A Pyramid as a Repository for Radioactive Waste

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Abstract: Nowadays, only deep layers of rock are explored in search of repositories, although it is very difficult to obtain reliable knowledge down there. Despite many obvious advantages, above-ground repository concepts are not being discussed for fear that they may not be politically enforceable due to their visual conspicuousness. The pyramids, the only remaining wonders of the world, show that permanent above-ground solutions can be built whose lifespan is beyond our imagination. With a comparable structure, the search for a repository can be completed in a future-proof manner.

Introduction

The search for a repository for radioactive waste is not only unsolved in Germany. A few basic conditions must be observed: safety in the event of attacks or accidents, flooding and groundwater, accessibility and retrievability of the stored materials - even after several hundred years. In addition, there are boundary conditions such as the distance to residential buildings.

Strangely enough, it is always assumed that a repository must be underground. How so? You can't see what's beneath the surface, so the problems don't go away. On the contrary: down there, many challenges such as water ingress, structural changes and regular checks are getting worse. There is no experience of how the deep underground changes within thousands of years.

This arbitrary restriction of the search to underground deposits - cemented by the adopted StandAG in Germany - is a ban on thinking that I reject. It is unscientific to define the direction of investigation (here: downwards) from the outset and to cling to it without thinking. Who says A, does not need to say B. He can also realise that A was wrong. There is no shame in revising previous wrong decisions. Wolfram König heads the Federal Office for Nuclear Waste Management Safety and explains: "Don't close your eyes". Right! We also have to think outside the box and - literally - think above ground! The way up is paved with fewer obstacles than the way down. We do not live in holes, but in houses above the ground, which we build according to our needs.

My suggestion

You build the repository above the surface of the earth in the form of a giant pyramid. At any height, the structure is constructed as you need it and think it is right - according to the current state of the art. If later changes are necessary, they can be done with manageable construction with manageable effort.

Anyone who has ever stood in front of the Pyramid of Cheops near Cairo has noticed that no substantial damage has been done to this gigantic building in the past 4600 years. That is why it is the only remaining "wonder of the world" and will surely survive the following 9999 years with little change. If you are seriously looking for a repository concept that is likely to remain stable for thousands of years, you cannot avoid comparing your plans with these oldest preserved large buildings on earth. From today's perspective, they were built with primitive tools made of natural stone and have survived some earthquakes and wars amazingly well. Based on all previous experience, a comparable service life cannot be expected for modern large buildings made of reinforced concrete. Despite all the forecasts, many counterexamples have disappeared after a few years.

The pyramid is inherently earthquake-proof and the interiors are separated from the surroundings by meter-thick, unconnected stone blocks. Gravitation serves as the "glue", which will not change in the following million years. Such a repository can withstand any fighter jet and the design with sloping walls can withstand neighboring explosions. The construction of unconnected stone blocks can absorb vibrations very well - incomparably better than a hard wall made of reinforced concrete.

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Since water damages every structure in the long term, countermeasures must be taken to extend the useful life of the structure. Well-known methods are known for structures above the earth's surface because the rain always comes from above. There are many buildings worldwide that have survived unsettled weather for centuries. Earlier generations knew how to build natural stone buildings so that the interiors are earthquake-proof and rainproof - this knowledge is still available.

In underground storage, there are no reliable methods of keeping dry apart from the continuous pumping out of penetrating water, as many full mines and the “Asse” depot prove. It is neither possible to predict groundwater flows and their changes in the long term, nor are there effective, tried-and-tested protective measures that can be implemented, so to speak, "with luck" in the hope that they will still be effective after thousands of years. All experience shows that underground repositories are predictably inherently unsafe against water ingress with all consequential damage to the stored material.

It is also often discussed that not only society must be protected from the repository, but also "the repository from society". It should be barricaded against future desires for the dangerous content. But what for? A country that wants to own radioactive material can produce the desired quantities in the short term and relatively easily, as can be observed worldwide. Since the necessary techniques are known, the production also succeeds in relatively poor countries like korea, and they will save themselves the way to Germany in order to plunder the pyramid there full of rubbish.

The position of the trash pyramid is widely recognizable and its sheer size serves as a warning sign that you should not approach it carelessly or accidentally. The almost unstructured outer surfaces can be easily monitored - this simplifies securing against unauthorized entry. Sloping, smooth outer walls preclude climbing or driving on and are also not landing areas for aircraft of any kind. If the angle of inclination of the side surfaces is chosen to be approximately equal to the angle of debris, natural effects such as snow load or earthquakes as well as unusual mechanical effects such as aircraft impact, explosion and shelling can damage the structure not fundamentally or even destroy the pyramid. The structure is inherently stable and a high-quality mechanical barrier against extreme effects. The internal waste bins are correspondingly well protected.

For a structure above the surface of the earth, the experience "the deeper we go, the less data we have" is irrelevant. A garbage pyramid can be planned and built in such a way that it is clear at all times what is going on inside and outside the building. The Egyptians were able to construct above-ground pyramids with all the necessary details and without modern construction machinery. And these ancient buildings could still be improved and supplemented today if you wanted to. In the case of underground deposits, this is almost impossible afterwards.

Location of the Pyramid

We have many large military training areas in Germany, far from inhabited areas and on soils that can hardly be used for agriculture and which are therefore very suitable as long-term storage areas. Since military training areas are largely contaminated with ammunition and ammunition parts due to military use, entering and driving is extremely dangerous and therefore prohibited for civilians. Therefore, the construction of a garbage pyramid means no loss of usable floor space to complain about. But it will be a welcome nature reserve.

There is no training site in the immediate vicinity of mining activities or industrial plants with a high risk of accidents. The distance to inhabited areas reduces the grounds and likelihood of an action against the approval notice. All sites have been state property for a long time, so there is no reason to fear legitimate lawsuits from property owners, associations and municipalities around the location region. This advantage simplifies and speeds up the location search procedure and can hardly be overestimated in the densely populated federal territory. The existing military restricted area facilitates the construction of a garbage pyramid in the middle of the site as well as subsequent surveillance.

Many military training areas have been decommissioned and / or are located in areas where limestone occurs, for example the Heuberg military training area in southern Germany. Therefore, the meter-sized building blocks - like 5000 years ago in Egypt - can be obtained in the immediate vicinity, which reduces the construction costs. The entire site is state owned and has good transport links. The inhabitants of the surrounding, mostly sparsely populated areas would be happy if the noise pollution by military exercises was stopped or at least reduced. Measures to protect the landscape can be dispensed with near the center of a military training area. There is no reason to build the garbage pyramid on top of a hill.

A solitary, approximately 150 m high limestone pyramid in the depression of a military training area may be noticed, but it is noticeably smaller than the frequent and huge spoil tips of potash mines. And it does not pollute the environment in any way: No frequent truck traffic and no ecological problem, because foreign substances (salts and heavy metals) that may have been contained in the past have been washed out of the building material limestone for millions of years. It will be another million years before the limestone is dissolved by "acid rain". By then, the radioactivity inside has largely disappeared. The leachate is harmless compared to that which runs off the "Kali mountains" or even the legacies of the uranium mining of Wismut AG. The containers in the garbage pyramid will be dry and easy to locate even after more than 500 years. Everyone knows and nobody will enter the trash pyramid uninvited. What if someone starts digging after a few thousand years, out of curiosity or out of archaeological interest in the world of the 21st century? The Netherlands chose a similar route: the striking, colorful building COVRA, where everyone who comes closer senses that it contains something special. I suggest a yellow and black stripe pattern like a wasp. Everyone understands these warning colors, even if they cannot read. You hardly need guards, because if Greenpeace wants to take an action, all you have to do is register. And terrorists might get to the building. But no further. A garbage pyramid does not burden future generations with unreasonable tasks.

The so-called 10-H rule in Germany, which limits the distance of a wind turbine from homes, is also irrelevant. According to this, the wind turbine noise source must be at least ten times as far away as the system is high. The garbage pyramid generates neither noise nor periodic shadows and has no civilian neighborhood near the middle of a military training area.

Before the location is selected, no drilling and extensive data collection are required, the geological condition of the subsurface is of secondary importance, and the load-bearing capacity can be easily determined. The properties of limestone as a geological barrier against radioactivity are known and they hardly change due to moisture. No military training area is known for its unstable underground. A shifting of groundwater flows underground and the chemical reactions triggered by it are no longer a decision criterion in a waste pyramid. The decisive factors are visible marks on the surface of the earth that are easy to control at all times.

The planning of a repository in an inhabited area always provokes resistance: no mayor, no regional parliament wants to provide its own land as a nuclear dump. At a military training area, no municipality has to allow ground surveys to be carried out on their terrain. There are no predictable resistances, neither now nor later.

Size estimation

With the base length of 230 m and the height of 140 m, the Cheops pyramid describes the volume of 2,580,000 m³. These dimensions are reference for the following considerations. An increase in the external dimensions of only 26% would double the volume of the pyramid. Since it is about the assessment of a construction project, dimensions in the units tons and cubic meters are useful. It's not just about the measurable and therefore known radioactivity of the waste to be stored, but also about the inevitable packaging and safety distances between castor containers.

The low- and medium-level radioactive waste currently stored in Germany comprises around 120,000 m³ - and would fit into the Cheops pyramid about 20 times. The later expected increase to

300,000 m³ will also fill less than 12% of the total volume. There is still plenty of room for the approximately 15,000 tons of radioactive heavy metal, the volume (including protective container) of which probably does not exceed 10,000 m³ (other estimates calculate 30,000 m³). Even with very "airy" storage, this amount disappears in the total volume of the trash pyramid. That is why very large safety distances can be easily achieved - in contrast to underground vaults. A single repository would be sufficient to accommodate all radioactive waste that has been or will be generated in Germany.

The heat development

Castor containers develop a lot of heat over a very long period of time because they contain highly radioactive substances. With underground storage, the natural air circulation is not sufficient and must be ensured by forced ventilation. It is irresponsible to provide an energy-intensive technical destruction device and to hope that it will survive crises and wars for thousands of years without maintenance and with little energy. During the Fukushima disaster, we saw the consequences of a multi-day loss of external energy (luckily only from a great distance).

In the case of underground storage facilities, it is planned that the thermal energy generated in the garbage "flows off" to the surroundings through heat conduction. This is possible with a sufficiently low energy density, but requires good thermal contact with the surrounding rock and leads to a constructive contradiction because air is a poor heat conductor: the hot containers should have good thermal contact with the surrounding rock (filling material?), But at the same time have no contact to minimize the risk of corrosion.

In contrast, a 140 m high pyramid can be constructed in such a way that the chimney effect up to the top ensures permanent ventilation without external energy. Maintenance-free for any length of time, intrinsically safe and without using flammable materials. The central chimney does not have to be designed like a vertical pipe into which bombs or other objects can be thrown. The limestones can be arranged so that the cooling air flows through the garbage pyramid in a meandering shape.

Since the trash pyramid is a dry cooling tower, the principle also works in a water-poor region and does not produce any visible steam. This simplifies the search for a location because the environmental influences will be minimal despite the high thermal energy to be dissipated. Hot air is invisible, rises very high and does no damage there. The developing thermal hose always starts at the top of the garbage pyramid and cannot peel off like a cyclone and wander across the site. Health hazards due to contamination of the environment can be ruled out in the long term because no water is involved in cooling. The gaps must not be closed due to air cooling. In contrast to underground storage, it is therefore not necessary to develop suitable filling materials and to monitor their consistency later.

The radioactive waste containers are designed to be gas-tight, but the diffusion of individual atoms cannot be ruled out in the long term. In addition, there are rock particles that separate from the limestones and fall onto the waste that is stored. After a long time they could become weakly radioactive and then carried away by the cooling air. There are two different cases:

- Gases diffuse out of the containers, for example helium isotopes. These are harmless, escape into the atmosphere with the cooling air and are carried upwards especially if they are specifically lighter than air.
- In the long term, it cannot be ruled out that heavy metals such as uranium diffuse out of the containers and are somehow entrained in the cooling air. In this very unlikely case (also for the dust mentioned above), a centrifugal separator is installed in the pyrmids, which reliably separates all components (including dust) that are specifically heavier than air. With the already predictable small amount of diffused material, a centrifugal separator (dust separator) is maintenance-free for millennia and works without the supply of external energy. The collected particles remain in the trash pyramid and therefore do not have to be checked

or "disposed of".

The future security of the pyramid

In previous discussions, it was often overlooked or excluded that we manage the entire problem of “final disposal of radioactive waste” from the narrow perspective of our current state of knowledge. Many concerned people are overestimating their limited knowledge and announce: "This waste is harmful and dangerous and is guaranteed to be unusable forever!"

Is it really like that? Who knows that now? How can someone be sure that we have reached or exceeded the zenith of human knowledge? A hundred or a thousand years ago, weren't people also certain that there would be no further expansion of knowledge?

Probably there will be better ideas for a repository concept in a few hundred years that nobody is thinking about yet. Then the contents of the garbage pyramid can be transferred to a subsequent repository with manageable effort. Is that still possible with an underground repository? A look at the "Asse interim storage facility" is not very hopeful. Now, time is of the essence, we have been looking for a solution for far too long. Once the trash pyramid is erected and filled, later generations have a lot of time to come up with even better solutions.

Doesn't anyone think that later generations might be grateful for a huge storehouse full of valuable raw materials that is easy to exploit? Maybe we're just too stupid to see the treasure that today's radioactive waste will offer to future generations? Who is smart enough to be able to finally judge that? It would be presumptuous to consider our current incomplete knowledge as the upper limit of all knowledge that cannot be surpassed in the coming millennia. Just keep in mind how condescendingly many of us are now smiling at the level of knowledge that previous generations were undoubtedly proud of. Electric current was invented 200 years ago, and there was no electronics or radio technology 100 years ago. Back then, some were already dreaming of flying to the moon. And now? In Germany in particular there are too many despondent, unimaginative spirits who fearfully want to ban and bury everything they don't understand. The "German Angst" is widespread.

Einstein recognized very realistically: The opponents of an idea are not convinced, they die out. Should we wait so long?

Later generations will probably consider our current misgivings to be fearful "experts" who think they are omniscient. In reality, these were just imaginary lay people. We must not paste the lack of imagination with overconfidence and ideological stubbornness. It is strange that the popular criticism of the use of nuclear energy is often led by people who have little knowledge of the physical basics, but who are constantly inventing new arguments.

Anyone who now claims that radioactive waste is bad and dangerous and is guaranteed to be worthless forever, may be a gifted expert in the eyes of his “followers”. Will future generations judge him that way? Sometimes dark visions of the future are tried to prove the hopelessness of all efforts:

1. Climatic changes cannot be predicted over a period of 1 million years. A glacier could come from the Alps and push the remains of the garbage pyramid from Heuberg overland for kilometers. Therefore, there should be no above-ground repositories.
2. A volcano could erupt in the immediate vicinity of the repository and blow buried contents into the atmosphere. Therefore, there must be no underground repositories.
3. A giant meteorite could hit and atomize both types of repository. Then the vaporized radioactive contents of the repository lowers the prospect that humanity can survive. Therefore, there must be no repository at all.

Each of these possible catastrophes will eventually hit Earth, we don't know the time. Maybe in a few years, maybe only in the distant future. It is therefore pointless to regard the extreme half-lives of certain isotopes as the minimum lifespan of a repository. Without reliable forecasts of when the three scenarios will become reality somewhere in Germany, it makes little sense to take a period of

more than 20,000 years into account in planning. Only those who want to create panic will name longer values. Experienced statisticians tend to limit themselves to shorter periods.

Don't forget: Intelligent people have only existed for 100,000 years. Does it make sense to plan anything over ten times as long?

We have to do something. If you want a solution, you will find a way to finally build a repository. Those who do not want a solution invent reasons to make the search more difficult. This is where people differ.

Conclusion

I am convinced that the statement "Germany has decided to permanently dispose of all types of radioactive waste deep underground" is an incomplete decision that leads to a dead end from which no way out has been found so far. The search has not progressed for years and requires a fresh start. This can begin by discussing the advantages and disadvantages of the pyramid design. No repository concept is perfect, but I am convinced that the garbage pyramid has by far the least risks and side effects.

The requirements for the location selection, the approval and the operation of repositories are usually reduced with this design and in certain points they are even irrelevant. A sufficiently large garbage pyramid is the optimal and at any time correctable repository concept with return and recovery options. And it is always better and safer than many small interim storage facilities spread across the country.

The required service life of a repository of several thousand years is far beyond the range of experience for engineering constructions. This does not apply to pyramids made of natural stone blocks of the type that were developed in Egypt 5000 years ago. This type and design meets very high and unusual safety requirements and has survived many generations without maintenance. The limestone building material has been pre-aged for many millions of years, so there are no significant structural changes to be feared within the comparatively short useful life of several tens of thousands of years, and the condition of the building does not have to be monitored during the storage period. No other repository concept can demonstrate this unique feature, in particular no deep storage. In geology, every prediction is based on conjectures, hopes and untested assumptions. With underground deposits of clay, salt or granite, geological surprises can never be ruled out. With the above-ground garbage pyramid, you have every detail under control. Now and later.

In the case of a garbage pyramid, the following applies: The necessary isolation period of the content is comparable to the previously proven structure duration of analog buildings made of natural stone in Egypt. In comparison, our geological knowledge for deep geological formations in Germany is negligible and does not allow long-term predictions. This limits the maximum possible verification period for underground storage to almost zero.

In the amendment to the StandAG by the German Bundestag and Bundesrat, “a learning process is proposed that enables decisions to be revised.” Very good. Now is the time to rethink the overall concept. Maybe we can escape the mental hole that we have dug in the search so far.

About me: Many years ago I studied nuclear physics at the Technical University of Munich and graduated with a diploma. I was very interested in the exact functioning of nuclear power plants and atomic bombs. After I understood that, my career choice changed and I never worked in the nuclear energy department. However, I have always followed developments in this area with great interest and also looked for solutions to the challenges arising from the use of nuclear energy.

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