SITE SELECTION AND GEOLOGICAL RESEARCH CONNECTED WITH HIGH LEVEL WASTE DISPOSAL PROGRAMME IN THE CZECH REPUBLIC

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ABSTRACT

Attempts to solve the problem of high-level waste disposal including the spent fuel from nuclear power plants have been made in the Czech Republic for over the 10 years. Already in 1991 the Ministry of Environment entitled The Czech Geological Survey to deal with the siting of the locality for HLW disposal and the project No. 3308 "The geological research of the safe disposal of high level waste" had started.

Within this project a sub-project "A selection of perspective HLW disposal sites in the Bohemian Massif" has been elaborated and 27 prospective areas were identified in the Czech Republic. This selection has been later narowed to 8 areas which are recently studied in more detail.

As a parallel research activity with siting a granitic body Melechov Massif in Central Moldanubian Pluton has been chosen as a test site and the 1st stage of research i.e. evaluation and study of its geological, hydrogeological, geophysical, tectonic and structural properties has been already completed. The Melechov Massif was selected as a test site after the recommendation of WATRP (Waste Management Assessment and Technical Review Programme) mission of IAEA (1993) because it represents an area analogous with the host geological environment for the future HLW and spent fuel disposal in the Czech Republic, i.e. variscan granitoids. It is necessary to say that this site would not be in a locality where the deep repository will be built, although it is a site suitable for oriented research for the sampling and collection of descriptive data using up to date and advanced scientific methods.

The Czech Republic HLW and spent fuel disposal programme is now based on The Concept of Radioactive Waste and Spent Nuclear Fuel Management ("Concept" hereinafter) which has been prepared in compliance with energy policy approved by Government Decree No. 50 of 12th January 2000 and approved by the Government in May 2002. Preparation of the Concept was required, amongst other reasons in connection with preparations for the Czech Republic's accession to the European Union and in connection with the Joint Convention on the Safety of Spent Fuel Management and on the Safety of Radioactive Waste Management adopted under the auspices of the International Atomic Energy Agency, which was signed by the Czech Republic in 1997.

According to the approved Concept it is expected that a deep geological repository in the Czech Republic will be built in granitic rocks.

INTRODUCTION

When the Czech government decided to finish building the nuclear power plant at Temelin (South Bohemia) and to up-grade its technical parameters to the European safety standards, the Ministry of the Environment requested the Czech Geological Survey to prepare a site selection project covering the whole Bohemian Massif. In 1991 a project proposal No.

3308 "Geological Research of Radioactive Waste Safe Disposal" (J.Kříž et all.) was submitted which has been reviewed and approved. It continued untill the end of 1997 and the financial means was provided by the Government Council for Science and Development from the state budget. The project was supervised by the Ministry of the Environment. The most significant document from this period was "Project of Deep Repository Development for Spent Fuel and HLW" funded by both the Czech Power Company and the Slovak Power Enterprises in 1993.

This concept was reviewed by WATRP mission (IAEA) in December 1993. The recommendations of this mission were implemented into revised Programme of Deep Geological disposal in 1994. The IAEA mission approved the steps of the programme reached so far in the Czech Republic and recommended to divide the future programme as follows:

Project and Realisation Activities Source Term and Near-field Interaction Site Selection and Far-field Interaction Role of the Public Legal Matters Quality Assurance Programme

In 1993 an agreement was signed by the governmental and non-governmental bodies responsible for the HLW disposal programme to assure that the financial means from the state budget will be used economically and effectively. In January 1997 the "Act on the Peaceful Uses of Nuclear Energy and Ionising Radiation" (Atomic Act No. 18/1997 Coll.) This Act transferred the responsibilities for radioactive waste management to the newly created Radioactive Waste Repository Authority (RAWRA). A Board of RAWRA was nominated as a supervising and consulting body consisting of 11 members of state administration, radwaste producers, mayors of the towns where the radioactive waste repositories are situated (Dukovany, Litoměřice, Jáchymov) and one member of the Senate.

SITE SELECTION AND TEST SITE MELECHOV PROGRAMME

The aim of this report is to inform about the site selection projects of the Ministry of the Environment in the years 1991 - 2001 (historical review) and describe the goals which have been reached and planned during the geological activities connected with the siting and test site project.

As a parallel research activity with siting a granitic body Melechov Massif in Central Moldanubian Pluton has been chosen as a test site and the 1st stage of research i.e. evaluation and study of its geological, hydrogeological, geophysical, tectonic and structural properties has been already completed. The Melechov Massif was selected as a test site after the recommendation of WATRP (Waste Management Assessment and Technical Review Programme) mission of IAEA (1993) because it represents an area analogous with the host geological environment for the future HLW and spent fuel disposal in the Czech Republic, i.e. variscan granitoids. It is necessary to say that this site wont be a locality where the deep repository will be built, although it is a site suitable for oriented research triggered to the sampling and collection of descriptive data using up to date most sophisticated and advanced scientific methods.

From the geological point of view the Czech Republic is located in the Bohemian Massif. The Bohemian Massif is structurally and genetically a composite cratonic block

standing out as a horst above the surrounding platform-type units of Mezo-Europe. In the south and south-east it adjoins the young Alpine-Carpathian orogenic belt. The Massif attained the stage of an advanced crustal consolidation during the Variscan tectonogenesis (380 -280 M.y. ago), although it contains some Cadomian elements (older than 550 M.y.). The platform cover consists of the Mesozoic and younger units which were subjected only to the Saxonian tectonic processes.

During the first stage of site selection programme 27 perspective localities were selected regarding geological, hydrogeological and geophysical point of views. The major part of the Czech Republic territory is built up by crystalline rocks (more than 60%). These rocks exhibit favourable characteristics for hosting a HLW repository.

Rock type	Number of localities	Size in km ²
granites	15	712
paragneiss, migmatites	5	415
metasediments	4	490
ultramaphic and basic rocks	3	61
Total	27	1678

Table 1. Numbers and the size of selected localities.

The selection of the above mentioned 27 localities was reviewed and 13 most prospective sites were recommended for critical assessment based on archive data. As a result of this assessment (1995 - 1997) a set of 8 localities, all of them being in granitic rocks, were recommended for the further detailed geological survey (Fig. 1).

Table 2. Numbers and the size of the last 8 selected localities.

Locality No.	Name	Size in km ²	Geological unit
5/1	Růžená	29,0	Central moldanubian pluton
6/1	Klenová	30,6	Central moldanubian pluton
6/2	Kunějov	26,2	Central moldanubian pluton
7/1	Lodhéřov	52,2	Klenov massif
14/1	Tis u Blatna	21,4	Tis granite
14/2	Blatno	15,9	Tis granite
30/1	Chyšky	56,1	Central Bohemian pluton
30/2	Vlksice	56/4	Central Bohemian pluton

According to the acceptable basic geological criteria the Melechov Massif laying in the Central moldanubian pluton was selected as a study and testing locality. The selection criteria were as follows:

regular shape (with the size more than 10 km²) homogeneous rock geochemical homogeneity low seismicity no potential for natural resources no ductile deformation

SITE SELECTION HISTORICAL REVIEW

1991 As stated above, the site selection process has started with the project of Czech Geological Survey in 1991 called "Geological Research of Radioactive Waste Safe Disposal". Within this project a sub-project "A selection of perspective HLW disposal sites in the Bohemian Massif" has been elaborated and 27 areas were identified.

An overall critical research of the information data has been done based on enormous potential of the geological maps of different scales covering the whole Bohemian Massif. There have been studied reports about hydrogeology, geophysics, geochemistry and other natural science branches from the selected areas. Simultaneously the experiences of other countries were taken into consideration, mostly those where granites as host rocks were assumed. Cooperation has started in this field of research with the Swedish SKB, Swiss NAGRA and the Geological Survey of Finland. The financing of this collaborative projects was covered by The Ministry of Environment.

1992 The selection of localities was performed by the Czech Geological Survey and a critical review of the strategy of the whole programme was completed by specialists from SKB. They recommended to start testing more modern methods of scientific research on the testing site situated in the granitic host rock of the Melechov Massif.

1993 Reports "Proposal of semiquantitative criteria of geological aspects of the host environment of deep depository in the Czech Republic", "Metodology of the geological exploration of the host structure for deep depository in igneous rocks" and a critical assessment of geophysical research was done covering all of 27 areas selected in the year 1991.

1994 – 1997 A complex and systematic applied research in geology, hydrogeology, geophysics and structural geology was completed covering part of non-destructive descriptive geological characteristics of Melechov Massif. A digitised geological map in the scale of 1 : 10 000 was prepared

1998 A Final Report was reviewed and submitted to the government. The Final Report gave basic information about the Melechov Massif as well and recommending this granitic body as the test site for HLW and spent fuel disposal programme.

1999 – 2002 Test Site Melechov project

TEST SITE MELECHOV MASSIF

The Melechov Massif was selected as a test site after the recommendation of WATRP (Waste Management Assessment and Technical Review Programme) mission of IAEA (1993) because it represents an area analogous with the host geological environment for the future HLW and spent fuel disposal in the Czech Republic, i.e. variscan granitoids. It is necessary to say that this site will not be a locality where the deep repository will be built, although it is a site suitable for research into the sampling and collection of descriptive data about this type of geological environment using advanced scientific methods.

Progress Reports have been presented about the Melechov Massif research by the Czech Geological Survey and reviewed in each year 1998 – 2001. The descriptive

characterisation of Massif study and Polygons Selection continued in 2002 (Fig. 2). According to the research completed so far, the following summary can be stated:

- 1. Melechov Massif is large enough to simulate the properties of general granitic region with many varieties, some parts being of a very homogeneous structure. A geological map in the scale of 1:10 000 in digitised form has been prepared and published by CGS.
- 2. Melechov Massif is from the density and magnetic properties points of view a very homogeneous body deeply rooted in the geological environment (15 17 km). It has sharp contact with surrounding metamorphic moladnubian complex, except of the part where the granite gradually passes to the moladnubian rocks.
- 3. Geophysical gravimetrical measurements and the detailed geological mapping divided the area of Melechov Massif in two parts. One is more homogeneous type Stvořidla Granite without any distinctive physical inhomogenities, and the second one, called Lipnice Granite, is less homogeneous and more tectonically affected rock. (Fig. 2)
- 4. The results of the first geophysical studies are suitable for the establishing the local seismological monitoring net within this area
- 5. Airborne gamma-spectrometry followed by gamma ground measurements divided different parts of the Melechov Massif very distinctively after the Thorium content (Fig. 4).
- 6. Structure of the Melechov Massif was studied and approved as the area for testing the tectonic phenomena typical for the granitic bodies (Fig. 3).
- 7. Also from the mineralogical point of view, the Melechov Massif is very good test site. Many open pits of granitic rocks give an opportunity to study the mineralogy of dikes and zones. There are not advanced hydrothermal zones and the subtype Kouty Granite with its homogenity and fault mineralisation represents a good example of homogenous body suitable for mathematic modelling.
- 8. From the hydrogeological point of view the results do not disqualify the Melechov Massif as test site and being a part of GEOMON monitoring net of small catchments represents a typical example of granitic hydrochemical environment.

Test Polygons

Four Polygons were selected to represent all types of Melechov Massif (Fig. 2) on which detailed geological, geophysical , hydrogeological, structural, geochemical etc. research will be executed. Works are planned to cover all non-destructive geoscience methods and prepare suitable data for the localisation of boreholes in which carotage measurements, geophysics, hydrogeological tests, physical properties of different rock types, petrographical and petrochemical study of samples and mathematic modelling of fluid migration and micro and macro structures will be completed. The 4 polygons are defined as follows:

- (P-1a) Melechov Type coarse grained biotite-muscovite granite
- (P-2a) Lipnice Type medium grained muscivite-biotite granite
- (P-1b) border zone South complex of granites and gneisses
- (P-2b) border zone North complex of granites and gneisses

The mile stones of the research on above polygons are as follows:

2002 – 2003 project preparation, surface detailed geological, geophysical, hydrogeological and geochemical research on polygons P-1a and P-1b

drilling program on polygons P-1a and P-1b, carotage, hydrodinamic studies, hydrogeology

- 2004 the same program on polygons P-2a and P-2b and discussion of results. Progress Report 1
- 2005- Field works and drilling program completed. Final Report and Conclusion.

THE CONCEPT OF RADIOACTIVE WASTE AND SPENT NUCLEAR FUEL MANAGEMENT

The Czech Republic HLW and spent fuel disposal programme now is based on The Concept of Radioactive Waste and Spent Nuclear Fuel Management ("Concept" hereinafter) which has been prepared in compliance with energy policy approved by Government Decree No. 50 of 12th January 2000 and approved by the Government in May 2002. Preparation of the Concept was required, amongst other reasons in connection with preparations for the Czech Republic's accession to the European Union and in connection with the Joint Convention on the Safety of Spent Fuel Management and on the Safety of Radioactive Waste Management adopted under the auspices of the International Atomic Energy Agency, which was signed by the Czech Republic in 1997.

According to the above approved Concept it is expected that a deep geological repository in the Czech Republic will be built in granitic rocks.

The main objectives of the Concept are as follows:

- To determine strategically justified, scientifically, technically, environmentally, financially and socially acceptable principles for radioactive waste and spent nuclear fuel management in the Czech Republic;
- To develop a basic system framework for the decision-making of those authorities and organizations responsible for radioactive waste or spent nuclear fuel management in the Czech Republic;
- To communicate in a straightforward way information concerning the long-term management of radioactive waste and spent nuclear fuel to organizations involved in this field and to the general public.

The Concept sets out the basic aims and the direction of the development of the radioactive waste and spent nuclear fuel management system. Crucial for implementation of the Concept is a speedy verification of the feasibility of a deep geological repository in the Czech Republic (i.e. to identify and confirm a suitable site) or a demonstration that transmutation or spent nuclear fuel recycling has been successfully developed.

The following specific targets are set out below so as to provide a framework for fulfilling the aims of the Concept:

a) Legislation

Target	Date
To harmonize the Atomic Act and related regulations	2003
concerning radioactive waste management with EU legislation	

b) Low/Medium-level	Waste Management
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Target	Date
To operate existing near-surface repositories in compliance with requirements for radiation protection and relevant licenses issued by the State Office for Nuclear Safety and within the EIA Process	continually
Coordination and implementation of a research program on minimalisation of radioactive waste arisings and development of new methods for radioactive waste processing	continually
Preparation of schedule for final closure of parts of repositories Richard and Bratrství with radioactive waste disposed of before the Atomic Act came into force	2003
To create the necessary conditions for operation of the system of central processing of radioactive waste for generators from outside the nuclear power engineering sector (small generators) supervised by RAWRA	2003
To allocate or build storage capacity for radioactive waste that cannot be accepted at existing near-surface repositories	2004

Target	Date
To construct a spent nuclear fuel storage facility as per Government Decree No. 121/1997 and Government Decree No. 695/2001	2005 and ongoing
To support and coordinate the involvement of research institutions in the development of new techniques for spent nuclear fuel reprocessing and transmutation and use all the available technologies for lowering the risk of high level waste and spent fuel	continually
To continue the research activity on Melechov Test Site	2003 - 2006
To select sites with proper geological conditions taking into account local developments at proposed sites. After evaluation of relevant results include two sites into land use plans (main and reserve one) for deep geological repository	2015
On the basis of geological work performed and complex data analysis confirm the suitability of one site for a geological repository	2025
To prepare the necessary documentation for construction of an underground research laboratory and performance of long term experiments for confirmation of safety of deep geological repository	2030
Operation of deep geological repository	2065

c) High-Level Waste and Spent Nuclear Fuel Management

d)	Economic	Aspects
~	Беонюшие	nopeeus

Target	Date
To assess the creation and distribution of nuclear account funds, amend, if necessary, the government decree concerning payments to the nuclear account with the aim of maintaining a long-term, stable and adequate balance on the nuclear account	continually
To provide for the appreciation of free funds from the nuclear account in compliance with the Atomic Act	permanently
To check, on a regular basis, the creation of provisions for decommissioning nuclear facilities so as to provide for sufficient future financial resources	continually

e) Other

Target	Date
To systematically inform the public about issues concerning radioactive waste management (information centres, brochures, Internet, etc.)	permanently
To provide independent scientific and technical support for RAWRA's Board to facilitate evaluation of work carried out as part of the deep geological repository development programme	2002-2005

CONCLUSIONS

The Government of the Czech Republic designed the priorities of radwaste management programme including the future activities connected with HLW and spent fuel disposal. The frame for this is given in the Concept of Radioactive Waste and Spent Nuclear Fuel Management approved by the Czech Government in 2001.

The Radioactive Waste Repository Administration (RAWRA) is responsible, according to the Atomic Act, for the operating repository sites of LLW in Litoměřice (Richard), Jáchymov (Bratrstvi) and Dukovany and beside others administrative activities has to finance the Test Site and Site Selection Programme from the nuclear account.

The Melechov Test Site research programme has started in 1993 and continued in more detailed and field and laboratory methods were applied.

Four Polygons were selected representing all types of Melechov Massif (Fig. 2) on which detailed geological, geophysical, hydrogeological, structural, geochemical etc. research will be executed. Works are planned to cover all non-destructive geoscience methods and prepare suitable data for the localisation of future boreholes in which carotage measurements, geophysics, hydrogeological tests, physical properties of different rock types, petrographical and petrochemical study of samples and mathematic modelling of fluid migration and micro and macro structures will be completed.

It is necessary to say, looking to the far end of fuel cycle, that the state authorities slowed down the above designed program of Test Site research and also the Site selection because of the state budget shortcuts having in mind that the need for deep geological repository will be urgent not untill the late sixties of this century.

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EXPLANATION OF FIGURES:

Fig.1: Sketch map of granitoids in Bohemia

1 – Pre-Variscan Pluton, 2 – 8 Variscan Plutons (2 – tonalite-granodiorite, 3 – durbachite, 4 - low differentiated granites, 5 – strong differentiated granites, 6 – Lithium mica granite, 7 – volcanic complexes, 8 – Cista Type granite

8 perspective localities all printed in red colour 1 - Růžená, 2 - Klenová, 3 - Kunějov, 4 - Lodhéřov, 5 - Tis, 6 - Blatno, 7 - Chyšky, 8 – Vlksice

TL – Test Site Melechov NA - Natural analogue Ruprechtov

- Fig. 2: Geological Sketch Map of Melechov Massif (after B. Mlčoch 1998) with designed 4 test polygons:
 - (P-1a) Melechov Type coarse grained biotite-muscovite granite
 - (P-2a) Lipnice Type medium grained muscivite-biotite granite
 - (P-1b) border zone South complex of granites and gneisses
 - (P-2b) border zone North complex of granites and gneisses
- Fig. 3: Melechov Massif Airborne Survey Total Magnmetic Field and Tectonic Zones
- Fig. 4: Melechov Massif Airborne Survey Diagram of K - Th content