450 Meters Deep into 1 Million Years Safety

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On the shore of the Gulf of Bothnia, in western Finland, a deep geological repository comprising a system of underground tunnels 5 kilometers long and circa 450 meters deep is being hollowed out of magmatic gneiss, the local solid bedrock. Named Onkalo, the Finnish name for "cavity", this repository is on track to be the first attempt to implement the preferred official and permanent solution for high-grade nuclear waste disposal. It is being built to be sealed off and never opened again once the accumulating spent (or used) nuclear fuel rods of the Finnish – and only the Finnish – have been buried and secreted in the tunnels deep underground. To that end, its construction follows the models for "robust-storage" (IAEA, 2006) that are being developed by many countries worldwide, and that conform to mandated solutions that regard geological facilities to be the most stable and secure option to deal with the risk posed by dangerously radioactive wastes, to our health and safety.

Since 1954, the year the world's first nuclear power plant became operational, significant experimental research and development programmes have been undertaken to determine satisfactory disposal sites and methods to shield the wastes produced by nuclear reactors from the environment. These comprise socio-technical combinations of many actors and factors that are, in many respects, only hypotheses of stability and functionality. The fundamentals of the recommendations for the disposal of waste in deep porous beds was first compiled in the *Status Report on the Disposal of Radioactive Wastes*, as a logical and necessary part of the *Study of the Biological Effects of Atomic Radiation* [1] published in 1957. The report states that deep underground disposal (or geological) facilities are best suited to the task of holding and leaving large volumes of high-level waste and nuclear fuel to rest, far into the distant future associated with radioactive half-lives and lethal emissions. Such disposal, it is argued, is capable of meeting the monumental forces of geological time and the gradational movement of radioactive materials that are active for millions of years. [2] For the material to be left undisturbed, these facilities must be built in environments unlikely to be affected by natural geological phenomena, unattractive to exploratory drilling or other anthropological interest, and also protected against acts of radiological sabotage and theft.

Accordingly, the Waste Management Committee of the International Nuclear Energy Agency, the group responsible for fostering international cooperation, stresses the importance of gathering information on long-term geological change and geo-storage processes through an analysis of the present characteristics and incidence of natural resources of any site, their differences in the

1 This was a study providing information on the nature and problem of radioactive wastes that proposed processes for a permanent disposal and background information on reactor processes, along with certain aspects of the economics of waste and a review of the potentialities and problems of land disposal.

2 As example, the half-life of uranium 235, for example, is 700 million years.

geological past, and the likelihood of changes in the future. The depth at which the disposed-of material is to be placed depends largely on the type (and probable date of formation) of the host rock and the probability-based isolation capacity of the conditioning materials. The Committee reports that the main component of the tunnels, i.e. concrete, has inbuilt geological durability, and thus is likely to survive within the underground realm. Hardened into an artificial rock, concrete has good enough geological credentials to act as a fossil-containing rock – the stratum whose consistent characteristics scientists and engineers correlate with a hardiness over time. Architecture is hence considered to have the capacity to mimic geology, these facilities built to approximate the fossilisation of radioactive, and future, threats.

Fossiliferous Futures

Deep geological facilities for nuclear waste disposal entail the combination of waste form, waste packaging, engineered seals and geological formations to provide (very) long-term isolation, confinement and containment of high-level waste with no need for surveillance or maintenance – in contrast to the intermediate disposal facilities that currently exist, above the ground or near the surface, in ponds and other confinements, some of which are located in flood and earthquake zones. [3] Conceived as a purely technical design problem of multiple, autonomous barrier defences, these facilities are thought to be secure enough to protect us from the release and migration of radionuclides into the environment, by both stopping or retarding the capacity of radioactive waste materials to exit the interior of the repository, and protecting these materials from the intrusion or penetration of anything (like the groundwater) or anyone from the outside. They are constructed according to the intention to build an incorruptible place; the ideal protection-exclusion space, enclosed firmly in the underground mass. For that, it is necessary to take measurements and assure geophysical monitoring to ensure that the models will meet the safety levels required to deal with the realities of the nuclear materials and the future that these engineered and natural barriers will need to accurately limit for perceived perpetuity. Much of this work is conducted with (not only for) the future. It is focused on the plausibility of possible outcomes, the application of better criteria, the employment of the most enduring materials and the development of better models of future (environmental and repository) conditions.

In Finland, the planning and preparation to deal with the stock of nuclear waste through this program started in the 1970s, around plant sites chosen based on thorough evaluations. The scope and the schedule were defined in 1983, and the decision was ratified in 2011 with the stable geologic environment of the magmatic bedrock (estimated to be approximately 1900 million years old), of the Onkiluoto Nuclear Power Plant, chosen as the site for the country's (very) long-term disposal of spent nuclear fuel: altogether circa 300'000 tons of high-level radioactive waste, a number that increases by an additional 12 000 tons annually. The construction of Onkalo started in 2004. The encapsulation plan – for the handling, storing and permanent disposal of waste – is expected to be completed by the year 2100 and to be sealed in 2120 to last one million years, without maintenance or surveillance and with no return of waste to the surface.

Posiva Oy [4], the licensed expert organisation that monitors and earmarked the site relies on existing and accessible empirical data – as well as the socio-scientific methods for collecting and dealing with it – to ensure that Onkalo will behave as predicted and remain isolated, for them to be able to respond appropriately. The experts are working with security standards based on theoretical and scientific assumptions (scales of risk, ideas of liability, ethical considerations and limits of predictability) in order to assert the "facts" of the measured life of the solid bedrock and the expected timescale in which radioactivity will decay, and to support and sustain an

3 Examples include the Fukushima Daiichi nuclear disaster but many other sites are mentioned in the flood assessments performed by the US Nuclear Regulatory Commision (NRC) and/or the UK Department for Environment, Food and Rural Affairs (Defra) available online.

4 A joint company by Fortum and TVO, two Finnish nuclear plant operators.

epistemological realism as a means to manage and balance the ethical and technical considerations with the concerns of the public (and policymakers) about nuclear safety. Of course there is no practical way to actually eliminate the waste, spatial solutions are acts only of planned containment. The waste itself is the only commander of its own disposal, as it decreases its half-life over millennia.

It is, thus, hard to deny that this epistemological realism is a disturbing element in the arguments used to legitimate Onkalo. The temporality of the wastes to be deposited and the impossibility of accurately modeling all available futures renders our basic trust in the materiality – the infrastructural space (engineering and conditioning) and the geological barrier - to appear only to be a pretence of theory, an intrinsic fallacy that is ultimately a source of epistemological fallibility. In the end, if there is a consistent line that seems to run through Onkalo`s work it is, instead, a kind of belief or faith that is, in itself, not scientific.

Amongst all the various forms that this belief in the efficacy of burying radioactive materials takes, there is no guarantee that a site, nor a ground, will perform as projected over the one million years it is to be left undisturbed. Nor is it guaranteed that future generations will have great success (or better transmutation technologies) to deal with the waste stored there than we do at present. The proponents know that inadvertent intrusion into the site might result in accidental releases of radioactivity; the site cannot be secured for such (non) foreseeable futures, and it is inevitably, and inherently, subject to the uncertain. Thus, it provokes an inquiry into the future fraught with possibilities. In the words of key stakeholders in the Onkalo project:

> *When you do a project like this you must state what you know, and you must state what you know that you don't know. And also what you don't know that you don't know (Esko Rukuola, principal advisor of Finland's regulation, radiation and nuclear safety authority, in Madsen, 2009).*

> *When you make a decision concerning this kind of thing, which takes you to 2100 when the final sealing takes place, there will always be uncertainty. So you have to trust (Timo Aikas, Positiva's Vice-President in charge of Onkalo's engineering, in Black, BBC News, 2006).*

> *Eventually, but at very different times for different parts of the disposal system, uncertainties are so large that predictions regarding their evolution [the evolution of the required assumptions about surface environmental processes, radiological exposure modes and even of a well-chosen site and design] cannot meaningfully be made (Nuclear Energy Agency, 2004).*

In fact of course, the only certainty about the future is uncertainty. It remains unknown: a natural and certain uncertainty. The safety of both Onkalo's epistemological foundations and of the bedrock itself embody limits of control and knowledge but also of physical and intellectual capacities. In this notion is included the relationship between the known and the unknown, in line with the epistemological riff[5] of Donald Rumsfeld (2002) and Slajov Žižek's extrapolation of it, extending to 'unknown knowns' (Žižek, 2004) – i.e. things which we intentionally refuse to acknowledge that we know. Awareness of both the 'known unknowns' and 'unknown knowns' of future realities inflates the danger of Onkalo, as of the other geological storage facilities, rendering risk management and contingency planning to the realm of speculation. The authorities and group of experts involved maintain the conviction that the deeper the diggings, the more firm, stable and immovable will be the ground. Yet the further that is dug,

5 Rumsfeldian epistemological riff derives from the United States Secretary of Defense, Donald Rumsfeld, public response to the threats and lack of evidence linking the government of Iraq with the supply of weapons of mass destruction to terrorists' group.

the more Onkalo's territory extends into the very earthliness of the Earth and the more complicated becomes the (en)closure of the repository itself. The further that is dug, the more 'unknowns' that are generated.

Conditional Fiction

The very recruitment of the Earth's body and the depth at which the Onkalo facility is to be placed confounds any possibility of the waste's enclosure through limiting structures – at both the micro and macro levels. The architectural solution employed to 'put a lid on' the waste cannot possibly encompass the crust of the earth as a whole. The artifice of human security can be further perceived due to the facility's reality as a gap in the bedrock. It is exclusively an interior, hollowed out of the vast and formless body of the Earth – an interior which renders the whole of the earth as the facility's host building. Thus, far from visibility, in the future, once the tunnel and especially the canisters have decomposed, geological facilities like Onkalo will be perhaps (only) discerned as dots, a pattern of radiation encrusted as an influence on the host rock. Legible as an artificial fossils, their symmetry to "natural" fossils does not signal an equivalent within the realm of nature but rather the fact of their - organic and radioactive materials both - being contingent on, and supplicant to, nature's forces. To respond effectively to the unpredictable changes that will inevitably take place under the Earth's surface is outside our control. Such a capacity is a fiction. There is a gap both in the rock, and in our abilities.

An awareness of the fictive and faith-based convictions which are foundational to the idealised design of future-bound deep geological facilities destabilises the certainties of nuclear waste entombment – literally undermining the perceived conditions of geological security that led to their being planned and built in the first place. Whilst employing extensive and fantastically advanced studies for nuclear waste to remain unseen and undisturbed, these facilities gamble with the Earth's stability, disregarding fossil formations as rare occurrences, fruit of a series of truly special events.

In Onkalo, we are fortunate that the natural geological formation provides an excellent medium for the excavations and works being undertaken to ride our environment of nuclear waste, but to complete the task there is an unprecedented need for, and guarantee of permanence being built in the absence of any certainty regarding the success of objectives of isolation, confinement and containment designed to deal with the wastes. This will either give rise to the withholding of radiant hazards or bring forward potentially catastrophic results. Applying Reza Negarestani's words, 'Anything can happen for some weird reason; yet also without any reason, nothing at all can happen. Things lead into each other according to a logic that does not belong to us and cannot be correlated to our chronological time' (Negarestani, 2008: 49). This is the part played by contingency – a realm of possibilities beneath the world of actuality. It remains to be seen if Onkalo´s success is psychological or physical – a desperate attempt to keep alive the fantasy of a concrete solution to the generations-old problem of radioactive wastes, or a winning strategy for eradicating radioactive threats. Is it radionuclides or simply our fears that will more effectively be buried in Onkalo?

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