CHAPTER 8

GEOLOGICAL DISPOSAL OF RADIOACTIVE WASTE IN THE CZECH REPUBLIC

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8.1 INTRODUCTION

The Czech Republic has appeared on the map of Central Europe since 1/1/1993 after the split of Czechoslovakia in two parts; the other is the Slovak Republic. With its 10.3 million inhabitants and a territory of 78,864 km^2, the country is comparable with e.g. Belgium, Switzerland or Austria. The Czech Republic belongs to the more successful transformed states of the former Soviet block: A steady decrease of inflation (9% in 1995), increase of GNP(4.6% in 1995), non-deficit budget and low unemployment (3.5% in 1995) are signs of a stabilized economic situation.

The intensive industrialization of the country requires among other things, a high production of energy: the installed capacity is 13,793 MWe, of which 1,760 MWe is nuclear. Consumption of electric power, some 58 TWh in 1995, is provided from internal resources for 94%, of which nuclear plants provide approximately 21%. This power is produced in NPP Dukovany with four VVER 440 MWe blocks. Another nuclear facility is under construction: the Temelin plant shall operate two VVER 1000 MWe units. After their connection to the grid in 1997-8, the share of electric power produced by NPP should reach almost 45% of the national electric power production, and some coal burning plants will be decommissioned.

8.2 ORGANIZATIONAL STRUCTURE OF WASTE MANAGEMENT

Radioactive wastes are produced and managed in the Czech Republic in three independent fields: uranium mining and milling, nuclear power plant, and other institutions (medicine, research, industry). The government controls all activities through the Ministry of Trade and Industry. The owner of uranium production facilities, DIAMO, is a state enterprise. The state also owns 67.46% shares of CEZ, which is the operator of Dukovany and Temelin NPPs. The company legally responsible for collection and disposal of institutional waste, NYCOM, is controlled by a “golden” share of 5% by the Czech state as well. Independent supervision of all activities is performed by the State Office for Nuclear Safety which regulates and licenses both from the point of nuclear and radiological safety. The Ministry of Environment indirectly influences these activities, as it is responsible for decisions in the Environmental Impact Assessment procedure.

The waste producers are obliged to treat, condition and dispose all radioactive waste at their own expense. However, especially for disposal activities, the responsibility may be transferred to another licensed organization. This procedure is obligatory for the disposal of institutional waste, as NYCOM is the only licensed operator of repositories for these wastes.

8.3 WASTE PRODUCTION AND MANAGEMENT STRATEGY

The amount and characteristics of radioactive wastes produced in the Czech Republic vary according to the source. While uranium mining and milling produces huge volumes in the tens of millions of cubic meters of low contaminated material, other users of radioactive materials treat hundreds or thousands of tons of medium and highly radioactive wastes.

In the Czech Republic, uranium has been mined in seven regions and in some isolated shafts as well. Since the early fifties, about 100,000 MT of U have been produced. The ore was milled in at least four facilities. Wastes that have been produced during excavation are stored in surface piles. They contain more than 46 million MT of tailings contaminated with 5 - 300 ppm of U and 0.06 - 2.4 Bq/g of ^{226}Ra. Nearly 57 million m^3 of milling waste are stored in tailings ponds; the solid phase is contaminated with 0.3 - 5 mg/l of U, 5 - 30 Bq/g

^{226}Ra, and other chemical and radioactive pollutants. Furthermore, there are some 270 million m^3 of contaminated underground water that must also be treated. Rehabilitation of sites with surface deposits from uranium facilities is in progress; mine tailings are used for closure of abandoned mines while sludge ponds are dewatered and overcovered with low permeable soil layers. This is the basic and quite successful method of environmental protection against an influence of natural radionuclides.

The operation of NPP Dukovany produces annually 400 - 500 m^3 of conditioned low and intermediate level radioactive wastes. The prevailing radionuclides are typical fission products, such as ^{137}Cs, ^{90}Sr, and activation products (^{54}Mn, ^{60}Co). Liquid effluents are evaporated and bituminized while solid wastes are segregated, compacted and, when suitable, supercompacted. Sludges and ion exchange resins are dried and disposed in polyethylene High Integrity Containers. All these wastes are buried in the surface repository at the Dukovany site. It is designed so that it can also accept operational wastes from NPP Temelin; their amount and form after conditioning are basically the same as from NPP Dukovany. As the decommissioning of both facilities generates nearly 50,000 m^3 of wastes acceptable for disposal in this repository, its capacity will have to be enlarged, unless some more volume saving treatment methods are applied. Nuclear power plants, however, also produce wastes that shall be disposed of in a deep geological repository (DGR). The significant part of those wastes are in the form of spent fuel (nearly 3,000 MT) and decommissioning high level waste (HLW, some 20,000 m^3).

Institutional wastes were already produced in the Czech Republic in the 1920's; nevertheless, they have been treated, conditioned and disposed of at a central location since the late 1950's. During this period nearly 3,400 m^3 of wastes with gross activity exceeding 10^{16} Bq were accepted for disposal, currently with an annual increment of several tens of m^3. The wastes were contaminated mostly by ^{60}Co (54%), ^{137}Cs (37%), ^3H (7%), ^{241}Am (1%), etc. Sealed sources are kept at the storage site, or, when acceptable, grouted in drums with concrete. Liquid wastes are solidified with concrete (in seventies by bituminization) and solid wastes are low pressure compacted.

8.4 NEAR SURFACE REPOSITORIES

Intensive utilisation of radioisotopes and nuclear research facilities required commissioning of repositories able to accept institutional wastes. For this purpose the Hostim repository was the first in former Czechoslovakia which was put into operation. From 1953 until 1965 about 400 m^3 of institutional wastes were placed in two galleries in an abandoned limestone mine several tens of meters below the surface. The predominant disposed radionuclides were ^3H, ^{14}C, ^{60}Co, ^{90}Sr, ^{137}Cs with a total activity 0.1 TBq. Packages with higher activity and long lived nuclides were transferred to other facilities prior to the repository shut down. Currently, backfilling of void spaces in galleries is proposed for stabilization and ultimate closure.

In 1964, a new repository went into operation. It was also situated in an abandoned limestone mine 40 - 60 m below the surface: the Richard II complex was used as an underground military factory during World War II. This facility is designated for institutional wastes with the exception of those contaminated by natural radionuclides. The total activity of 2,700 m^3 of disposed wastes has reached 10^{16} Bq mostly formed by ^{90}Sr, ^{241}Am (both 31%), and ^{60}Co (30%). Approximately 95% of the total activity is in the form of sealed sources, while the main unsealed nuclide is ^3H. The overall available capacity is estimated to be 3,800 m^3 of wastes, although the expansion of disposal spaces for a further 2,800 m^3 has been considered. This reconstruction is strictly opposed by local authorities.

The third repository, Bratrství, is used for wastes contaminated only by natural radionuclides (^{226}Ra, ^{210}Po, ^{210}Pb, uranium and thorium isotopes). The facility was built in an abandoned uranium mine (granitic host rock) in Jáchymov, well-known town where M. Curie-Sklodowska took tailings for her experiments. During its operation, that started in 1974, about 250 m^3 of conditioned wastes were put there. The remaining capacity of 40 m^3 of wastes will be filled within 3-5 years. The major nuclides contained in these wastes are as follows: ^{226}Ra (10^{12} Bq), ^{232}Th (10^9 Bq), and others (10^9 Bq). Some wastes (mainly alfa bearing) are to be transferred to a deep geological repository after it is available.

A surface repository for low and intermediate level wastes has been in operation since 1993 at the Dukovany site. The repository spaces are formed by two double-rows of vaults, the dimensions of each are approximately 6x6x18 m. The existing volume, in 112 vaults of approximately 60,000 m^3, can be extended by construction of 8 new double rows. The radioactive inventory shall not exceed 10^{16} Bq. The facility has a fully engi-

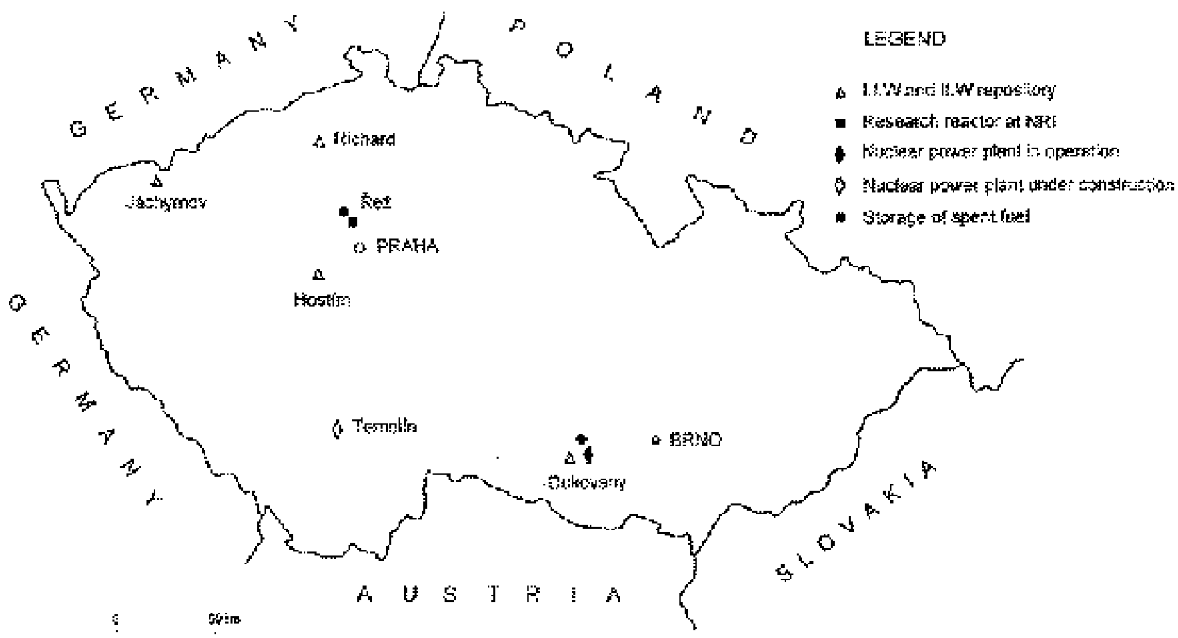

Figure 8.1. Location of nuclear facilities in the Czech Republic.

neered structure; reinforced concrete walls are isolated by asphalt-propylene microconcrete layer. The water movement on site is controlled by three independent drainage systems. A final multilayer capping will be installed after the doublerows are filled with waste. The void spaces in vaults are to be grouted with a concrete mortar.

Geographical locations of all the above mentioned repositories are shown in Figure 8.1.

8.5 SPENT FUEL MANAGEMENT

Spent fuel is not considered to be a radioactive waste in the Czech Republic. However, the producers must deal with it as a high level waste. Production of the spent fuel depends on the time of operation of the nuclear reactors. Provided that each unit will be in operation for 30 years, the Dukovany plant will produce fuel assemblies containing 1,504 MT of uranium metal, while the Temelín facility production will be 1,342 tons. The third producer, the Nuclear Research Institute in Rez, operates two research reactors of which one is used for irradiation (LVR-15 MW) while the other is only a critical assembly for physical studies. At the present time, there are more then 300 bundles of different types in storage at NRI.

The current scheme of the NPP spent fuel management is based on the assumption that it will be directly disposed of after some 50 years in storage, . However, no final decision has been made. Therefore, a dry in-cask storage facility was put in operation at Dukovany in 1995. It uses iron casks CASTOR VVER 440 developed by GNS (Germany) and produced in cooperation with SKODAWORKS Plzen. Each cask can contain 84 assemblies. The capacity of this facility was limited by a governmental decision that respected the requests of local authorities to 600 MT of heavy metal. This practically means that by 2005, a new storage facility must be operational. Its capacity shall be at least 2,200 MT of uranium, with enough reserve for a considerable period-of NPP operation.

Spent fuel from the research reactors is kept in dry storage and a water pool within the NRI. Due to the high enrichment (80, resp. 40 %), it will probably be reprocessed so that the fissile material is under international supervision.

8.6 DEEP GEOLOGICAL DISPOSAL PROGRAM

Some activities aimed at the research aspects of a deep geological repository in former Czechoslovakia started in the mid eighties. Nevertheless, problems concerning disposal of HLW and spent fuel were studied separately in different organizations and institutions until 1992. In 1993, the Nuclear Research Institute Rez plc. (NRI) was entitled to coordinate the activities which would lead to the development of the Czech geological repository. This year, a general geological disposal program was released and successfully reviewed by a WATRP mission (organized by IAEA) with recommendations for further direction of the program. Since 1994, the Program has been supervised by a Steering Committee of Six Institutions (C6).

The essential technical parts of the deep geological disposal program are:

- siting (and related geological activities such as an underground research laboratory and natural analogue study);
- repository design and disposal engineering;
- development of engineered barriers;
- safety analyses and performance assessment; and
- alternative disposal options (transmutation).

QA/QC, program/projects management and integration, program information systems, and external relations are additional activities of the Program. The Program has been focused mainly on preliminary and generic studies so far, and it considers hard host rock as a most probable option.

8.6.1 Repository design and disposal engineering

Preliminary conceptual disposal system design including infrastructure has been worked out. The present reference design considers two access shafts (one for personnel, one for waste), one ventilation shaft and a system of main and horizontal parallel disposal drifts. Other alternative designs are proposed that differ mainly in access tunnel design (for example spiral and inclined access to the underground). Particular alternative designs were evaluated preliminarily on the basis of safety and feasibility.

An optimization study of spent fuel conditioning prior to disposal indicates a preference for minimum restructurisation of fuel assemblies. An encapsulation unit is designed as an integral part of the disposal system at the site. Several repository transport and handling system options have been proposed.

The preferable excavation method for underground spaces has not been selected yet; the importance of the extent of disturbed zones is questionable. The problem is analogous to an underground cavern built for storage of gas; this was mined in granitoid host rock more than 1000 m below the surface in the Pribram uranium mining region. The alternative use of backfill and sealing materials is also studied.

Calculations of radionuclide contents and heat output (ORIGEN code) for spent fuel with different burnups have been performed. According to preliminary heat transfer calculations an optimal configuration for disposal rooms and disposal boreholes was designed.

A cost analysis of the disposal system was also carried out. The objective was to propose an algorithm for determining the waste producers fee for disposal of radioactive wastes (0.05 CZK/kWh). This study estimates an overall disposal system cost of approximately 100 billion CZK (i.e. approx. 3.5 billion US$).

8.6.2 Development of engineered barriers

Bentonite (and bentonite-based mixtures) was selected as a suitable buffer and backfill material. A bentonite availability study identified many deposits in the Czech Republic; the main criteria considered were material quality and planned volume of buffer and backfill. A preliminary design of a disposal container was proposed by the main Czech steel product manufactures; alternative materials, such as titanium and stainless steel, were also considered.

Planning of experiments, such as spent fuel leaching, engineered barriers degradation, corrosion of disposal container, has started. The main objective of these experiments is validation of models. Both laboratory and field experiments are to be used.

8.6.3 Performance assessment

Performance assessment is considered to be of key importance in the Program because of the necessity to prove long-term safety of the disposal concept. In a preliminary stage, all near-field and far-field features, events and processes (FEPs) have been continually identified, databased and evaluated. Suitability of codes shall also be evaluated. A safety analysis methodology was studied, including methods of probabilistic safety analysis (PSA). In 1995, a study using the Czech format for an Environmental Impact Assessment was performed.

8.6.4 Alternative disposal options

Transmutation technology has been studied as a complementary but not fully replaceable option to the disposal of spent fuel. Preferably, accelerator driven systems seem to be the most promising. When considering the practical aspects, many unsolved problems have been identified, such as continual hot chemical separations, complicated physical systems, non-verified technology, unresolved benefits and costs. Although mainly generic and system studies were performed, long-term experience of NRI staff with fluorine chemistry and reactor physics as well as the theoretical background of the Nuclear Physics Institute, skills of employees of the SKODA machinery works and promotion of reactor designers speak for reasonability and good starting points for initiation of the respective research and development experiments. Transmutation is a typical problem requiring wide international involvement, and thus, Czech specialists are linked with several US, European and Japanese institutions.

8.6.5 Public/external relations

Taking into account the high population density in the Czech Republic and the deep environmental feeling coming from a damaged natural environment, the strong NIMBYsyndrome and general disapproval with the disposal concept are expected. As a consequence, the societal and political factors in a deep geological repository program will be very important.

The communication program is aimed not only to inform the general public but it shall also initiate some direct public participation in decisions. The communication policy is based on open, full and understandable information for the public. Current activities include publication of a series of informative articles in newspapers and magazines, editing of purposeful brochures, preparation of video presentations, presentation of the Program on the conferences and lecturing at universities. RACE methodology (research, analysis, communication, evaluation) is being applied; the final step is carried out in the form of a public opinion poll. Poor knowledge of radioactive waste management rather than dissent from any disposal solution and, surprisingly, general agreement with nuclear power generation are the main findings of the first public opinion polls.

An inseparable part of external relations is cooperation with foreign organizations involved in radioactive waste management, such as ANDRA, GRS, AECL, and ENRESA.

8.6.6 QA/QC

A quality assurance system is being created along with the quality and management guides/manuals; especially ISO 9,000 and 14,000 are taken into account. The system follows two general directions: QAof the Program management and QA binding technical activities within performance of the Program.

8.6.7 Scope of work in 1996

In 1996, the Program activities are focused on the revision of the Deep Geological Disposal Program. The objectives are to formulate general as well as detailed projects and plans based on evaluation of acquired experience and on information gained since the start of the Program. System re-engineering principles will be explored; they involve the complex, multidisciplinary and time/cost consuming character of the problem to be solved. License, technical and system requirements are being identified along with critical points of the Program. The year 2035 is the main time constraint, when the deep geological repository shall be operational.

8.7 GEOLOGICAL ASPECTS OF DEEP GEOLOGICAL REPOSITORY

8.7.1 Brief Geological History of the Czech Massif

The selection of an optimal geological unit for DGR is, among others, always limited by the geological structure of the territory. Moreover, in the case of the Czech Republic, this fact is underlined by a small areal extent and by a significantly complicated geological structure.

According to the classical geological Stille's division, the Bohemian Massif, belongs to the Meso - Europe, e.g. the vast zone, which was consolidated in the late Paleozoic period during the Hercynian orogeny. Within the European Hercynides, the Bohemian Massif ranks among the Variscides which create partial branches of the Hercynides. The Bohemian Massif, which represents the easternmost known part of the Variscan branch, forms the absolute majority of the territory of the Czech Republic. Brunovistulicum, a block consolidated during the Cadomian orogeny or even earlier, is situated in the eastern part of the territory of the Czech Republic. In the west, this block forms the underlying unit of the eastern part of the Bohemian Massif; in the east, it forms the underlying unit of the West Carpathians, which belong to the Alpine-Carpathian orogenetic belt (Neo - Europe).

The Hercynian history was closed by folding associated with emplacement of numerous plutons and extensive regional metamorphism. This folding had reworked the whole region and often obscured the earlier, Cadomian and probably also some Caledonian structural elements. From this point of view, the Bohemian Massif has a tripartite structure consisting of the following vertical groups:

- Precambrian (Cadomian) basement;
- Crystalline and Paleozoic affected by Hercynian orogeny; and
- Post-Hercynian platform cover.

8.7.2 Basic geological requirements for host rock

The basic requirements for the geological unit that should become a host structure for DGR can be defined as follows:

- sufficient area (tens of square km) and thickness (at least 1000 m);
- lithological homogeneity of the unit with minimal hydrothermal alterations and rock veins;
- tectonic fractures and displacement as low as possible;
- no deposits and indications of mineral resources;
- permeability as low as possible; and
- seismic and geodynamic stability of the region.

8.7.3 Geological units of the Bohemian Massif from standpoint of basic requirements for host rock

Individual geological units can be evaluated from the point of view of suitability for DGR siting as follows:

Post-Hercynian platform cover. Post-Hercynian platform cover on the territory of the Czech Republic can be divided according to age into:

- Permo-Carboniferous sediments;
- Mesozoic sediments; and
- Tertiary sediments.

Permo-Carboniferous sediments occur in the territory of the Czech Republic in two different forms. In the northeast part of the Czech Republic, only a basin is situated where the parallel Namurian developed gradually from the marine Lower Carboniferous. In other parts of the Czech Republic, there are numerous limnic Permo-Carboniferous sediments placed discordantly upon various older units. We regard Permo-Carboniferous sediments as unsuitable for DGR because of their lithological variety and relatively extensive tectonic displacement.

The absolute majority of Mesozoic sediments in the territory of the Czech Republic are of Upper Cretaceous age. Continental sediments of Lower Triassic and epicontinental sediments of Upper Jurassic have no significance because of their small range. Lacustrine sediments of the Upper Cretaceous are known in the southern part of the Czech Republic, where they filled two separate basins. As far as their lithological nature is concerned, they are composed of sandstones, siltstones and claystones with rapid vertical as well as horizontal changes. In the north of the Czech Republic the Bohemian Cretaceous Basin is widespread. Its area is approximately 14,000 km^2. The largest supply of high quality drinking water in the Czech Republic is found in sandstones. Mesozoic sediments are regarded as unsuitable for DGR because of their lithological nature.

The majority of Tertiary sediments is mostly of lacustrine origin. They occur, on the one hand, in the northwest of the Czech Republic (accompanied by alkaline volcanism of Tertiary and Quaternary age), where they form the filling of the vast, tectonically predisposed, system of basins, and, on the other hand, in the south of the Czech Republic, forming the overlying beds of Upper Cretaceous sediments. As far as their lithology is concerned, they are characterized by rapid horizontal, as well as vertical, changing of clays and sands. In the northwest there are important and intensively exploited lignite seams, which are part of these sediments.

As far as the DGR is concerned, the Tertiary sediments do not have desirable features, especially because of their lithological variety and significant tectonic fractures.

Crystalline and Paleozoic affected by Hercynian orogeny. This group includes metamorphosed pre-Cambrian and Paleozoic rocks and non-metamorphosed rocks of Lower Paleozoic (Cambrian to Middle Devonian). Cadomian and Hercynian plutonic rocks are numerous.

Non-metamorphosed Cambrian to Middle Devonian formations occur in several separated basins. The formations in question are predominantly shales, siltstones, carbonates, sandstones and conglomerates, often accompanied by volcanism. In our opinion these formations are not suitable for DGR siting, because of their

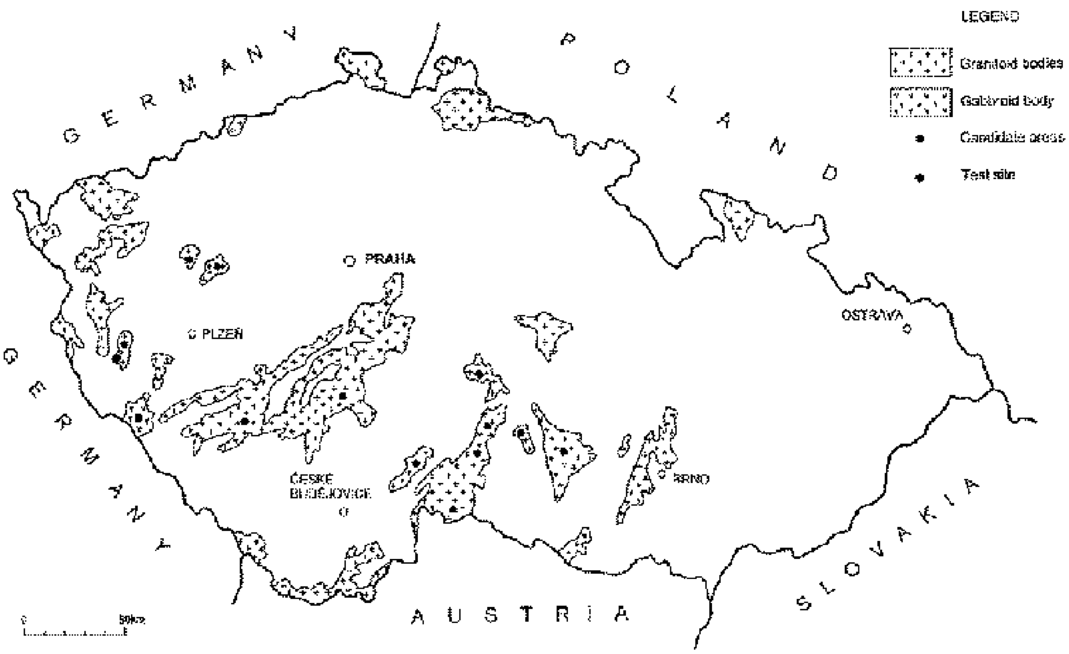

Figure 8.2. Location of candidate areas and test site in the Czech Republic.

intensive folding, tectonic displacement and in view of varied lithological composition and karstification of limestones.

Units of metamorphosed rocks prevail in this group. Elements of Cadomian metamorphism appear in most of these units. According to geological and geochronological data, the Cadomian metamorphic activity can be observed from 650 to 550 Ma. Presence and role of the Caledonian metamorphism is still discussed by experts. The Hercynian regional metamorphism is most significant in the territory of the Bohemian Massif. This metamorphism started in the Ordovician, culminated in the Upper Devonian and ended in the Carboniferous.

In view of the very complicated tectonic structure, often and rapidly changing intensity of metamorphosis and lithological variety of metamorphosed units, where moreover numerous intercalations of crystalline limestones, graphite layers or quartz veins occur, we do not regard the metamorphosed units as suitable host rocks for DGR.

The occurrence of extensive plutonism is a characteristic feature of the above mentioned group (Fig. 8.2). The following plutonic complexes have been distinguished:

- metaplutonites of uncertain age, which occur predominantly in the form of orthogenesis in marginal parts of the Bohemian Massif;
- plutonites associated with Cadomian orogeny, which form several granitoid and gabbroid bodies in the west and north parts of the Czech Republic; and
- plutonites associated with Hercynian orogeny, which are the most frequent on the territory of the Bohemian Massif.

The Hercynian plutonites are exclusively granitoids. The two largest bodies - the Moldanubian Pluton with area of 8,000 square km approximately, and the Central Bohemian Pluton with the area of 3,200 square km approximately, as well as many smaller bodies belong among them. According to geochronological data, the age of the majority of the above mentioned granitoids is between 350 - 300 Ma, and their development is connected to the late tectonic phase of Hercynian metamorphic stage.

We consider granitoid bodies connected with the Cadomian as well as Hercynian orogeny as suitable for DGR .

P recambrian (Cadomian) basement. Precambrian basement untouched by the earlier Hercynian orogeny occurs in the territory of the Czech Republic just in Brunovistulicum. This unit as a whole is not suitable for

DGR location especially because of its significant geological variety.

8.7.4 Description of General Project Objectives

The present state of activities on DGR siting in the Czech Republic results from work which was performed during the last 5 years. An area selection of 27 suitable regions was performed on the basis of existing regional geological information by the Czech Geological Survey.

The siting process continues with the approval of the General Project of Geological Activities for Deep Geological Repository Siting , which was elaborated by NRI staff. The project cut the number of potential areas from 27 to 13. From this number, 12 areas are located in granitoid bodies and one in an ultrabasic body. The area of relevant sites ranges from 120 to 20 square km.

The General Project became a principal document, upon which all geological activities concerning development of the deep geological repository are performed. Principal geological activities are planned in accordance with the General Project for approximately the following 15 years. It is assumed that the deep geological repository will be put into operation in 2035.

The activities described in the project are divided into the following stages:

- research activities;
- seismicity, geodynamics and neotectonic monitoring;
- critical evaluation of pre-existing geological information;
- site characterization ; and
- site confirmation.

The project does not deal in details, neither with an underground laboratory nor natural analogues. These activities are supposed to be solved by independent projects, whose time schedule and logical structure will be co-ordinated with the General Project, especially with the stage of research activities.

Stage of research activities. The main task of this stage is development, practical verification and elaboration of obligatory methodological procedures relevant to the deep geological repository siting. These activities will be performed at the test site selected in geological conditions similar to those, where the construction of the repository is proposed. The site in question is Moldanubian Pluton apophyse. DGR will not be built at the testing site, but we will consider the siting of an underground laboratory there. Currently, characterization of the site is being performed. The project of research activities will be completed in 1997, and the activities are supposed to start in the same year.

Stage of seismicity, geodynamics and neotectonics monitoring. In view of the above mentioned geological structure of the Bohemian Massif and its incorporation in the European Hercynides, no significant motions can be expected, but on the other hand insignificant motions cannot be excluded with sufficient certainty. However insignificant the motions might be, they could negatively influence the DGR safety. That is why we pay the necessary attention to monitoring the stability of the relevant part of the Bohemian Massif.

These activities will be started at the end of 1996 or in the beginning of 1997. In a preparatory phase, all available information on hardware and software concerning scanning data and their transmission to the processing center as well as their processing and evaluation will be gathered. Simultaneously, selection of suitable posts for seismometers, determination of sites suitable for neotectonic studies, densification of the network of existing observing points will be realized. The remote sensing evaluation will also be realized within this stage.

Stages of critical evaluation of pre-existing geological information, site characterization and site confirmation. These stages represented activities, which will result in selection of the optimal site for DGR in the territory of the Czech Republic. The activities began in 1995 and at present, a critical evaluation of available geological information is in progress. Starts of the next two stages are scheduled for 1998 and 2003. Contents of the single above mentioned stages are as follows:

The stage of **critical evaluation** of pre-existing geological information includes collecting of geological data from archives. The principal evaluating criterion is the nature and quality of each information and its utilization for siting. The data being evaluated concern geology, geophysics, hydrogeology, hydrology, climatology, geochemistry, seismology, but also demography, environmental protection and the most significant conflicts of interests. Approximately 7 sites are supposed to be selected from existing 13 at the end of this stage and recommended for the next stages.

Within the **site characterization** stage, a non-destructive (not disturbing rocks in the depth, where DGR might be situated) geological survey will be performed at all sites. This stage will include:

- geological mapping at a scale of 1 : 10,000 and structural geology studies;
- aerial and surface geophysics, especially gravity measurement, magnetometry, geoelectric methods, logging measurements in all bore holes and other necessary methods;
- boring works down to a depth of 200 - 300 m;
- detailed petrologic and mineralogic studies;
- geochemical mapping;
- hydrological and hydrogeological characterization of the site; and
- engineering-geological mapping and geotechnical characterization of the site.

These activities are supposed to be performed on sites with an area of 10 - 50 square km each. In addition, the granitoid body surrounding metamorphosed complexes will be examined to the necessary extent in justified cases.

A detailed descriptive characterization of the whole territory will result from this phase. On the basis of this characterization, a final decision on the suitability of the examined site, or its part for DGR siting, will be made. This stage results in a selection of two or three sites for further investigation.

The **site confirmation** stage. Destructive phase of activities will be started in one of the candidate sites, the others will serve as spare ones. Boring and special geophysical methods will be used predominantly in this stage. According to the assumptions of the General Project, the details of the verified site for DGR construction in the Czech Republic should be known by 2010.

8.8 CONCLUSIONS

Disposal of radioactive wastes has been practiced in the Czech Republic for more than 40 years. Different geologic environments were selected as host rocks for those subsurface facilities. This experience allows us to carry out successful research and development of a deep geological repository able to accept both decommissioning long lived and/or high level wastes and spent fuel from nuclear reactors. When considering the available geological systems and its variability in the Czech Republic, hard rocks, namely granitoid bodies, seem to be the most hopeful rocks for construction of a deep geological repository. The relevant national program was initiated in the early nineties aimed at development of this underground facility.

Technical abilities, however, are not fully supported by existing legal tools and the organizational system. Parallel management of radioactive wastes arising from different sources will probably survive till the newly prepared Atomic Law passes through the Czech parliament. In dealing with radioactive waste management, the governmental proposal contains several new principles, namely:

- state guarantees safe disposal of radioactive wastes, although the waste generators must bear the respective costs;
- import of radioactive wastes for their disposal on the Czech territory is forbidden;
- Nuclear Account, established out of the state budget, collects fees from waste producers to ascertain enough financial sources for final disposal of all radioactive wastes; the Account is controlled by a committee consisting of representatives of waste producers, state institutions and public; and it is under the supervision of the Ministry of Finance;
- new Office of Repository Management is created; it provides disposal services in existing facilities and is responsible for research and development in this field, including development of a deep geological repository; and
- a position of the State Office for Nuclear Safety as an independent supervisor in nuclear and radiological issues is stressed.

The Atomic Law shall be completed with a set of nearly 20 decrees providing the concrete regulations for users of radionuclides.

Even if the existing legislation is updated, siting of nuclear facilities, such as storage and disposal facilities, will have to face the high population density in the Czech Republic (130 inhabitants per square km) and all the negative consequences that this fact may imply. Nevertheless, it is believed that all kinds of radioactive wastes and spent nuclear fuel will be safely conditioned