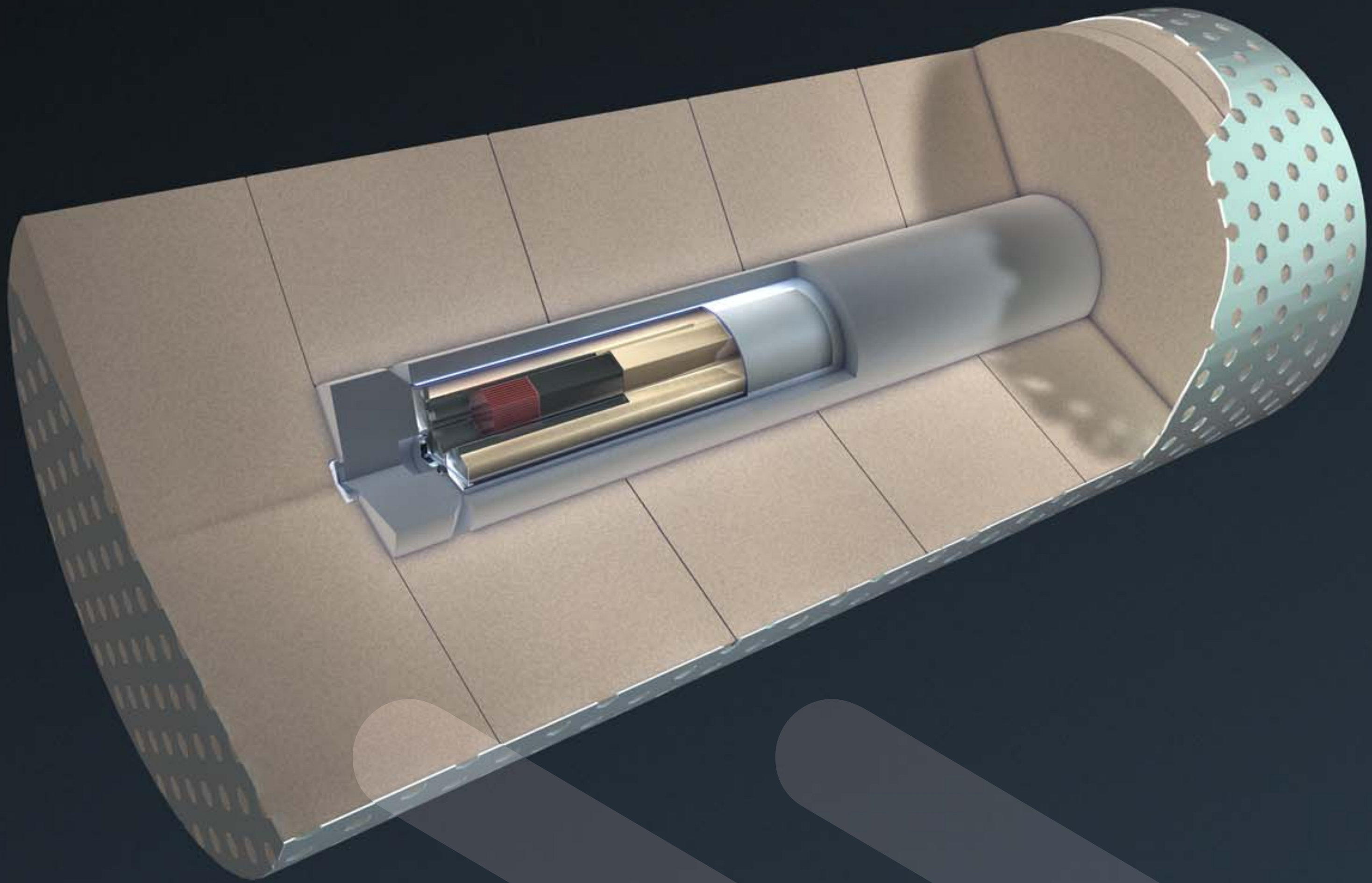
Deep Geological Repository

for radioactive waste and spent nuclear fuel



Radioactive Waste
Repository Authority

§ 26
18/1997

The Radioactive Waste Repository Authority (RAWRA) is a state organisation established under the provisions of Article 26 of Act 18/1997 on the peaceful uses of nuclear energy and ionising radiation (the Atomic Act) and on amendments to certain other acts.

RAWRA's mission is to ensure the safe disposal of existing and future radioactive waste, in compliance with the requirements of nuclear safety and human and environmental protection.

This publication is concerned with the Czech Republic's deep geological repository project. The aim of the project is to ensure the long-term and safe disposal of spent nuclear fuel from nuclear power plants (NPPs) as well as other types of high-level radioactive waste generated in the nuclear power sector, industry, the health sector and research institutes.

Information contained in this publication is targeted primarily at the general public, particularly at local people and elected representatives who live in municipalities in which site investigation work is planned so as to verify their eligibility for the future construction of a deep geological repository. The publication is intended to provide only a brief overview. More detailed information is available in other RAWRA publications and on the RAWRA website or by contacting RAWRA directly.

Partnership between RAWRA and the communities concerned, transparency at all times, the provision of complete information, the full participation of the municipal authorities concerned and local people in the decision-making process – together with safety and technical and economic conditions – make up an integral and very important part of the project. The project can only go ahead if mutual confidence has been established and sufficient guarantees provided concerning safety and human as well as environmental protection, and the communities concerned are assured of the overall benefits of the project for them in terms of further local social and economic development.

2050

500 m

WHAT IS A DEEP GEOLOGICAL REPOSITORY?

A deep geological repository is a facility for the safe and secure permanent disposal of spent nuclear fuel and, to a lesser extent, high-level radioactive waste generated in the nuclear energy, industrial, research and health sectors.

It is envisaged that the Czech repository will be constructed in a suitable granite rock mass approximately 500 metres below ground level. It is planned that construction work will commence in 2050. Until then research, investigation and design work will continue as well as dialogue with the public concerning the search for a suitable location for a deep repository and preparations for its eventual construction.

Most experts consider a deep geological repository as a feasible and safe way in which to manage spent nuclear fuel. However, it is not an easy task; spent nuclear fuel and high-level radioactive waste must be safely isolated from the environment for hundreds of thousands of years. No wonder therefore that extensive discussion has been held on this subject and a huge number of questions raised, to the most common of which this publication aims to provide the answers.

Spent nuclear fuel management

Spent nuclear fuel and high-level radioactive waste already exist in the Czech Republic. A further 80 tonnes or so are generated annually, mostly consisting of spent fuel from nuclear power plants.

Practical experience gained over the last thirty years has proved that both spent nuclear fuel and high-level radioactive waste can be safely stored, e.g. in special metal or concrete containers the walls of which are thick enough to absorb radioactive emissions, effectively isolate the material and thus protect both human beings and the environment.

Theoretically, the spent nuclear fuel disposal issue could be resolved, or at least postponed, by means of long-term storage; roughly every 100 years the spent fuel could be transferred into new containers. Such a method, however, would be expensive and, more to the point, would unfairly shift responsibility for the final disposal solution to future generations.

A further spent nuclear fuel management option consists of reprocessing as a result of which fresh nuclear fuel is obtained which can be used in specific types of reactor. However, a certain amount of high-level waste still remains after reprocessing which eventually must be disposed of. Consequently, even countries which use the reprocessing method (e.g. France) are planning for the construction of deep geological repositories. In any case, nuclear fuel reprocessing technology is not available in the Czech Republic.

In addition, scientists are working on new technologies for the further reprocessing of high-level waste which would reduce the total volume of waste and/or the length of time for which it must be isolated from the environment. Such technologies are currently in the early stages of development and it is by no means certain they will be used in the future.

100 000 years

A permanent solution...

Following a detailed assessment of all the possible options, the Czech Republic, as well as most other countries in which nuclear power plants are in operation, views the construction of a deep geological repository as the only realistic, responsible and both technically and economically viable solution.

Radioactive waste management is the responsibility of the State

Following the passing of the Atomic Act (Act 18/1997), the State assumed responsibility for safe radioactive waste disposal in the Czech Republic. Under the provisions of this act RAWRA, a state-owned organisation, is responsible for a number of activities associated with waste management and research and development relating to radioactive waste management, including the deep geological repository development project.

Supervision by RAWRA's Board

The efficient use of RAWRA's funds is overseen by a Supervisory Board consisting of eleven members, the responsibilities of which are set out by the Atomic Act. Membership of the Board comprises representatives from a number of state authorities (the Ministries of Industry and Trade, of Finance and of the Environment), radioactive waste producers and the general public, i.e. three representatives of communities near which operational radioactive waste facilities are situated (Jáchymov, Litoměřice and Dukovany) and a Member of Parliament. Board members are appointed by the Minister of Industry and Trade.

Financing from the Nuclear Account

The financing of radioactive waste management is based on the "waste generator pays" principle. In the DGR reference project, the total costs of repository development and construction were put at CZK 47 billion in 1999 prices. Costs relate principally to the search for suitable locations and a detailed investigation of the rock environment at the finally selected site.

The funding for eventual repository construction is gradually being accumulated in a special account held at the Czech National Bank and administered by the Ministry of Finance; more than CZK one billion is paid into this account each year by ČEZ, the Czech nuclear power plant operator, and by other radioactive waste producers. The account held approximately CZK 14 billion at the end of 2010.

Fuel assembly with nuclear fuel used at the two Czech nuclear power plants – Dukovany and Temelín
(At the MSZ – Mashinostroitelny zavod fuel fabrication plant)

CASTOR storage containers at the interim storage facility for spent nuclear fuel at the Dukovany NPP
(Source: ČEZ; photo: Jan Sucharda)

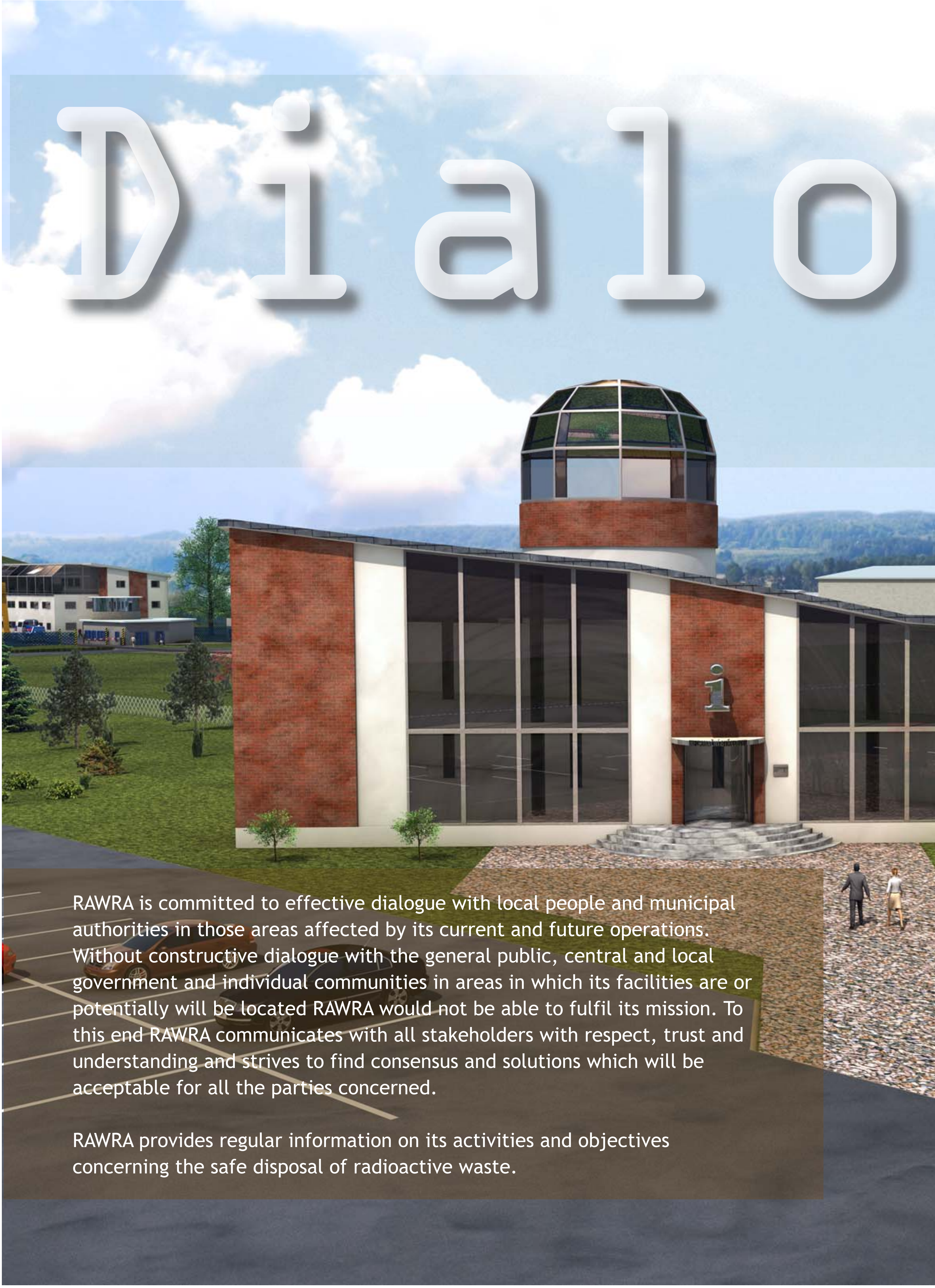
Spent nuclear fuel is currently stored in NPP complexes
Six nuclear reactors are currently in operation in the Czech Republic – four of them at the Dukovany NPP and two at the Temelín NPP. These reactors are responsible for producing approximately 30% of the country's electricity. Approximately 4,000 tonnes of spent nuclear fuel will be produced in total during their design lifetime. NPP lifetime, however, can be extended and the construction of further reactors is envisaged.

Fuel assemblies containing spent nuclear fuel are at first sight no different from fresh fuel assemblies. Fresh fuel, however, is not radioactive whereas spent fuel contains a number of highly radioactive elements produced as a result of the fission reaction at the NPP under very high pressure conditions and a temperature of around 300ºC in the reactor; the radioactive properties of these elements, once created, persist under the much milder conditions of storage and handling.

Spent nuclear fuel is transferred from the nuclear reactor into an adjacent cooling pool where it is kept for several years following which it is loaded into CASTOR containers which are then transferred to an interim storage facility within the NPP complex. After 50 to 60 years the radioactivity of the fuel in containers decreases roughly 200-fold.

The CASTOR container is a 4-metre high cylinder made of cast iron. Its 37cm thick cask body protects the surrounding environment from the high activity levels of the fuel inside; staff are thus able to work safely in the immediate vicinity of the container, if necessary. Each container has a capacity of 10 tonnes of spent nuclear fuel.

Dialo



RAWRA is committed to effective dialogue with local people and municipal authorities in those areas affected by its current and future operations. Without constructive dialogue with the general public, central and local government and individual communities in areas in which its facilities are or potentially will be located RAWRA would not be able to fulfil its mission. To this end RAWRA communicates with all stakeholders with respect, trust and understanding and strives to find consensus and solutions which will be acceptable for all the parties concerned.

RAWRA provides regular information on its activities and objectives concerning the safe disposal of radioactive waste.

Visualisation – Information centre at a deep geological repository site

Site investigation as well as the eventual construction and operation of a repository must provide benefits for the communities concerned.

PARTNERSHIP BETWEEN RAWRA AND THE COMMUNITIES CONCERNED

RAWRA is well aware that it is important that the municipal authorities concerned and local people be provided throughout the whole of the repository development process not only with a sufficient amount of information but also with the respective powers and guarantees. RAWRA is committed to cooperating and reaching consensus with its partners on the future course of action and eventual solution.

The word "consensus" can be taken to mean, for example, a situation wherein a community in whose locality a deep repository is to be constructed has agreed on the following position:
"We understand that a repository has to be constructed. We trust that you have acted and will continue to act responsibly with regard to the associated risk, will be highly environmentally conscious and will respect to the full the needs and justified requirements of local people. Yes, we are ready to take on the responsibility that clearly cannot be shared to the same extent by all the communities and people in our country. We consider the level of control as well as the decision-making tools at our disposal to be sufficient. We view the financial motivation offered and the related job and other opportunities to be a potential additional catalyst for the long-term development of our community."

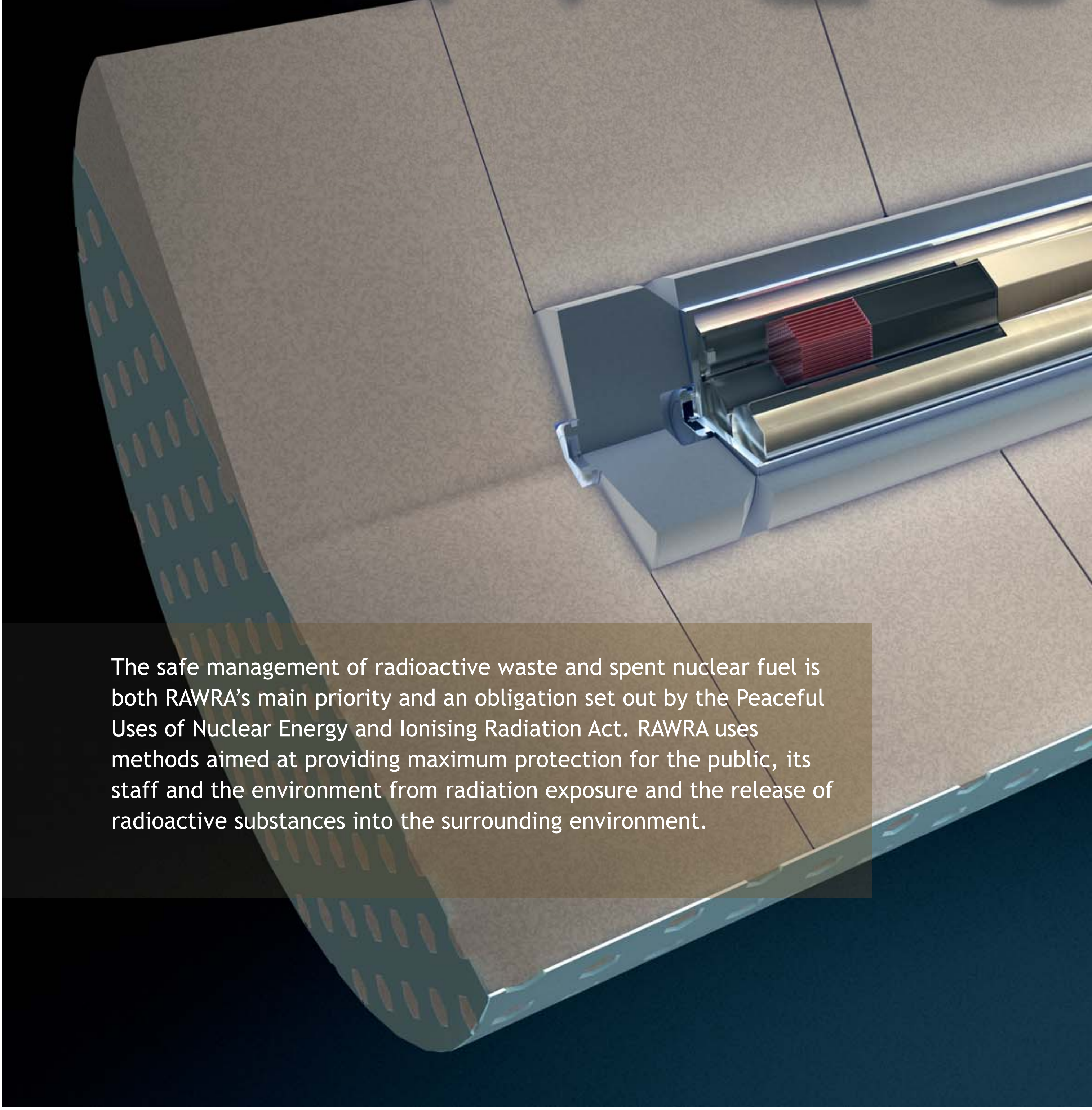
RAWRA has suggested the following principles for the creation of partnerships between the State and communities:

- Communities have the right to reject repository development.
- Communities have the right to participate in all the crucial negotiations which concern the planning of preliminary investigation work and future repository construction.
- Environmental consciousness and well-documented safety assurances should be considered a matter of course.
- Site investigation will be conducted only upon the consent of the communities concerned and following exhaustive discussion of the relevant details.
- Site investigation as well as the eventual construction and operation of a repository must provide benefits for the communities concerned, including financial compensation for geological research work in their vicinity from the very beginning of the site selection process.
- The whole process must be transparent, municipal authorities and local people must be kept fully informed through the use of modern information centres built at locations at which investigation work is to be carried out.

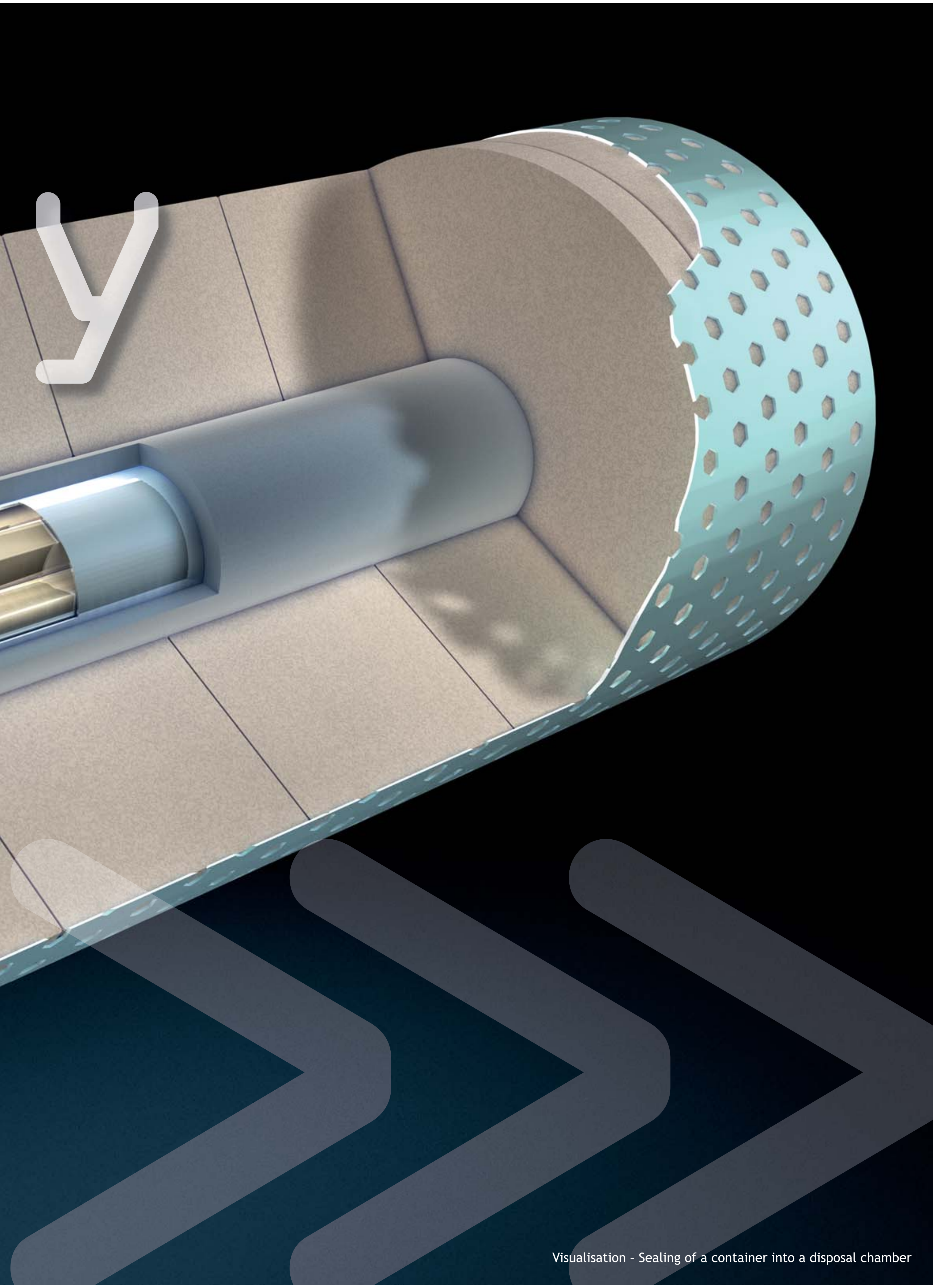
RAWRA is committed to applying the above principles to the full in all its activities and, at the same time, to pushing for relevant changes in legislation should it be required.

Many people from communities where candidate repository sites are located accepted an invitation to participate in an excursion to the Temelín NPP, the Onkalo locality in Finland and the SFR repository site in Sweden
(Fig. 3 – Visitors at Forsmark; source: SKB; photo: Curt-Robert Lindqvist)

Safet



The safe management of radioactive waste and spent nuclear fuel is both RAWRA’s main priority and an obligation set out by the Peaceful Uses of Nuclear Energy and Ionising Radiation Act. RAWRA uses methods aimed at providing maximum protection for the public, its staff and the environment from radiation exposure and the release of radioactive substances into the surrounding environment.



Visualisation – Sealing of a container into a disposal chamber

A system of multiple barriers within the deep repository ensures that radioactivity remains isolated from the environment.

DEEP REPOSITORY SAFETY

No repository can be constructed and operated without first proving beyond all doubt that it will be safe. The accuracy of safety analysis techniques using mathematical models is constantly being improved based on newly acquired knowledge and data obtained from practical measurement and research.

Safety barrier system

A system of multiple barriers within the deep repository ensures that radioactivity remains isolated from the environment. The system consists of geological, i.e. natural barriers and man-made engineered barriers. The multiple barrier system ensures repository safety for the required time period, i.e. hundreds of thousands of years.

Existing natural proof of safety barrier efficiency

Processes which may occur in a repository can be studied not only on computers and in laboratories. A number of natural events (analogues), some of them taking place over millions of years, provide proof that a given waste disposal system is able to meet the strict long-term safety requirements of a deep repository. Scientists use their knowledge of such natural events to verify and further refine relevant mathematical models.

Natural nuclear reactor at Oklo, Africa

One of the most well-known natural analogues consists of the natural nuclear reactor at Oklo, an underground uranium deposit in Gabon, in which a spontaneous chain reaction took place 2 billion years ago, similar to a fission reaction in today's nuclear reactors. The radioactive material produced by this reaction penetrated the surrounding environment only extremely slowly, i.e. at a rate of approximately 10 metres per one million years.

Uranium deposit at Ruprechtov, Czech Republic

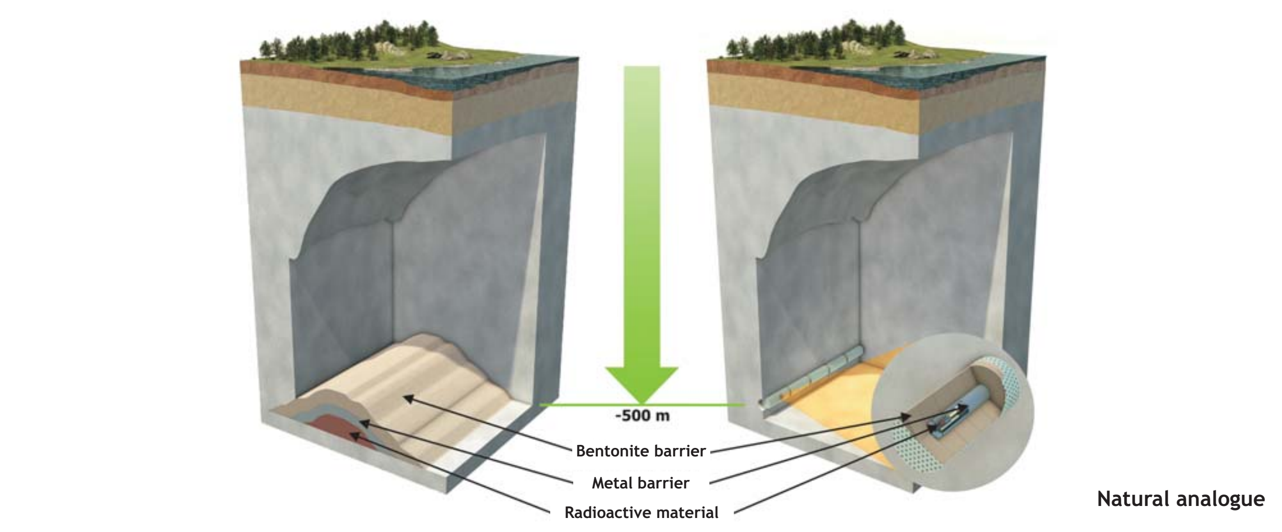
A similar, though smaller, natural analogue has also been studied in the Czech Republic (which is well known for its extensive uranium deposits) involving the migration of uranium deposited in clay layers at Ruprechtov in West Bohemia; as with the Oklo analogue, uranium migration into the environment is also extremely slow and, indeed, uranium cannot be detected at all at the surface.

Uranium deposit at Cigar Lake, Canada

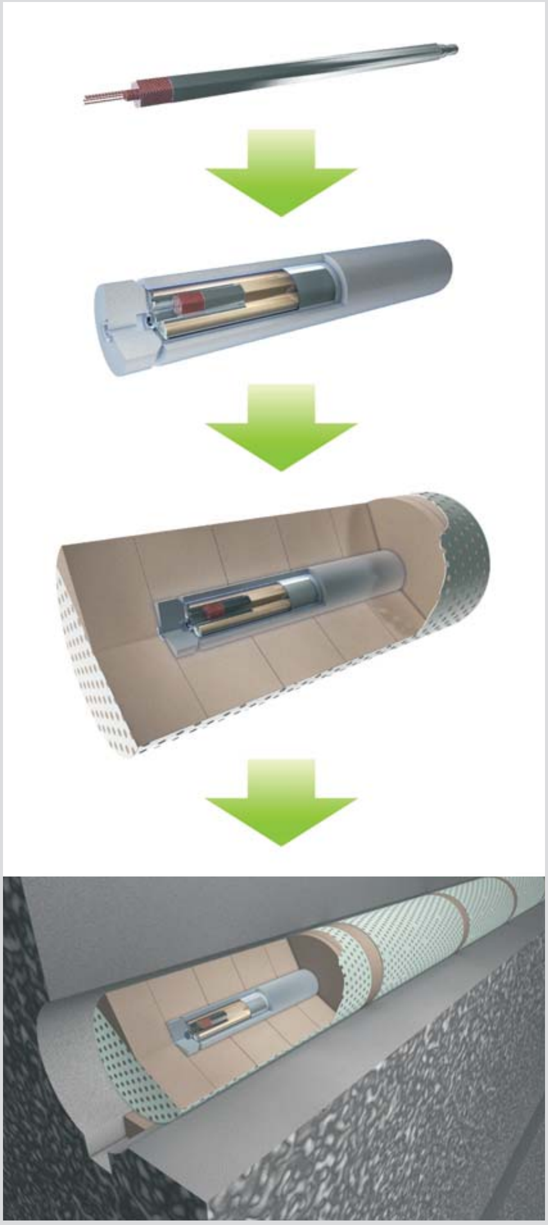
A high-grade (60%) uranium deposit was formed 1.3 billion years ago at a depth of 430 metres beneath Cigar Lake, Saskatchewan. The more than one million cubic metres of uranium ore lies on top of a granite rock mass and is covered with a layer of clay approximately 30 centimetres thick. Again, no uranium can be detected at the surface.

Metal objects found in the sea

Nature also helps scientists verify the durability of metal materials that might be used to manufacture containers for geological disposal. For example, copper objects which have been discovered in Greek and Egyptian shipwrecks which had been lying on the seabed for more than two and a half thousand years were found to be practically undamaged by corrosion. Using such objects scientists can verify their calculations of the corrosion rates of metals placed deep underground in the absence of free oxygen. It can be assumed that disposal containers made of highly resistant materials can maintain their integrity in a deep repository for tens of thousands to hundreds of thousands of years.



System of engineered and natural safety barriers



Fuel assemblies are able to withstand extreme conditions in the reactor. Nuclear fuel pellets of uranium oxide are loaded into fuel rods made of a highly resistant zirconium alloy.

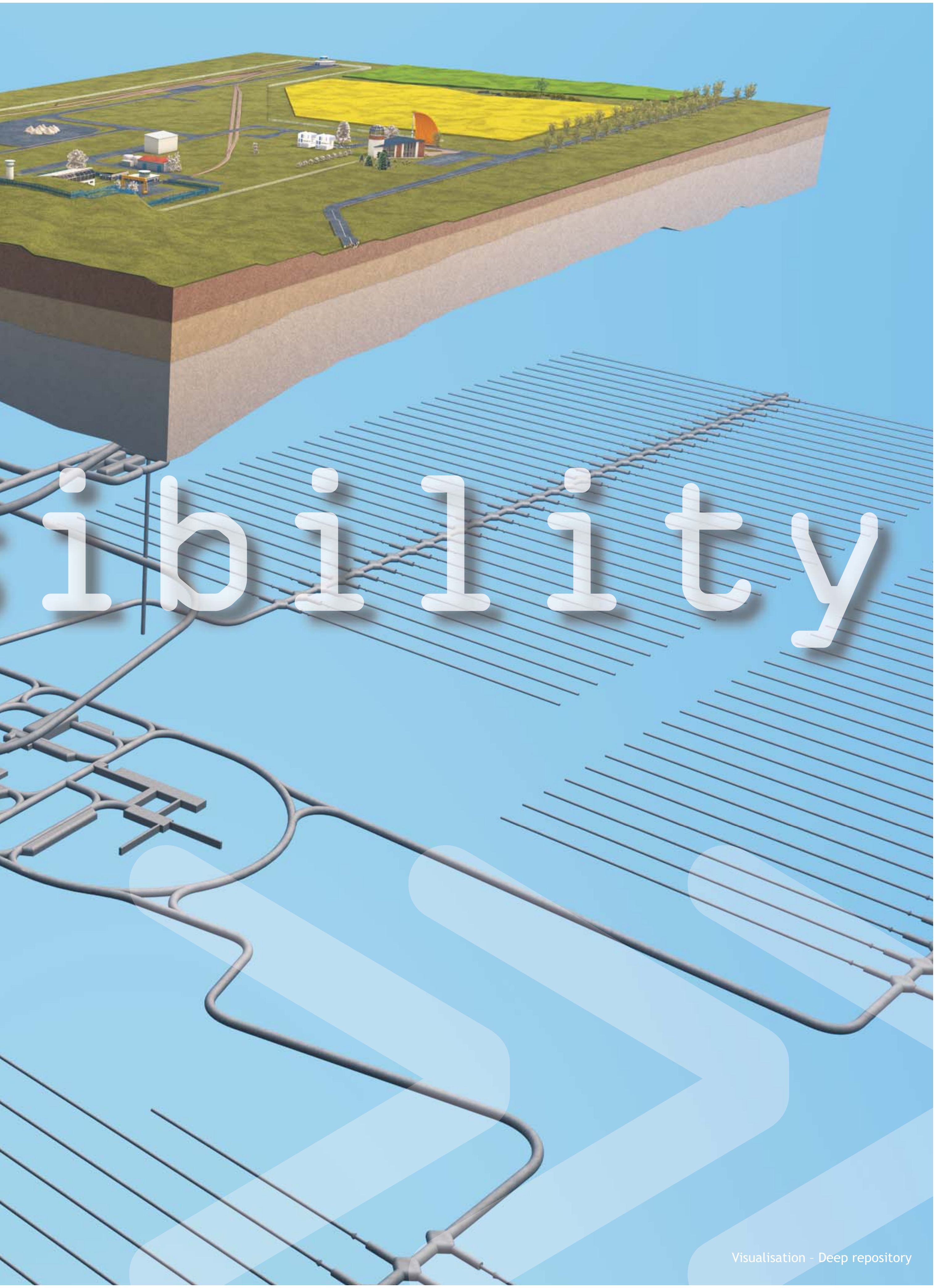
Metal disposal containers will be loaded with assemblies containing spent fuel and other high-level waste. These containers will be made of anti-corrosive and chemically stable materials (e.g. special steel with nickel, titanium and chromium, or carbon, titanium and copper additions).

Bentonite (clay) backfill will be used to fill the space between the container and the surrounding rock mass. The bentonite will swell in the humid repository environment thus sealing the container into the disposal chamber.

Natural barrier – rock mass: Radioactive waste will be disposed of in stable granite rock half a kilometre below ground level. This natural barrier is the most stable safety element of the whole disposal system. Thorough geological investigation will prove the suitability of the rock environment and, at the same time, rule out the occurrence of hazardous geological conditions such as local seismic activity or rock fractures. The natural barrier will prevent not only radionuclide migration but also any possible damage to the disposal facility in the extremely unlikely event of a plane crash or similar external incident.

Respons

RAWRA is well aware of its huge responsibility related to the fulfilment of its mission – ensuring safe radioactive waste disposal. RAWRA's performance is subject to regular quality and efficiency control audits. Reports on repository operation and any impacts on the environment are submitted to the relevant inspection authorities and made available to the general public.



Visualisation - Deep repository

Geological investigation results make up just one of the basic data sets used in the decision-making process regarding the suitability of a candidate site.

THE SITE SELECTION PROCESS

The search for a suitable location for a deep repository is being carried out in full compliance with the relevant recommendations of the International Atomic Energy Agency and other international institutions and consists of two stages – research and investigation.

Research stage - the search for potentially suitable areas for the siting of a DGR and the identification of rock environment characteristics commenced as early as in the 1980s. Preliminary studies were completed in the 1990s but detailed research continued post 2000 and eventually resulted in the selection of 6 candidate repository sites to be subjected to further investigation during the second stage.

Investigation stage - it is planned that the in-field collection and verification of data on geological structures and the underground area at candidate sites will commence in 2011.

Geological investigation intended to prove or rule out candidate site suitability consists of the following:
- Measurement on the surface – field measurements carried out by specialists.
- Rock sampling – shallow drilling to depths of up to 5 metres.
- The drilling of several boreholes to a depth of 500 metres.
- The drilling of a very small number of boreholes (with a diameter of a few centimetres only) to a depth of up to 1,000 metres).

Decision-making process regarding deep geological repository siting
Geological investigation results make up just one of the basic data sets used in the decision-making process regarding the suitability of a candidate site.
In addition to geological characteristics, a number of “non-geological” criteria must be taken into consideration including the technical feasibility of the construction of the repository’s above-ground facilities, transport accessibility and safety aspects as well as the environmental impact assessment and an assessment of the impact on the standard of living in the location concerned. Community consent will form an integral part of the site selection process, as clearly will economic considerations.

Some of the assessment criteria (e.g. safety criteria) are known as “eliminating” criteria which means that should they not be met, the respective location will be automatically excluded from the selection process. Other criteria (e.g. economic criteria) will be considered when comparing individual site suitability with a view to identifying the two most suitable locations (a main and a reserve site). Once this phase has been satisfactorily concluded, wide-ranging public discussion will be held following which a final decision will be taken on the future course of action.

The following documentation will be prepared as background materials for public discussion:
- The potential design solution of the deep geological repository to be constructed at the location concerned.
- Preliminary safety analysis proving that the deep geological repository will meet set safety requirements.
- The feasibility study proving that the project is technically and economically feasible and including an assessment of its socio-economic impacts.
- The environmental impact assessment study.

Continuation of investigation at the selected site
Further detailed investigation work is envisaged at the site selected and agreed upon as the most suitable.
The construction of an underground laboratory several hundred meters below ground level is planned as part of the future investigation stage in order to verify the properties of the rock massif.

Locations to be investigated:

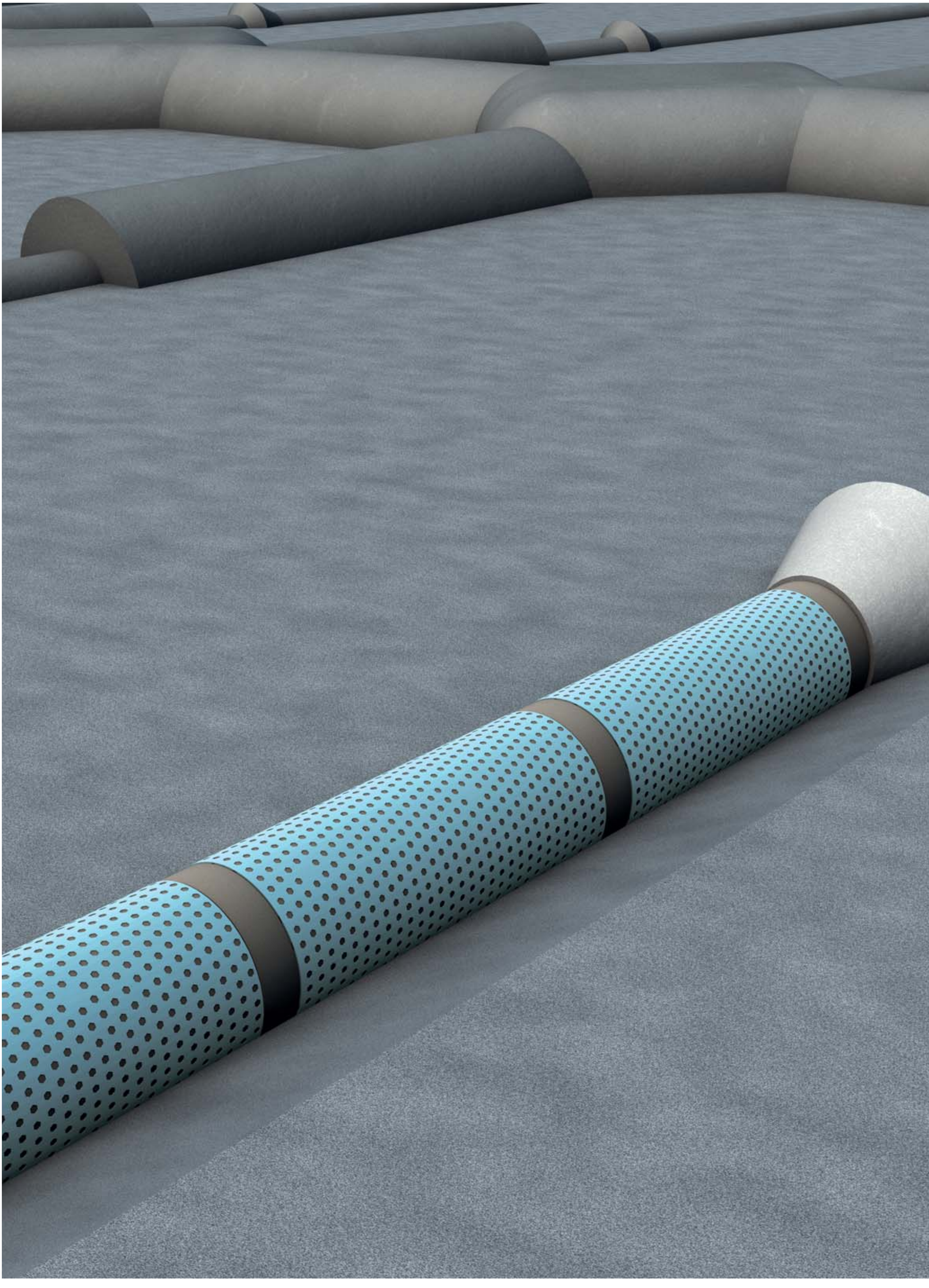
1	Březový potok	Plzeň region
2	Čertovka	Plzeň and Ústí-nad-Labem regions
3	Horka	Vysočina region
4	Hrádek	Vysočina region
5	Čihadlo	South Bohemia region
6	Magdaléna	South Bohemia region

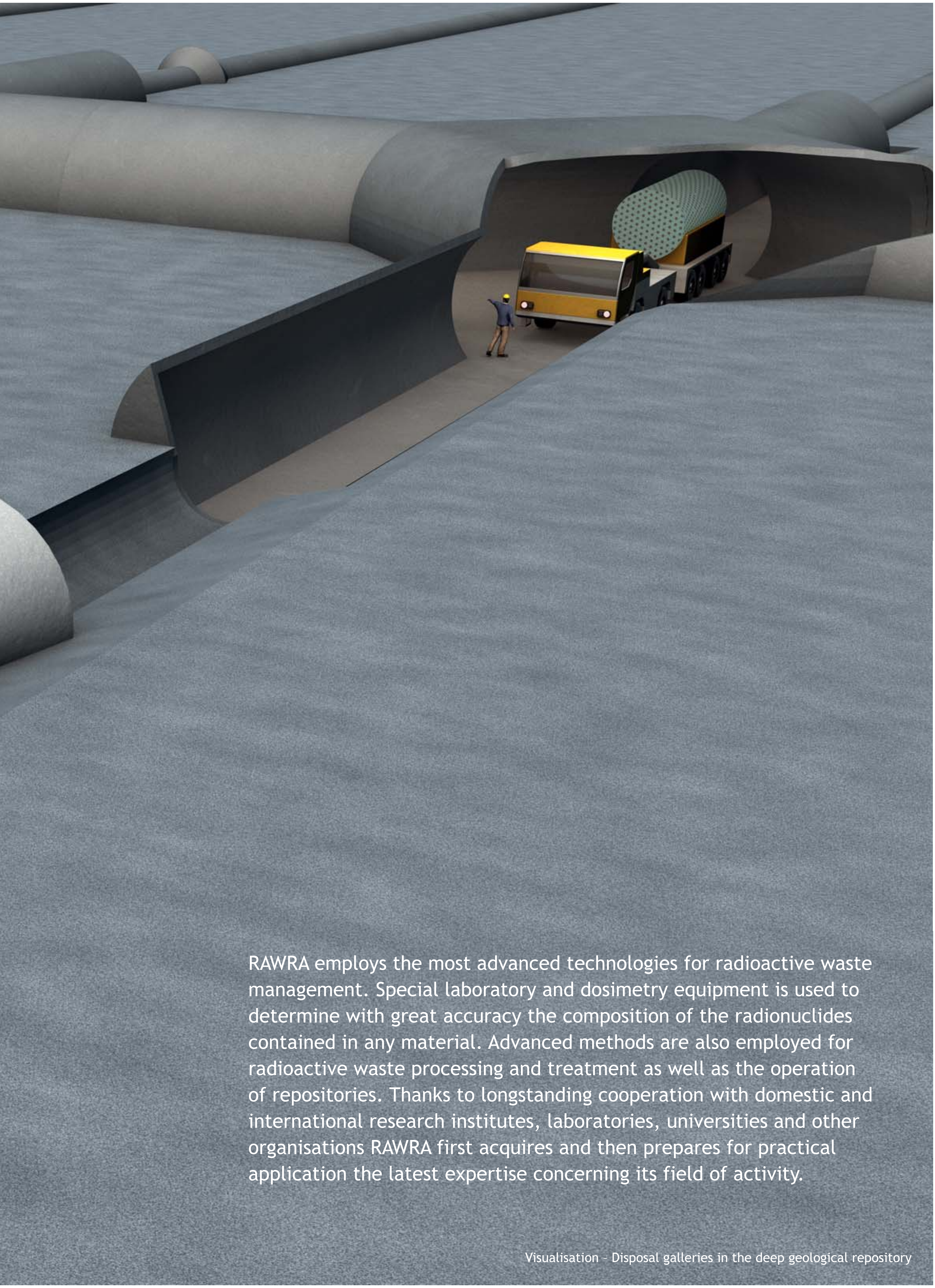
Additional locations to be investigated:

7	Kraví Hora	Vysočina region
8	Boletice former military area	South Bohemia region

Bentonite sample for experimentation at the Czech Technical University

Josef experimental mine facility – Students in an underground inter-university laboratory built for rock studies and characterisation





RAWRA employs the most advanced technologies for radioactive waste management. Special laboratory and dosimetry equipment is used to determine with great accuracy the composition of the radionuclides contained in any material. Advanced methods are also employed for radioactive waste processing and treatment as well as the operation of repositories. Thanks to longstanding cooperation with domestic and international research institutes, laboratories, universities and other organisations RAWRA first acquires and then prepares for practical application the latest expertise concerning its field of activity.

Visualisation – Disposal galleries in the deep geological repository

The disposal galleries will be constructed in a stable geological formation at a depth of approximately 500 metres.

REPOSITORY LAYOUT

The Czech concept for a deep geological repository is similar to those of a number of other countries. The final layout of the repository, i.e. structures, surface facilities etc., will depend to a great extent on the conditions at the specific selected site. RAWRA will remain fully committed to taking into account the requirements of municipal authorities and local people and to integrating the repository into the environment with a view to minimising the level of intrusion. For example, as many of the repository's facilities as possible will be constructed underground, where practicable, so as to significantly reduce the extent of the surface area.

Above-ground area

It is envisaged in the latest preliminary–reference documentation that all the structures and facilities will be situated in the above-ground area. It is assumed that radioactive waste and spent nuclear fuel will, following acceptance, be loaded into special highly-resistant disposal containers and transported to the underground facility in which it will be finally disposed of. At the same time, the construction of further underground disposal chambers will continue.

It is envisaged that the above-ground area will cover no more than ten hectares, probably considerably less, depending on the conditions at the site concerned.

Underground facilities

The underground disposal facility will be connected to the above-ground service premises by means of vertical access shafts and a spiral tunnel. The route used for the transportation of disposal containers will thus be separated from those used during the construction of disposal galleries and chambers, for staff access to the underground areas and for ventilation and escape route purposes.

The disposal galleries (boreholes) will be constructed in a stable geological formation at a depth of approximately 500 metres (depending on the geological conditions at the selected location). The length of the disposal galleries will reach up to 300 metres. A potential disposal method for the disposal of containers with spent nuclear fuel is shown in the picture. The most appropriate disposal method will be chosen once the final decision on repository construction is made (around 2050).

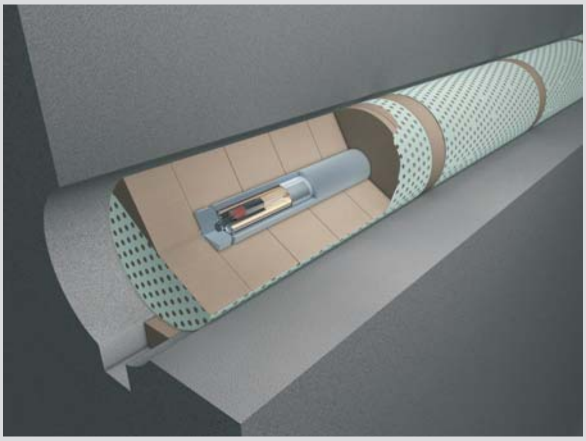
Disposal containers

The special design of the disposal containers will play a key role in the long-term safety of the repository and will be required to comply with a number of exacting requirements, e.g. long-term impermeability, chemical and stress resistance etc. The containers must therefore be made of a material which is both mechanically and corrosion resistant and which is able to maintain its integrity even after long-term exposure to radioactivity.

Czech experts are able to utilise best practice resulting from a Swedish-Finnish project involving a double-walled container consisting of a steel insert and an outer copper shell, as well as a Japanese project which employed a steel thick-walled container; the RAWRA reference project envisages a steel container.

Disposal containers will be surrounded by clay material (bentonite) which will help to dissipate heat from the surface of the container, seal them within the disposal chambers and protect them against water infiltration; this system is known as a “supercontainer”.

The repository's above-ground premises comprise an area for the handling of radioactive material which is provided with a separate safety protection system; this area is currently planned to cover roughly three hectares and will include electricity supply equipment, mine workings, ventilation equipment, workshops to provide mine facility services, administrative buildings, social facilities and transportation access.



Information centre
The above-ground premises will also include an information centre. Czech as well as foreign experience shows that information centres at nuclear facilities are very popular and are visited by upwards of tens of thousands of people annually.

Disposal of spent nuclear fuel in horizontally emplaced supercontainers
It is envisaged in the reference project that spent nuclear fuel will be emplaced horizontally in underground gallery walls in the form of supercontainers. A supercontainer consists of a corrosion resistant disposal container surrounded by bentonite (clay) backfill and an outer shell. An alternative option is vertical emplacement in the floor of the disposal gallery.

An important part of the site selection process in all countries is broad discussion with the public, primarily with local people and representatives of municipalities in areas with potential candidate repository sites.

DEEP WASTE DISPOSAL IN OTHER COUNTRIES

Research and preparations for the future construction of a deep geological repository are underway in most countries in which nuclear energy is generated. In some countries the decision on the siting and construction of a deep repository has already been made whereas others are at the stage of preparing documentation to be used for decision-making purposes. A number of countries, which do not have the suitable geological conditions for a deep repository, are storing their spent nuclear fuel and are pushing for the construction of an international deep repository.

Research of rock formations suitable for repository construction

Various types of rock formation have been studied worldwide: crystalline rocks (primarily granite and gneiss) as well as sedimentary rocks (clay, tuff and salt deposits). All of these rock types have been proved suitable for the construction and safe operation of a deep repository.

Crystalline rocks have been chosen in Finland, Sweden and Japan, and tuff or salt deposits in the United States. Salt deposits are considered the likely choice in Germany where salt formations have been extensively explored. France and Switzerland have chosen hard clay rock formations and Belgium clay deposits. It is planned that the Czech deep repository will be constructed in crystalline rock – granite or gneiss.

Site selection is a long-term process with public involvement in all countries

Site selection is a long-term process in every country planning to build a DGR. Many parties are involved: representatives of the general public as well as specialists from various sectors – geophysicists, geochemists, engineering geologists, hydrogeologists, designers, economists, ecologists, sociologists and many others. An important part of the site selection process in all countries is broad discussion with the public, primarily with local people and representatives of municipalities in areas with potential candidate repository sites. Their attitude is an important criterion in terms of the final decision-making process. It is of vital importance that they believe that the repository will be safe and accept its eventual construction as being beneficial for the future development of the community and the region.

Experience of other European countries

Sweden

Ten nuclear reactors account for 40% of total electricity generation. Spent nuclear fuel is stored at the CLAB central interim storage facility near the Oskarshamn nuclear power station. A granite rock mass near the Forsmark nuclear power station has been chosen as the final site for deep repository construction. Double-walled containers (steel and copper) will be used for disposing of the spent fuel. It is planned that construction will commence in 2012 and the repository will be commissioned in 2020.

Research into deep repository issues has been ongoing for a number of decades during which time an underground laboratory was built at Äspö in a granite rock formation 450 metres below ground level in which a huge number of real-scale experiments have been performed replicating the construction and operation of a deep repository – the drilling and study of the stability of disposal galleries, the emplacement of a mock-up disposal container with a weight of nearly 30 tonnes by means of a prototype deposition machine etc. The laboratory is visited by thousands of people annually.

Support facilities at the underground laboratory at Äspö, Sweden
(Source: SKB; photo: Curt-Robert Lindqvist)

Experimental facility for the research of gas migration in rock masses at the Grimsel underground laboratory
(Source: Nagra/Comet Photoshopping)

Aerial photo of the CLAB central interim storage facility
(Source: SKB; photo: Allan Borg Rotate AB)

2025 2030 2040

Finland
Four nuclear reactors produce 30% of total electricity generation and a further reactor is currently under construction. Spent nuclear fuel is stored in wet storage facilities (storage pools) at respective nuclear power stations. It is planned that a deep geological repository, located at Olkiluoto near the town of Rauma, will be commissioned around 2020. The construction of an underground laboratory commenced at this site in 2003.

France
58 power reactors producing 75% of the country’s electrical energy needs are currently in operation. Spent nuclear fuel is stored at interim storage facilities and about three quarters of it is reprocessed. High-level radioactive waste which is produced during reprocessing is vitrified and then stored in special containers. It is expected that a deep repository will be commissioned around 2025.

Germany
The country’s 17 nuclear power stations currently in operation are responsible for 26% of total electrical energy production. Up to 2005 a certain amount of spent nuclear fuel was transported to France and the United Kingdom for reprocessing and the resulting high-level waste is gradually being returned to Germany (the last waste shipment is planned for 2020). Spent nuclear fuel is stored at three central interim storage facilities and 12 storage facilities at respective nuclear power stations.

A deep geological repository is to be constructed by 2030; the Gorleben former salt mine has been provisionally selected as the most suitable site for the disposal of spent nuclear fuel and other high-level waste. Investigation work was carried out at this location from 1979 to 2000, however, work was then suspended for a period of ten years. A preliminary safety report has now been prepared and the further continuation of the programme is presently under discussion.

Switzerland
Five nuclear reactors provide about 40% of Switzerland’s total electrical energy needs. Up to 2005 spent nuclear fuel was sent abroad to be reprocessed; in 2006, however, this practice was put on hold for ten years. Both spent nuclear fuel and high-level waste generated from reprocessing are stored at the Swiss facility for high-level waste reprocessing and storage at Zwilag. The deep repository development programme envisages that one of three candidate sites, all of which are located in clay rock formations, will eventually be selected as the final site. Repository commissioning is planned for 2040.

Belgium
Seven nuclear reactors produce more than 50% of the country’s electrical energy. The commissioning of a deep geological repository is planned for 2030. Investigation work in clay rock formations at the Mol site is currently under way. The Hades underground laboratory has been in operation since 1980.

The Netherlands
A single nuclear power station produces about 4% of total electrical energy and spent nuclear fuel is transported abroad for reprocessing. Radioactive waste is kept at an interim storage facility operated by COVRA. It is envisaged that waste will be stored at this facility at least for the next one hundred years. The Netherlands is involved in various international projects aimed at determining a suitable location for an international repository to be used by countries which produce small amounts of radioactive waste or in which a suitable geological environment is not available. The construction of a deep geological repository in a salt or clay rock formation is being considered as an alternative option.

Scandinavian disposal containers with an outer copper shell
(Source: Posiva)

Construction of an underground laboratory in Finland
(Source: Posiva; photo: Jussi Partanen)

Geological investigation at the Onkalo underground laboratory, Finland
(Source: Posiva; photo: Jussi Partanen)

Proven technologies are currently available which can be employed both in terms of the storage of radioactive material and deep geological repository construction.

SUMMARY

Radioactive waste storage and disposal issues date back more than sixty years.

Spent fuel from nuclear power stations can either be stored (for several decades) or reprocessed and subsequently re-used, however, a certain amount of high-level waste will always remain and it must be isolated from the surrounding environment for tens of thousands to hundreds of thousands of years.

Research into a range of high-level waste isolation methods shows that deep waste disposal in a rock mass is the most suitable option in view of safety and technological and economic considerations since in such an environment the integrity of the disposal containers can be maintained and radionuclide migration prevented.

Proven technologies are currently available which can be employed both in terms of the storage of radioactive material and deep geological repository construction.

Consequently, most countries with a nuclear energy sector, the Czech Republic included, are amassing considerable amounts of money in special nuclear accounts to fund continuing research and development concerning eventual DGR construction.

In a number of countries (e.g. Sweden and Finland) a suitable location for a deep repository has already been selected, its safety proven and the consent of local communities for repository construction obtained. For other countries, including the Czech Republic, this will remain a challenge for several years to come.

Safety, human and environmental protection and close cooperation with the communities concerned, including their involvement in the decision-making process and assurances of the overall benefits of the project for them, form the basic preconditions for the successful construction and commissioning of the Czech deep geological repository.

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