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Geological Disposal of Radioactive Waste

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INTRODUCTION

Disposal of radioactive waste imposes complicated constrains on the regulator to ensure the isolation of radioactive elements from the biosphere. The IAEA (1995) states that "The objective of radioactive waste management is to deal with radioactive waste in a manner that protects human health and the environment now and the future without imposing undue burdens on future generation". The meaning of this statement is that the operator of the waste disposal facilities must prove to the regulator that in routine time and in different scenarios the dose rate to the public will not exceed 0.3 mSv/y in the present and in the future up to 10,000 years.

For low and intermediate level waste (LILW), these constrains can be accommodated using near surface repositories. However, for high level waste (HLW), transuranics waste (TRU) and spent fuel; these conditions cannot be fulfilled by near surface repositories, which depend strongly on the nature of their engineered barriers, climate and the intensity of geomorphology processes. Such construction (e.g. cements, steel etc.) have a live span of hundreds to thousands of years. In the case of HLW the activity after such periods of time can still be many orders of magnitudes above the clearance level. Additional, The IAEA recommends an institutional control period of 300 years after the disposal site's closure, including passive and active monitoring. This period may be too short regarding the long lived and toxic radionuclides (RNs). Moreover, climate changes and erosion processes can impose strong constrains on the life-span of engineered barriers and on contamination migration from them.

Thus the IAEA (2006) recommended deep geological disposal as long-trem solution for HLW, such as TRU and spent fuel. A geological disposal is defined as : isolating long lived radioactive waste from human environment by placing them deep underground in repositories located in host rocks characterized by high stability and low or no groundwater flow" (IAEA, 2003). A geological repository is considered as the best approach to ensure the isolation of the HLW from the biosphere. Construction, operation and closing of geological repository require considerable technical and scientific background in thr design, engineering and safety assessment of such a facility (IAEA, 2003).

The depth of a geological formation and its characteristics are the ultimate barriers between the waste and the environment in the long run. Thus, to accommodate these characteristic a relevant geological formation must have: 1) Low hydraulic conductivity. 2) Low fractures and joint density. 3) High distribution coefficient (Kd) for RN contaminants. 4) Low or no groundwater flow.

There are three major lithologies that were investigated and considered as adequate for a deep disposal site. Clay-rich formations are considered adequate principally because of their very low permeability and high adsorption coefficients (Kd) for most RNs. Salt rock, when under hyper saline solution conditions, is insoluble and highly impermeable. Finally, crystalline rocks (e.g. granite), when un fractured, also have low permeability and relatively high Kd.

IMPLEMENTATION OF GEOLOGICAL DISPOSAL AROUND THE WORLD

Today, no country has an authorized and operating geological disposal facility. The main obstacles is in the regulation process arise public acceptance issues and stakeholders approval, together with the regulatory and authorization applied requirement. Specifically, the demand for retrievability of the buried waste in the future, in some countries (e.g. France) imposes much safety, regulatory and engineering challenges. Additionally, far future (i.e 10^5 y) modeling and speculation create large uncertainties and difficulties in communicating with the public.

Nevertheless, most of the western countries have taken significant steps towards the implementation of such repository, examples of which are given below.

USA: Waste Isolation Pilot Plant (WIPP) is operating in New Mexico at 655 m depth in a 600 m thick of salt formation that has been stable for more than 2000 million years. It is defined as storage and not as final burial site. The site is aimed for military TRU waste only. On the other hand, 30 years of research into the implementation of geological disposal site in Yucca Mountain, Nevada in a tuff formation have been ended in extinguishing the project and in search for a new location for the site/.France: The French National Radioactivity Management Agency (ANDRA) is constructing a deep disposal site at about 500 m depth in clay-argillite of Callove_Oxfordian formation. At the Meuse/Haute-Marne Underground Research Laboratory (URL) located at Bure (300 km east of Paris). The site is expected to become operational in 2020.

Belgium: A clay formation (boom clay) at a depth of about 240 m in north east of the country is being considered as a possible disposal site, but so far no final decision has been made.

Germany: The Gorleben salt dome was investigated for its feasibility as a repository since the mid-1980s. I 2000 a moratorium was imposed on the Gorleben site and it was re-opened for investigation in 2010. Decision about the future use the site is expected in 2020.

Sweden: A site in granite bedrock about 500 m below surface was located at Fosmark. The site is expected to be opened in 2025 and to be in full use in 2027.

Finland: Finland is constructing a national repository named Onkalo in a crystalline bedrock formation. The repository is located in Olkiluoto at a depth of 400-500 m. An underground rock characterization facility was established at the site. The repository is expected to be operational by 2020.

Switzerland: Two active undergrounds research labs were established. One in an Opalinus clay formation (Mont Terri) and one in granite rock (Grimsel). No decision has been made on the final location the repository.

Other countries: Russia and Hungary have sited specific locations and defined the geological formation and aimed for suitable kind of disposal. The UK and Canada are in the stage of approaching local communities for accent to entrain geological repository.

In summary, it can be seen that most western countries involved in nuclear activity are in the process of locating, investigation and acquiring public acceptance in their quest towards geological disposal implementation.

THE ISRAELI CASE – PRELIMINARY RESULTS

The small size of Israel, the large population density in the central and northern parts and the proximity to an active fault zone (the Dead Sea Rift) make the choice of suitable site difficult. Additionally, the common target rocks for geological disposal (e.g. salt, clay, and granite) are unavailable in Israel in thick, depth and un-fractured formations.

The Yamin Plateau (YP) in the north east of the Negev holds the Israeli national site for radioactive waste since the 1969th. LLW is disposed in near surface trenches. However, other waste forms (i/e. spent fuel) are stored as being inadequate for near surface disposal. The government of Israel gave the NRCN through the IAEC the mandate to examine the possibly of locating a geological waste disposal site in YP. The marl and chalk lithologies of the Mount scope Group are being examined for their suitability to serve as host rocks for geological repository. These lithologies are characterized by low hydraulic conductivity and high retardation capacity for RNs. It should be noted the Judea and Kurnub aquifers (Fig. 1) reside 200-300 m below the target formation.

Four boreholes of 3" diameter perpendicular to the geological structure (Figs. 1, 2) were drilled down to 300 m depth in order to investigate the stratigraphy, depth and thickness of the target units. The presence, direction and joints' density were studied using a unique camera (TeleViewer). Cores were sent for geo-technique analyses to check the parameters of mass rock quality. In-situ inspections within boreholes were conducted to measure the hydraulic conductivity values, using "double packer" technique, and the bulk densities of the rocks unit through P and S seismic velocities. Additionally, primary estimation of the rocks retardation capacity for the expected contamination (through their stimulants) was done, yielding satisfactory values. So far, the main finding is that none of these measured parameters negate the possibility of geological waste disposal is those deep formations, but more research is needed

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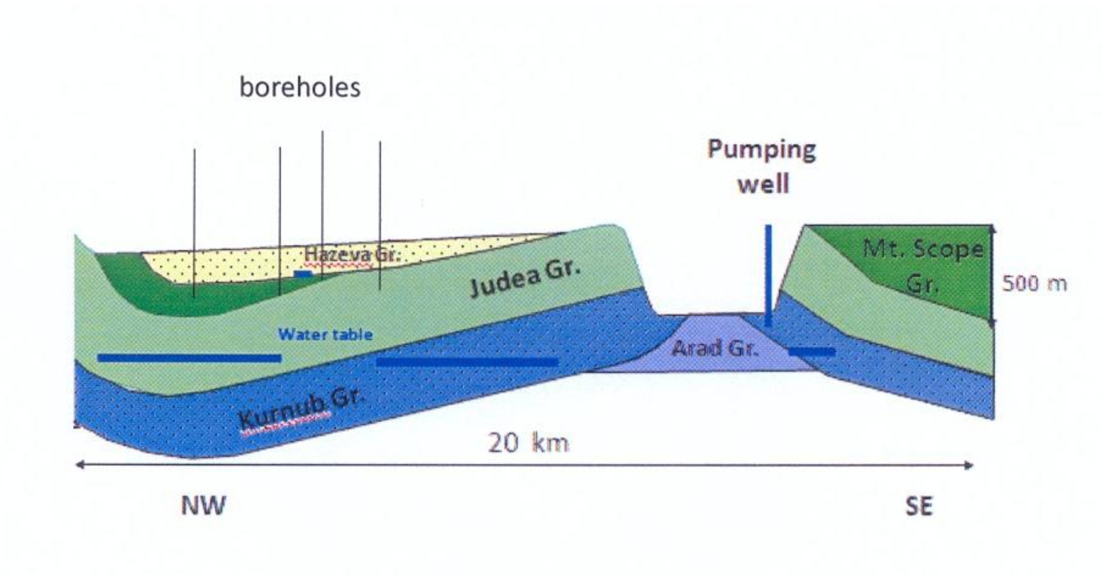

Figure 1: The geology structure of Yamin Plateau

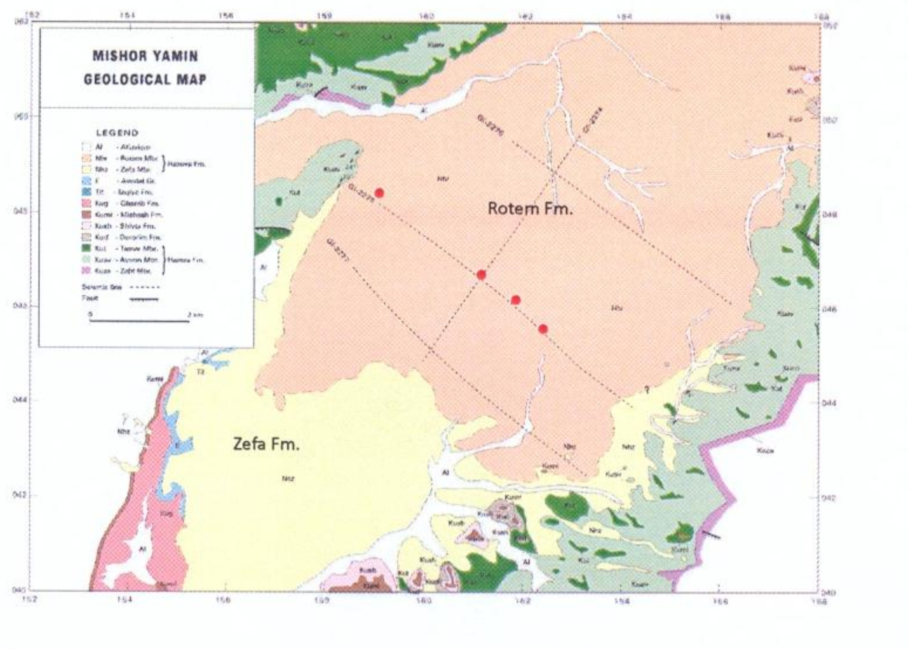

Figure 2: Geology map of Yamin Plateau