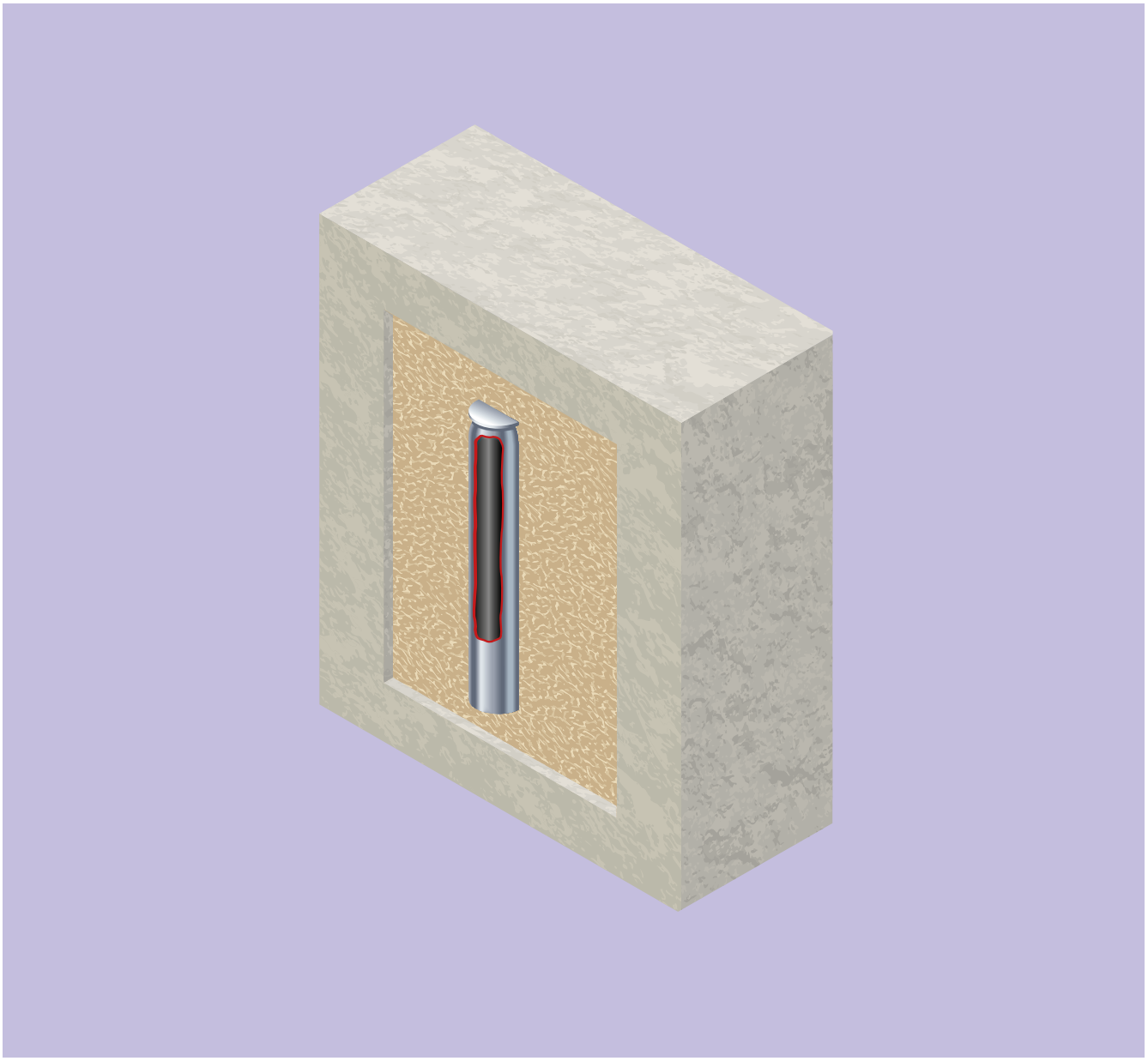
The multi-barrier approach



Radioactive Waste Management

The multi-barrier approach

Geological disposal provides safety through a combination of man-made (engineered) and natural barriers that work together to provide **isolation** and **containment** of radioactive waste. This is called the multi-barrier approach.

Isolation means putting the waste well away from people and the surface environment. It is provided by:

- The depth of a GDF, which will be between 200 and 1000 metres below the surface in stable rock. Deep underground, the waste will be much better protected in the event of earthquakes, tsunamis and long-term environmental changes such as future ice ages.
- The choice of a site away from known areas of significant underground resources such as fossil fuels or minerals are scarce. This reduces the likelihood of humans disturbing the facility in the future.

Containment means keeping the waste where we put it. It is provided by:

- The solid form of the radioactive waste itself.
- The long-lasting metal or concrete waste container.
- The material placed immediately around the waste containers to add further protection. We call this buffer or backfill.
- Other engineered features of a GDF such as the seals in tunnels or vaults.
- The stable underground environment in which the facility is built.

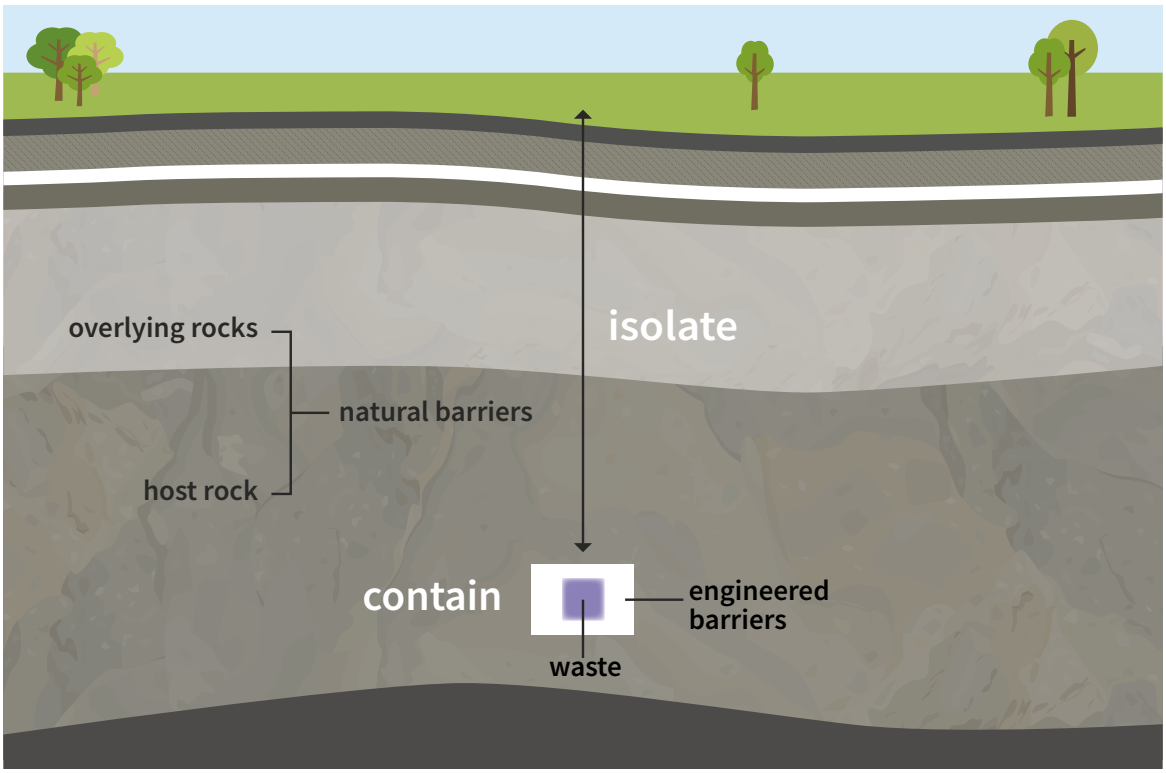


Figure 1: How the barriers of a GDF provide protection from radioactive waste.

Unlike other hazardous wastes radioactive waste gets less dangerous with time. This is because it undergoes radioactive 'decay', i.e. it gives off radiation and eventually becomes a stable (non-radioactive) material. It will take many tens or even hundreds of thousands of years for radioactive waste to decay to harmless levels. We therefore engineer barriers that will work together with the natural barrier of the rock to provide safety. We also think about how the environment around a GDF might change over such a long timescale.

The barriers in a multi-barrier approach include:

1. **The waste form**
   Only solid waste will be sent to a GDF. High Level Waste, a liquid by-product from reprocessing nuclear reactor fuel, is transformed into blocks of glass for storage and disposal. Other wastes are mixed with cement or sometimes set in a resin matrix.

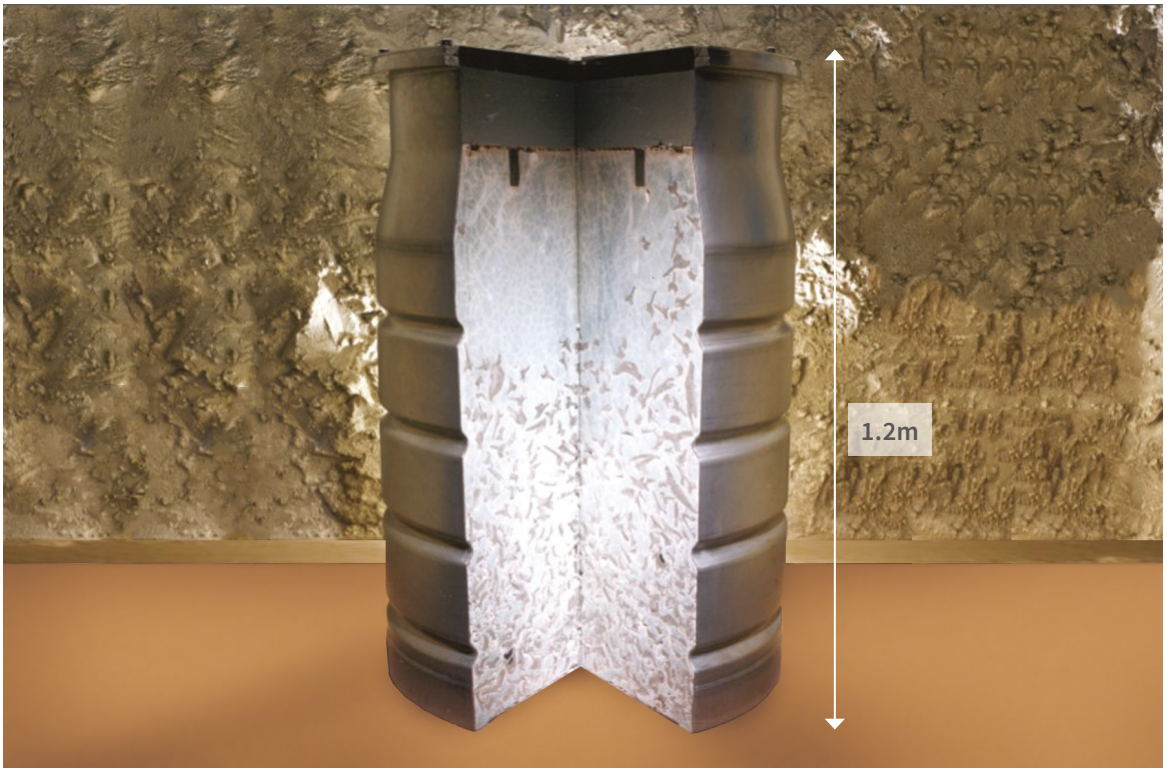


Figure 2: Cut-away showing an Intermediate Level Waste drum containing simulant waste mixed with cement.

2. The waste container

The waste is put into containers made of concrete or a metal such as cast iron, stainless steel or copper. After a GDF is closed, containers provide a physical barrier that prevents or limits the release of radioactivity.

A container may be designed to last for anything from a few hundred to many tens of thousands of years, depending on the materials used and the thickness of the container walls. Some radioactive waste has already been placed in containers, ready for disposal, while other waste has yet to be packaged.

Figure 3: An example of a disposal container for spent fuel that is planned for use in Finland. This container is made out of copper, with a cast iron insert (shown on the right) for added strength.

3. A buffer or backfill

The space between the waste containers and the rock walls of a GDF will be filled with bentonite (a type of clay), cement or crushed rock. This protects the containers and prolongs their life. No container will last forever, but when containers do eventually fail, this barrier will slow down the release of radioactivity out of the GDF.

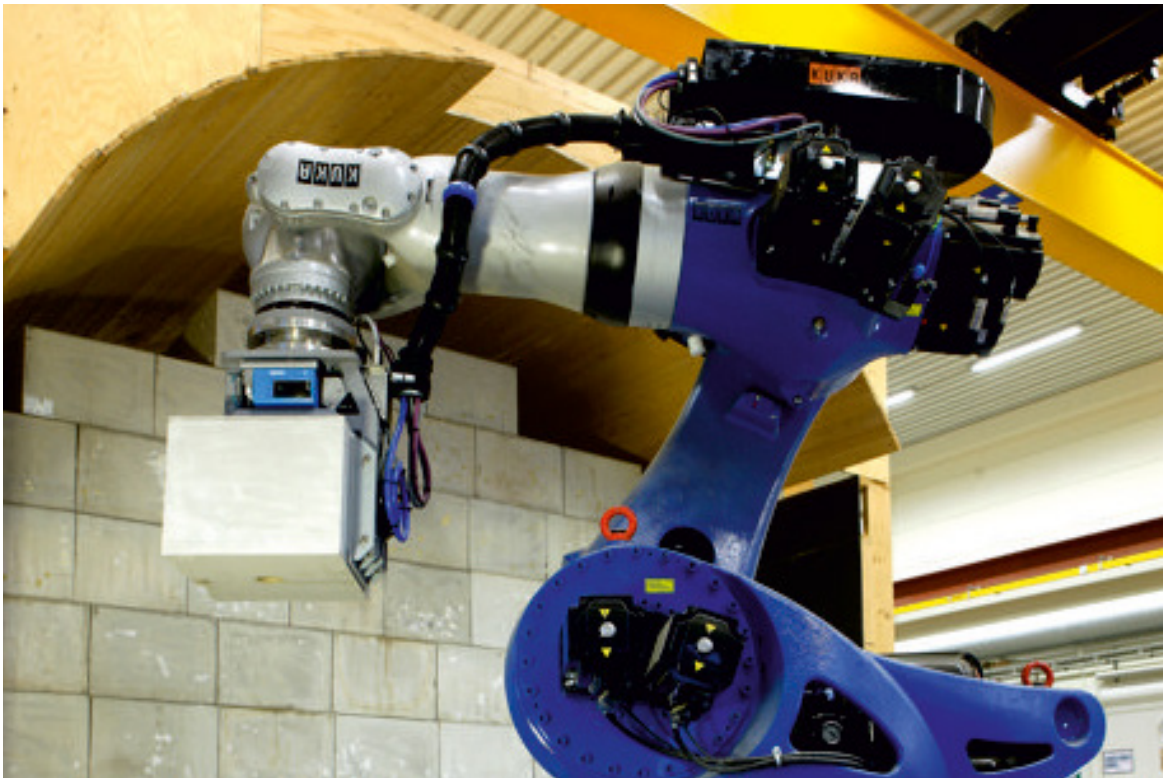


Figure 4: Testing the installation of bentonite blocks proposed for use as a buffer material. Each of the blocks is about 50 cm high.

4. Seals

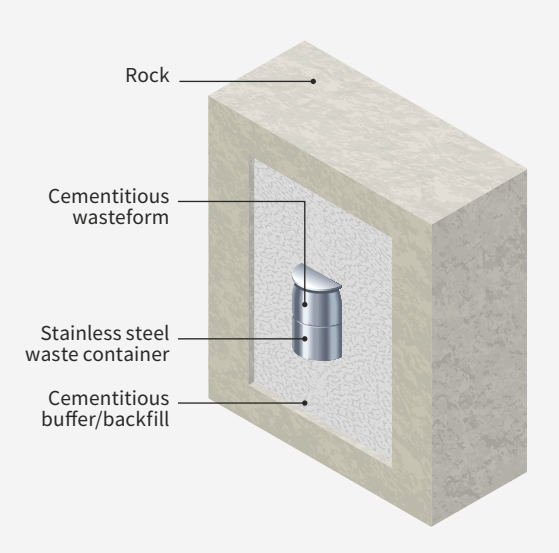
Before a GDF is closed, all the excavated space will be backfilled and access ways will be sealed to prevent human access. Far into the future, when other engineered barriers have degraded, the seals will limit the movement of radioactivity along the tunnels and shafts.

Figure 5: A full-scale seal experiment, part way through construction. Copyright Andra.

5. The rock barrier

Placing radioactive waste deep underground puts it far beyond people's reach, so that it is safe and secure. The rock will shield people from the radiation and, depending on the rock type, will either limit or completely prevent radioactivity from moving towards the surface when other barriers eventually degrade. Disposal deep underground will also ensure that the waste can never be exposed at the surface even in the event of a change in sea level or future ice ages.

Intermediate Level Waste



High Level Waste

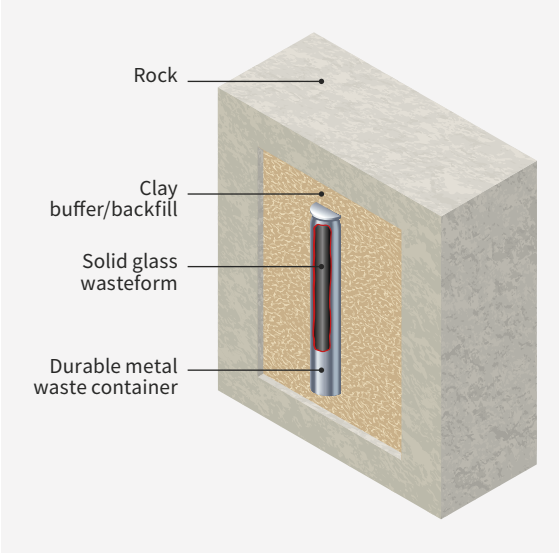


Figure 6: Examples of multi-barrier systems.

Together, these barriers will provide multiple levels of protection from the waste for many thousands of years. All the time, the levels of radioactivity in the waste will be falling.

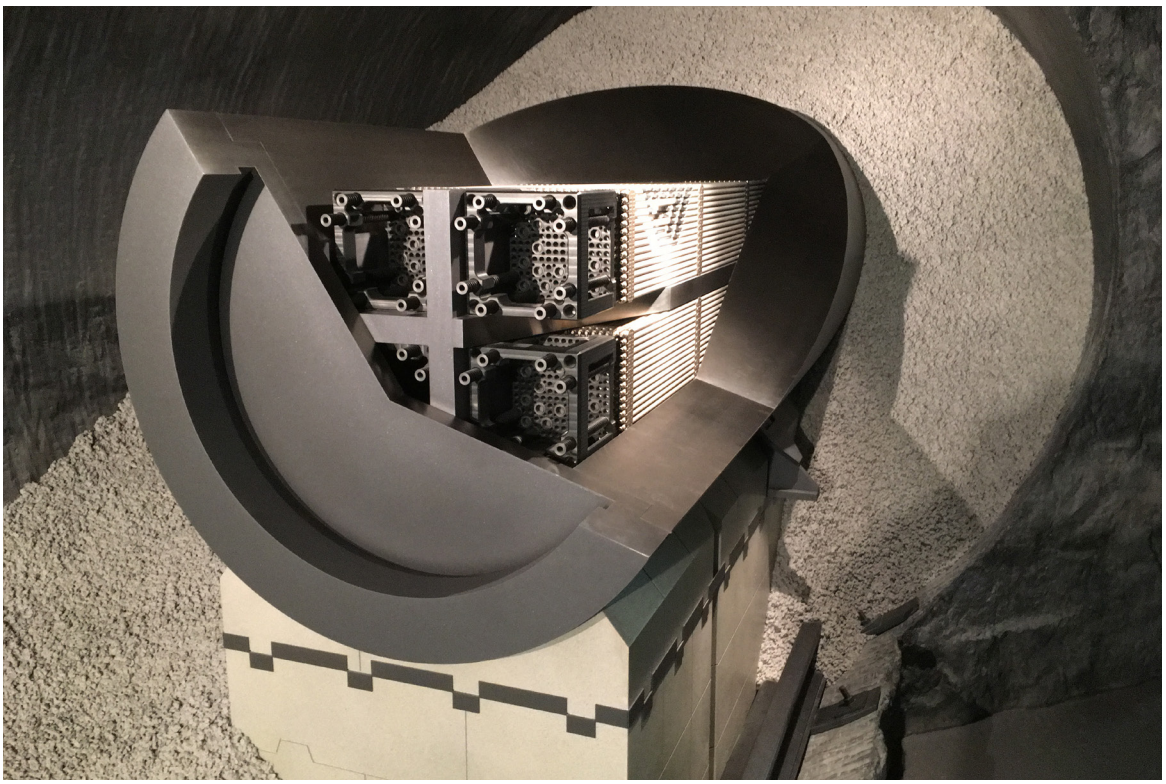


Figure 7: A multi-barrier concept from Switzerland.

To find out more, go to part 4 of The science files: 'What will a GDF look like?'