, Hardstrasse 73, CH-5430 Wettingen, Switzerland

[1] WIPP Waste Isolation Pilot Plant, New Mexico: Transuranic waste from research and production of nuclear weapons.

No geological, no engineered barriers (liquid waste emplacement at the surface)

- Example: Karachay Lake (Russia)
- https://en.wikipedia.org/wiki/Lake_Karachay

Geological barrier only, no engineered barriers (liquid waste injection in a sedimentary basin)

- Example: Krasnoyarsk (Russia)
- http://webarchive.iiasa.ac.at/Admin/PUB/Documents/RR-00-001.pdf
- http://webarchive.iiasa.ac.at/Admin/PUB/Documents/RR-01-001.pdf

Engineered barriers only (surface disposal of L/ILW)

- Example: Centre de la Manche (France)
- http://www.andra.fr/international/pages/en/menu21/andra/regulatory-texts/documents-relating-to-the-manche-disposal-facility-1587.html

Geological barrier and minimal engineered barriers (deep geological disposal of L/ILW, HLW)

- Examples: Asse, Gorleben (Germany)
- www.asse.bund.de
- http://www.bgr.bund.de/EN/Themen/Endlagerung/Downloads/Description_Gorleben_Part3_Geological-surface-underground-exploration-salt-formation_en.pdf?__blob=publicationFile&v=1

Multi-barrier systems: Geological barriers (host rock and confining units) + engineered barriers (waste form, canister, backfill):

Sweden, crystalline rocks (www.skb.se):

- http://www.skb.com/publication/2204001/
- http://www.skb.com/publication/1964194/
- http://www.skb.com/publication/1868223/

Finland, crystalline rocks (www.posiva.fi):

- http://www.posiva.fi/files/3002/POSIVA_2011-02.pdf

France, sedimentary rocks, crystalline rocks in the past (www.andra.fr):

- http://www.andra.fr/international/pages/en/menu21/waste-management/waste-management-issues-at-national-level/high-level-waste-and-intermediate-level-long-lived-waste/dossier-2005-1636.html

Switzerland, sedimentary rocks, crystalline rocks in the past (www.nagra.ch):

- http://www.nagra.ch/de/cat/publikationen/technischeberichte-ntbs/ntbs-2014-2015/downloadcenter.htm

Canada, sedimentary and crystalline rocks (www.nwmo.ca):

- http://www.nwmo.ca/uploads/DGR%20PDF/Geo/Geosynthesis.pdf
- http://www.iaea.org/inis/collection/NCLCollectionStore/_Public/27/065/27065127.pdf

Tab. 1: Worldwide solutions for radioactive waste disposal: Selected examples (Web links in operation on 24 October 2015).