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REASSESSMENT OF OLD REPOSITORIES - A CASE STUDY OF PÜSPÖKSZILÁGY L/ILW NEAR SURFACE DISPOSAL FACILITY, HUNGARY

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ABSTRACT

Hungary's only LILW disposal site is at Püspökszilágy (40 km NE of Budapest), on an elongated N-S oriented hill gently dipping to the south, built up of Oligocene impermeable silty claystone under a 5-15 m thick Quaternary loess cover. Püspökszilágy facility was ready to receive radioactive waste in 1976. In 1980 the previous disposal site, Solymár was decommissioned and waste packages were transported to Püspökszilágy. This moving was the first in Europe of its kind. Püspökszilágy radioactive waste treatment and disposal facility is a near surface type repository with concrete trenches and disposal wells. The waste acceptance system, the recording and isotope inventory improved a lot compared to the Solymár facility but still it is not as proper as the most up-to-date practices.

The Ministry of Health supervised the facility until 1998 when the Central Nuclear Financial Fund and the Public Agency for Radioactive Waste Management (PURAM) were established. Criticism concerning the safety of the facility came out in the early nineties when the facility applied for the final certificate and enlargement was considered. In 1994 the Hungarian Geological Survey made a resolution which suggested not to issue the final operation license. Among the reasons, the geological authority cited the poor geologic and hydrogeologic knowledge on the site. The Minister of Health issued an interim operation license with a termination of December 31, 2000.

The case history shows that without a well-planned, systematic site characterization program, which can provide reliable input data for safety assessment, a twenty years old repository can hardly fulfil the requirements of new regulations.

INTRODUCTION

In Hungary application of open and sealed radioactive sources in larger scale began at the second half of fifties. A research reactor was commissioned at 1959 in the Central Research Institute for Physics in Budapest. The first nuclear power plant unit went into operation in 1982.

Currently low and intermediate level radwaste (L/ILW) is generated by two groups of institutions; ones are the small-scale or non fuel-cycle producers including hospitals, laboratories and industrial companies. The other main waste producer is the Paks Nuclear Power Plant with its four WWER-440 reactors. (Fig.1.)

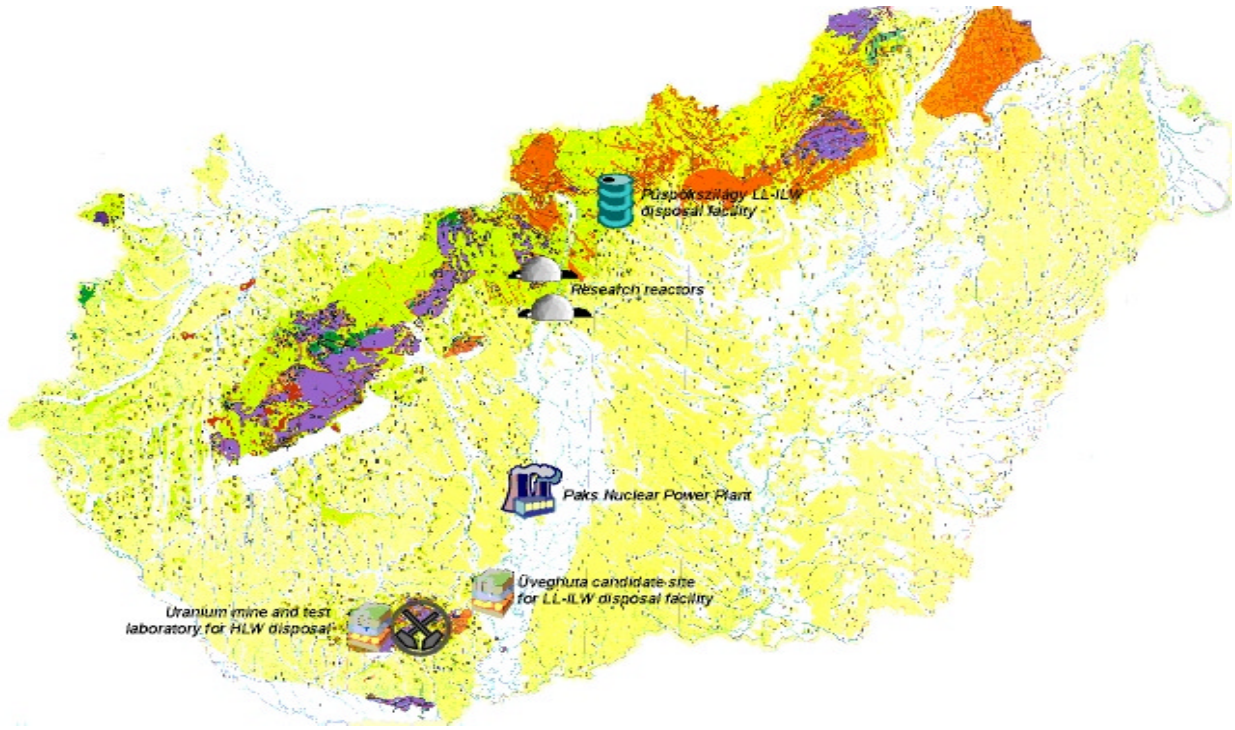

Fig. 1 Nuclear facilities of Hungary

In the early nineties there were approx. 2000 working places licensed for application of isotopes, mainly working with sealed sources. Their number has been continuously decreasing - dropped to 500-600 by now - because of the structural changes in the Hungarian economy. The first group generates ca. 10-30 m^3 L/ILW annually. This amount includes 10-25 m^3 solid, 4-5 m^3 liquid, 1-2 m^3 biological waste and 500-1000 pieces of spent radiation sources.

The management of radioactive waste in Hungary is dated back to 1960 when an interim storage was opened in Solymár (10 km NW of the capital city Budapest) without a systematic site selection or site characterization procedure. The facility had no reliable inventory of the institutional waste originating primarily from medical applications and research institutes (e.g. sealed sources). However evidences show that the waste contained long-lived, alpha and beta radiating isotopes as well. The unfavorable geological setting and the primitive technical conditions (vertical wells without isolation and sealing) made the former regulators and decision makers to conclude that the site had to be decommissioned and abandoned.

This paper is to present the efforts that led to the establishment of the Püspökszilágy disposal facility and to review the arguments on the natural barriers that are touched during the reassessment of the repository for its final approval.

GEOLOGICAL EXPLORATION

Survey for a new LILW disposal site began in 1970 when a regional screening was carried out and the first geological expertise was issued.

There were two alternatives:

- emplacement into closed mines;
- disposal into appropriate clay host rocks.

The first alternative was disapproved. Accepting the second solution a screening of ca. 15 000 km^2 in a circle of 130 km radius around Budapest was carried out considering geological, hydrogeological, economical and medical criteria. The five area found suitable by geological viewpoints were:

- Bánk-Romhány
- Őrbottyán N
- Tinnye W
- Budajenő-Telki
- Páty.

These sites were explored by one drilling each and the intersected host rocks were Oligocene-Miocene deposits. The first four sites were disapproved by aspects other than geology.

Following this procedure five new areas were chosen. After the field examinations the next three remained:

- Páty NE
- Vácbottyán NE
- Püspökszilágy SW.

After one drillings each site Püspökszilágy SW was found a potential site and was explored by further three drillings. The geologically optimal sites fell out because of other criteria e.g. public acceptance, so Püspökszilágy became a candidate, however it was secondary by geological viewpoints.

The chosen Püspökszilágy site (40 km NE of Budapest) is an elongated N-S oriented hill gently dipping to the south, between the valleys of Szilágyi and Némedi creek. The nearest settlements are Püspökszilágy and Kisnémedi at about 1 km distance. The top of the hill is on the level of about 240 mBf. (above Baltic-sea base level), the Némedi creek valley is on 190 mBf. and the Szilágyi creek valley is on 180 mBf. The hill is built up of Oligocene impermeable silty claystone under a 5-15 m thick Quaternary loess cover. (Fig. 2.)

The western slope of the hill by the Némedi creek is precipitous and exposed to the winds coming generally from west. The heads of Oligocene layers are covered with Quaternary deposits on this side. The eastern smooth slope by the Szilágyi creek is the bedding plane of the Oligocene claystone, covered with Quaternary as well. The first concept was to emplace the disposal facility into the Oligocene claystone which seemed an ideal host rock functioning as a geochemical and hydrogeological barrier as well. That concept fits nowadays' hazardous chemical waste disposal

models in general. However, designers modified this plan by placing the facility into the Quaternary loess overburden.

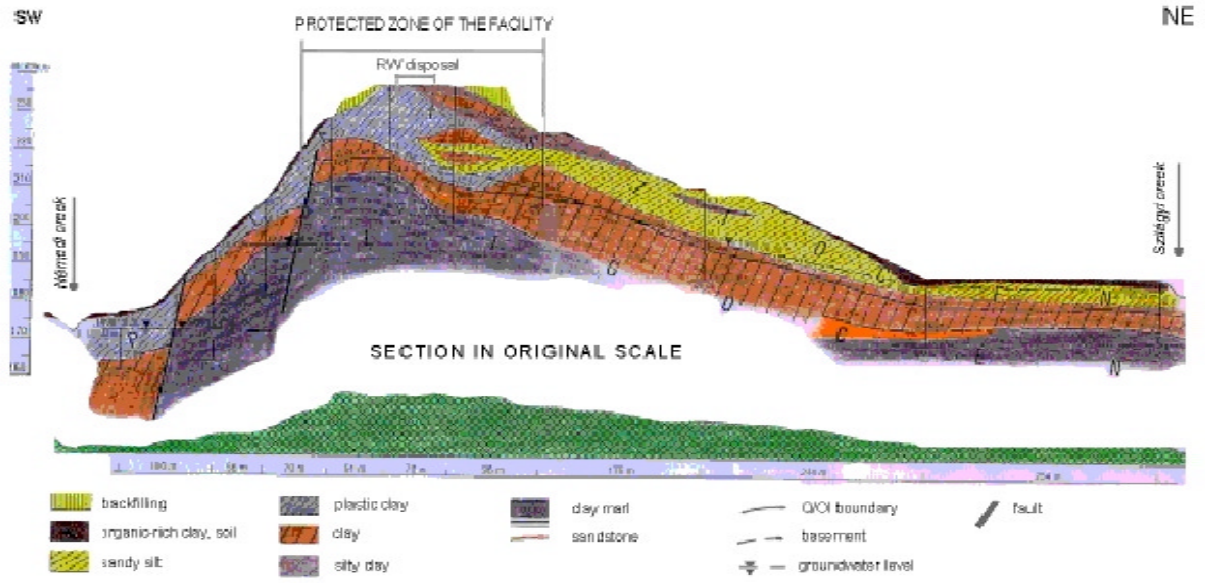

Fig. 2 Geological profile of Püspökszilágy

The geological site characterization program of the site started in 1971. Nine drillings were put down with depth of 15.0-31.5 m. They were located on the top of the hill, mainly on place of recent trenches. Geotechnical and DTA analyses were made on the samples; two of the drillings were transformed into interim monitoring wells and hydrogeological monitoring and measurements were performed in them. The facility was built and commissioned on the base of this limited site exploration. Later on, in the mid seventies a decision was made to enlarge the facility for the emplacement of the L/ILW of the Paks NPP. Hence geological research started again in 1977. 27 drillings were completed between 1977-83 with depth of 7.0-100.0 m. 17 of them became monitoring wells. Geotechnical studies and permeability measurements of the sediments were carried out. These drillings covered the flat top and the gently dipping eastern side of the hill by the Szilágyi creek. The report of the geological exploration was issued in 1988. In 1990 a new monitoring system of 20 wells with depth of 15.0-33.0 m was established. Some of them were placed on the precipitous western side of the hill by the Némedi creek.

Geophysical investigations were carried out by the Roland Eötvös Geophysical Institute in 1995. There were gravity measurements with a density of 16 stations/km^2; magnetic measurements to define the precise location of the andesite dykes in the area known from outcrops, and 5 seismic profiles were measured.

The VITUKI, a water management company, made isotope analysis regularly to define the quantity of T^3 in the groundwater and in the three-phase, unsaturated zone. They did C^{14} measurements as well to define the age of groundwater.

Most mass of the hill is built up of Oligocene claystone with thickness of 400-500 m on the site, dipping to the SE with 10-15°. Miocene andesite dykes pass through the claystone nearby the repository. Their strike is NW-SE, thickness is 3-15 m. Quaternary deposits covering the Oligocene layers are aeolian, loose clay, silty clay with paleosoil layers - not a typical loess. Its thickness is 4.8-31.4 m by the drillings.

There is an uplifted groundwater level under the repository in the depth of about 25 m. The level of groundwater follows surface morphology which is determined by the contour of the Oligocene sediments. The C^{14} water age data show a very slow movement to the direction of Némedi creek as well but the main direction of the groundwater-flow is to SE, to the Szilágyi creek on the Oligocene surface.

PÜSPÖKSZILÁGY REPOSITORY

Püspökszilágy facility was ready to receive radioactive waste in 1976. In 1980 Solymár was decommissioned and the waste packages were transported to Püspökszilágy. This moving was the first case in Europe of its kind. In the first ten years of operation the annually emplaced solid radwaste volumes varied between 67 and 490 m^3, the latter volume is from the Solymár facility. Despite the fact that the site was designed and licensed for institutional solid waste, 15 to 470 m^3 waste from the Paks Nuclear Power Plant was disposed annually since 1983. Due to this overuse by year 1998 an empty volume of 150 m^3 remained available.

For the time being Püspökszilágy repository is the only facility providing final disposal for radioactive waste in Hungary. The repository was formerly operated by the Budapest Branch of the State Public Health and Medical Officer Services. Since July 2. 1998 the newly formed Public Agency for Radioactive Waste Management (PURAM) has taken over the operation tasks. The collection, transportation and disposal of the waste was provided free of charge for the institutions that generate waste.

Püspökszilágy disposal facility was responsible to take over institutional radioactive waste from the producers and treat and dispose it properly. However, neither the original license nor the licensing of the extension deal with waste acceptance criteria. On the request of producers spent sealed sources have been accepted for disposal. There were two important exemptions to the take-over responsibility. Radium sources (needles, capsules, etc.) of medical applications had been collected and are being stored at the National Institute of Oncology. In the early years Püspökszilágy repository accepted ^{238}Pu and ^{239}Pu sources for disposal and these cases were discussed and agreed upon with Hungarian Atomic Energy Committee (HAEC) and Institute of Isotopes of Hungarian Academy of Sciences to comply with safeguard requirements, but presently this practice has been terminated and Pu sources are collected and stored in Institute of Isotopes.

There are concrete trenches and shallow wells for waste disposal purposes. The disposal units are categorized into four classes:

- the "A" type disposal system consists of the original 48 vaults, 70 m^3 each and the extension built during late eighties: 6 vaults, 140 m^3 each plus 12 vaults with 70 m^3 volume;
- the "B" type disposal system consists of 16 wells with diameter of 40 mm and 16 wells with diameter of 100 mm. The wells are stainless steel lined and 6 m long, located inside a concrete monolith structure;
- the "C" type disposal system consists of 8 vaults, 1.5 m^3 each used for organic solvent disposal;
- the "D" type disposal system consists of 4 wells with diameter of 200 mm. The wells are stainless steel lined and 6 m long.

The solid waste is generally packed into drums or plastic bags; the liquid and biological waste are put into cans or drums; the spent sealed sources are handled with shielded container. Solid waste put in plastic bag by the producer is repackaged into drums at the disposal facility. The liquid waste is sponged up with siliceous marl (diatomite) or cemented. Earlier biological waste was filled with bitumen in drums, at present this is also cemented.

Both unconditioned and conditioned wastes packaged in plastic bags or metal drums has been placed in layers and each layer is filled with concrete. Two trenches have already been sealed. Steel-lined concrete wells are used for the disposal of high activity waste. This waste comes from isotope users and are regarded as high-level waste based on the Hungarian National Standard for the Classification of Radioactive Wastes (HLW: dose rate at the surface is higher than 10 mGy/h).

The main radioisotopes are ^{3}H, ^{14}C, ^{2}Na, ^{54}Mn,^{60}Co, ^{90}Sr, ^{137}Cs, ^{192}Ir, ^{226}Ra, $^{238, 239}Pu$, ^{241}Am.

In 1983 the site was licensed to dispose low and intermediate level solid radioactive waste from the Paks NPP until the expected opening of the power station's own disposal facility. Unlike other waste producers, the power plant was charged for this service and was compelled to build as much new disposal capacity as it occupied. However, due to strong public opposition, the license was not granted for the construction of a new repository site at Ófalu (SW Hungary). Moreover, the inhabitants of the two villages in adjacent to Püspökszilágy repository protested against the disposal of waste of nuclear power plant origin, so the shipment from the NPP was interrupted in 1989. After years of negotiations and referendum at the villages in question, the NPP managed to reach an agreement and was authorized to dispose another 1000 m^3 of waste at Püspökszilágy. In 1992 the waste shipments from the nuclear power plant restarted. According to the agreement, not only the operator of the repository but also local communities were paid for each m^3 of waste. Since 1998 the service is no longer free of charge neither for the other isotope users.

MANAGEMENT OF SPENT SEALED SOURCES

In 1996 an attempt was made to assess the future disposal needs of spent sealed sources. By comparing the data stored in the National Register of Isotopes and the records of the disposal facility a surprising conclusion was made that a few percent of sealed sources has been shipped

back as waste for disposal and their activity represents only one percent of the original. It means there are 10-20 thousands sealed sources still in use in the country.

Till the end of 1996 the amount of spent sealed sources taken over by the disposal facility was 24 269 pieces with the activity of 23 146 887 TBq. Sealed sources should be stored in every licensed workplace according to the requirements of 7/1988 ministerial order of the Ministry of Health and Social Welfare. When a source becomes unnecessary for future activities of the given workplace or the isotope application activities are to be terminated the institution or the company has to offer its sealed sources to the Institute of Isotopes responsible for import and procurement of isotopes for the country and maintaining national register of isotopes. In case of rejection of the offer the institution or company can ask Püspökszilágy to take over the source(es) either for storage or for disposal.

Request for take over means written data supply for the operator of the disposal facility, including the following data:

- Institution, license number, address.
- Responsible person on radiation protection.
- Source characteristics (isotope, activity, date of manufacturing, dimensions of the active capsule, date of the last leakage test, number of the certificate, number of rejection letter issued by Institute of Isotopes).

Recently applied conditions at the workplaces with respect to take over of spent sealed sources include:

- Only intact sealed sources can be accepted. In case of leaking source the producer has to apply welded capsules or repair the source.
- The source has to be removed from any device instrument or application holder.
- Sources below 40 GBq have to be loaded into transport containers by the waste producer. Transport containers should be provided by repository staff if transportation is done by them. Single sources above 40 GBq can be handled as special individual cases requiring involvement of other than the producer and disposal facility operator institutions.
- Take over of sources has to be documented in written protocols and the documentation of the source (for example certificates, delivery protocols, periodic re-licensing, etc.) has to be handled over as well.

Packing of spent sealed sources prior to transportation is the responsibility of the producer. Large activity gamma-sources are usually put and sealed afterwards into a special disposal container (according to the shape it is called "disposal torpedo") by the Isotope Institute Plc. Gamma-sources having no surface contamination are not packaged, for their safe transportation lead containers are used. Alpha- and beta-sources have to be packaged into polyethylene casings.

Gamma-sources are not conditioned prior to disposal into the stainless steel lined bore-holes. Usually twice in a year the bore-holes are partially filled by cement grouting up to the level of sources. Spent alpha- and beta-sources have to be embedded into cement prior to disposal into

the "A" type vaults. Distribution of sealed sources with respect to disposal units/type and their activity is shown in Table I.

Table I. Sealed sources disposed off at Püspökszilágy repository (as of 1997)

Type of the Disposal unit	Activity (TBq)	No. of disposed Sources
„A" vault	103.82	17 831
„B" small diameter wells	119.21	2 057
„D" large diameter wells	8.44	4 381
Total	231.47	24 269

The disposal wells of "B" and "D" types had been designed basically for radiation protection requirements of the seventies for disposal of gamma emitting sources. These wells have 5 m long active length because the upper 1 m long part has to be cemented in case of closing the individual well. It was envisaged to provide the necessary radiation protection at the surface. The conical guidance part is protected during the operational phase by a lead plug. "B" type wells were design for the disposal of highly active cobalt sources. The amount of spent sealed sources and especially ^{60}Co sources was less then the expected during the design, so the wells are presently used for segregated disposal of sources.

Total capacity: 5040 m^3
Free capacity: 160 m^3 (as of Jan. 1999)
Total disposed activity: 455 TBq

Institutional waste:

7833 pieces 200 l drums	11 000 GBq
24 049 pieces 50 l plastic bag	1 300 GBq
644 m^3 miscellaneous (e.g. air filters)	8 000 GBq
Biological waste, 4 675 l	250 GBq
Waste water, 4 478 l	1 000 GBq
Organic solvent, 2 525 l	1 546 GBq
Sealed sources, 25 636 pieces	359 837 GBq
Contaminated soil	0.5 GBq
Smoke detectors, 2 627 pieces	30 GBq

Paks NPP origin (1983-1997)

Shipped volume	1 580 m^3
Emplacement volume	2 500 m^3
Disposed activity	847 GBq

FUTURE OF THE PÜSPÖKSZILÁGY REPOSITORY

The Hungarian Geological Survey, one of the authorities participating in the licensing procedure, has not consented to the issuing of the permanent license. According to its opinion the suitability of the site is not assured for disposal of radioactive waste due to hydrogeological problems and landslide risk.

The Paks NPP has capacity for several years of safe on-site storage of low and intermediate level radioactive waste. The present disposal site should only be used by other isotope user without adequate waste management infrastructure.

Up to now about 4800 m^3 of solid and solidified waste has been emplaced, but 2300 m^3 of that volume is originated from Paks NPP. The license of the facility is valid for low and intermediate level wastes. From the NPP solid, compacted waste was transported to the facility. According to the recording system of the facility the disposed activity is about 455 TBq.

For the sake of fulfillment of an updated safety analysis further investigations (geology, hydrology, biosphere, etc.) are to be carried out to complement the database of site. In order to set up the real inventory of the Püspökszilágy facility, an assessment procedure is being completed on the basis of accountancy of the circulation of radioisotopes, licensing prescriptions for waste producers and disposal data of facility. At present, a review of safety aspects is also being performed to state the missing data and to outline a research program so that a safety analysis could be achieved at the contemporary level. The aim of this analysis should be to calculate the long term effect of the emplaced waste and to define the "total activity" of the site in order to consider the extension of site and to justify the retrieval or not of long lived and alpha emitter radioisotopes. Püspökszilágy facility do not carry out chemical analysis and test of incoming waste. The facility accepts the data and information of the waste generator about the chemical properties.

The main objectives of the safety assessment are:

- To review the existing data and conceptual model of the site, in particular related to geology and hydrogeology.
- To develop recommendations for a research program of site characterization.
- To develop models appropriate for use in a safety assessment.
- To undertake a comprehensive safety assessment of the site.
- To establish the feasibility of remedial actions if required and of other potential developments at the Püspökszilágy facility.
- To transfer technology concerning safety assessment.
- To provide a review by Western experts of the safety and possible modifications to the Püspökszilágy facility.

Specific objectives are:

- Justification of management decisions regarding the potential need for intervention to improve safety performance.
- To develop of an understanding of the overall "disposal capacity" of the site as a basis for decision making regarding possible extension within its current physical boundaries.
- To develop consensus regarding the integration of key factors effecting safety performance.
- To demonstrate which, if any, categories, or sources of waste (e.g.: long-lived sealed sources) cannot be safely accommodate there.

- Consensus should be developed regarding the hydrogeological and geomorphological interpretation of the site.
- To establish a well-defined assessment context.

The Ministry of Health supervised the facility until 1998 when the Central Nuclear Financial Fund and the Public Agency for Radioactive Waste Management (PURAM) were established. Criticism concerning the safety of the facility came out in the early nineties when the facility applied for the final certificate and enlargement was considered. The Hungarian Geological Survey was taken into the authorization process of the enlargement of the facility in 1988 by the Budapest Branch of the State Public Health and Medical Officer Services. The Survey issued its first authority resolution in 1989, and four other ones until 1994. The expertise pointed out the incompleteness of the actual exploration projects, so the facility got interim operational license, which was extended several times on base of the complementary geological studies and the establishment of the monitoring system.

As mentioned above in 1994 the Hungarian Geological Survey made a resolution which suggested not to issue the final operation license. As a result, the Minister of Health issued an interim operation license with a termination of December 31, 2000. Until recent, due to financial constrains - Paks NPP did not supported the further research of the site -, sporadic and low-volume investigations were performed by different companies and private experts. In 1999 PURAM took the responsibility and started a new site characterization and confirmation program under the sponsorship of the Central Nuclear Financial Fund and partially by PHARE (Poland, Hungary Assistance for the Reconstruction of the Economy). As declared in the new regulation of a Ministerial Decree of 1997 the suitability of a nuclear facility has to be proved and assured in safety assessments and performance assessments. The new projects focus on the acquisition of more and quantitative geological data of the site.

NEW ASPECTS OF THE NATIONAL RADWASTE MANAGEMENT

Because there is no repository specifically designed for radioactive waste of nuclear power plant origin, the Püspökszilágy disposal site has temporarily received solid radioactive waste with restricted conditions (waste type, activity, contents and package). In 1992 a decision was made by Hungarian Atomic Energy Commission to launch a new project with the aim of selecting a site for a new repository for L/ILW of the nuclear power plant.

The technical concept is based on the installation of a multi-barrier system between the radioactive waste and the biosphere. Disposal of operational and decommissioning LLW and short-lived ILW is planned at the same site and in the same depth. Long-lived ILW is anticipated to be disposed together with the HLW.

In the framework of the National Project two main types of waste disposal options were defined and evaluated:

- near surface disposal in concrete trenches;

- subsurface disposal either in silos or drifts (tunnels) constructed by mining methods.

Currently the preferred option is a tunnel-type repository in a granite site near Üveghuta (SW Hungary).

The state-of-art in HLW (=spent fuel practically) management is satisfying. An interim storage of spent fuels was licensed and commissioned in 1997 in the protected zone of Paks NPP. Until 1999 in situ measurements were performed in a research tunnel of the Mecsek Uranium Mine to study the Boda Siltstone Formation, a candidate host rock for HLW final disposal. In year 2000 further exploration of Boda Fm. and other alternative host rocks will be continued.

SUMMARY

In 1994 the Hungarian Geological Survey made a resolution which suggested not to issue the final operation license because of the poor geologic and hydrogeologic knowledge on the site, the potential of slope erosion and landslide risk on SW side of the facility, the extremely short travel time (20-60 years) of meteoric water reaching the surface, and the recently detected tritium traces in groundwater. In 1999 PURAM took the responsibility and started a new site characterization and confirmation program under the sponsorship of the Central Nuclear Financial Fund and partially by PHARE. As prescribed in the new regulation the suitability of a nuclear facility has to be proved and assured in safety assessments. The new projects focus on the acquisition of more and quantitative geological data of the site.

The question of finalization of Püspökszilágy will be answered not only on the results of geological studies and safety assessments but the general status of L/ILW management in the country. Site characterization activities of the new L/ILW disposal site at Üveghuta granite have slowed down due to professional arguments and oppositions of the environmental lobby and local political players. As a consequence, the reassessment and certification of Hungary's first final L/ILW disposal at Püspökszilágy can be predicted by the very end of the XXth century.