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Characterization of the Lower Cambrian Blue Clays for deep geological disposal of radioactive waste in Lithuania

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According to the Lithuanian Strategy of Radioactive Waste Management, the opportunities for a deep geological repository of high and intermediate level long-lived radioactive waste and spent nuclear fuel must be considered. The Ignalina Nuclear Power Plant (INPP) produced a large amount of radioactive waste throughout more than two decades of operation of two 1500 MW reactors. Several alternative geological media were distinguished as potentially suitable for the construction of a deep repository in Lithuania. The lowermost Cambrian Blue Clays formation is one of the three most prospective geological formations. Its quality is somewhat lower than that of the crystalline basement and Triassic clays. However, it has some important advantages, such as distribution beneath and close to the Ignalina NPP. The thickness of the clay package reaches 115 m, the depth ranging from 200 to 1010 m. The thickest and lithologically most homogeneous succession is identified in the Ignalina NPP area. Some lithological heterogeneity, weak mechanical properties and illite-dominated mineral composition, hydraulic head difference (10–15 m) resulting in the upward fluid migration through the Blue Clays are considered as unfavourable parameters.

Key words: radioactive waste, clay, Cambrian, Baltic, repository

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INTRODUCTION

Since the beginning of the Ignalina NPP operation, spent nuclear fuel has been stored in ponds constructed in the reactor halls. The estimated total amount of spent nuclear fuel expected to be accumulated in the Ignalina NPP by 2010 is about 22,000 fuel assemblies, which corresponds to 2500 tons of uranium. In 1999 INPP started transferring spent fuel from the ponds to steel or reinforced concrete casks, which prevent radionuclides from spreading into the environment. There spent nuclear fuel can safely be stored for up to 50 years. Therefore the following questions must be answered without delay: is it technologically possible to construct a geological repository in Lithuania, what would be the cost of constructing a geological repository in Lithuania, and does Lithuania have any realistic alternative to the disposal of radioactive waste in a geological repository?

The layout and design of a repository depend on the properties of radioactive waste and geological medium. Investigation of the geological formation and selection of the site suitable for a deep radioactive waste repository is a complex and long process. The desk-top studies performed in Lithuania during 2001–2004 were focused on the screening of all potentially prospective geological formations of the country, *i.e.* the crystalline basement, Lower Cambrian clays, Silurian shales, Narva marlstones of the Middle Devonian, Upper Permian anhydrites and salt, Triassic clays.

The key geological criteria considered are the depth of the suitable host media, which has to be no less than 200 m, and the thickness of the impermeable formation at least 70 m. After inventory of the archive and published data three prospective formations – the crystalline basement, the Lower Cambrian Blue Clays, and the Lower Triassic Redbed Clay were selected for the next stage of study. According to preliminary estimates, disposal of spent nuclear fuel and other long-lived high activity radioactive wastes from the Ignalina NPP in Lithuania would cost about LTL 9000 M (this cost was calculated for the crystalline basement model) (Poškas et al., 2005). In terms of geology, the Blue Clays show some lower quality as compared to the crystalline basement and the Lower Triassic. However, it has a great advantage of being located just beneath of and close to the Ignalina NPP that reduces transportation costs, but most importantly, the prospect of building the radioactive waste repository in northeastern Lithuania may be accepted much easier by the local community than by other regions. Therefore, the Blue Clays remain on the list of the most prospective geological media for deep geological disposal of high-level radioactive waste. Furthermore, the clay formations are well studied in other countries that accumulated huge knowledge (e.g., Neerdael, Volckaert, 2001; Delleuze et al., 2002).

GEOLOGICAL SETTING AND STRATIGRAPHY

Lithuania is situated in the central and eastern parts of the Baltic sedimentary basin. The thickness of the sedimentary pile overlying the Lower-Middle Proterozoic bedrocks ranges from 200 m in south-east to more than 2 km in west Lithuania. Cambrian sediments comprise the basal part of the sedimentary cover.

The Cambrian sediments were deposited in two depocentres. The lowermost Cambrian deposits (Sabellidites–Platysolenites zones) are attributed to the Baltija Group restricted to the east of the country. It is dominated by the shallow marine claystones referred to as the Blue Clays, with rare quartz sandstone and siltstone interlayers, which grow in abundance close to the western shore of the palaeobasin (Jankauskas, Lendzion, 1992). The lowermost Cambrian overlies the Vendian sandstones and conglomerates that cover the Early Precambrian crystalline basement. The Baltija Group is overlain with the angular unconformity by the upper Lower Cambrian sandstones accumulated in the shallow marine basin, transgressed from the west.

Two parts, the Rudamina and Lontova Formations representing two sedimentation cycles, are defined in the Baltija Group. The thickness of the lower Rudamina Formation reaches 41.5 m (Jankauskas, 2002). It is comprised by dark-grey horizontally laminated clay, with sandstone and siltstone interbeds. The lower portion consists of greenish fine-grained quartz arenites cemented by dolomite cement, with siltstone and clay interlayers. Glauconite is abundant. In the upper part of the Rudamina Formation clayey interlayers are numerous. The boundary with the Vendian terrigens is marked by occurrence of glauconite and sabellitide fauna (Mens, Pirrus, 1986). The Lontova Formation is more widely distributed in the west (Jankauskas, 2002). It is subdivided into Molëtai and Alanta Sub-Formations which represent two sedimentation cycles. The Lontova Formation is comprised by the greenish-grey or bluish-grey thinly laminated and massive clay with subordinate sandstone and siltstone interlayers. The sandstone is a quartz arenite, massive or horizontally laminated. The thickness of the formation reaches 70 m.

The upper Lower-Middle Cambrian sediments cover the whole territory of Lithuania, except the Mazury-Belarus Highland in the south, its thickness ranging from several meters in the east to 170 m in the west. They are composed of a triple alternation of shallow marine sandstones, siltstones and claystones, which show different proportions across the basin. Sandstones dominate the eastern periphery of the basin.

In terms of tectonic structures, the Blue Clays basin is situated on the western flank of the Belarus High passing into the Baltic Syneclise in the west. The thickness of the sedimentary cover ranges within 400–800 m. It is represented by the Palaeozoic rocks of different lithologies, such as Lower Cambrian sandstones, Ordovician and Sil-

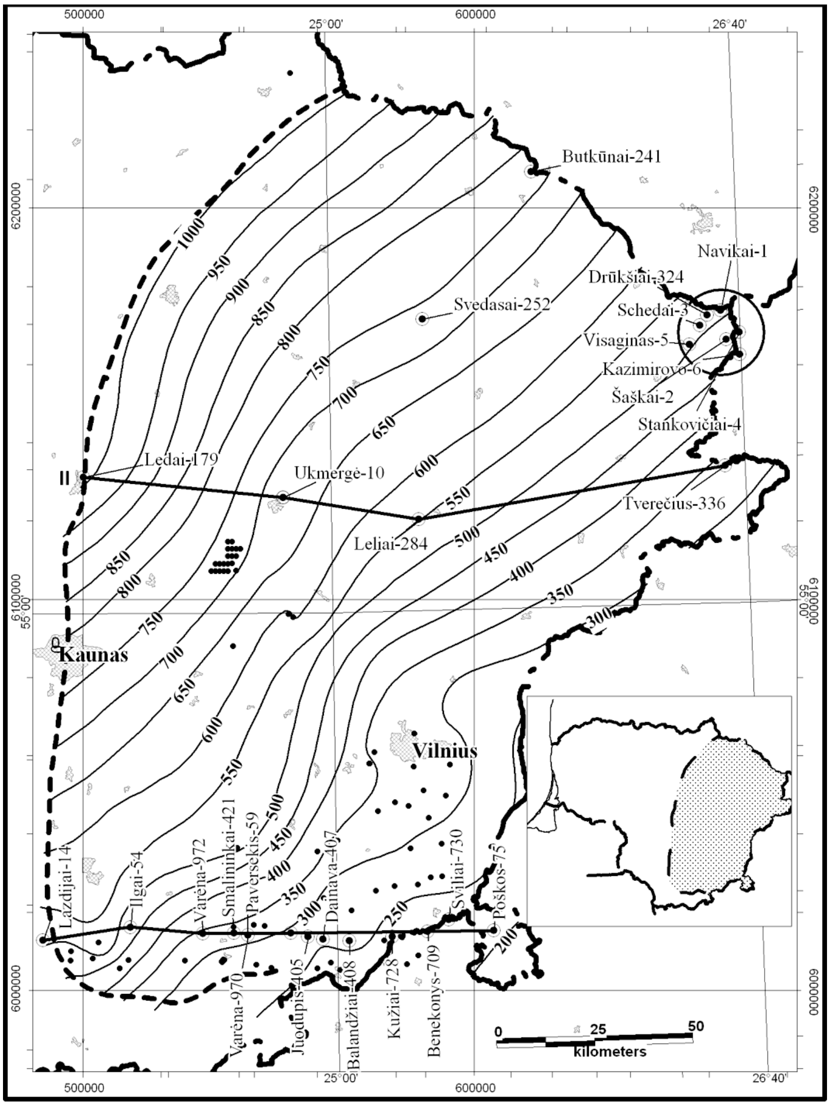

Fig. 1. Map of depths of the top of the Baltija Group. Location of geological profiles and wells are indicated. Thick hatched line shows limits of distribution of Baltija Group

1 pav. Baltijos serijos kraigo struktûrinis þemëlapis. Þemëlapyje pavaizduoti geologiniai pjûviai bei tirti græþiniai. Punktyrine linija pavaizduota Baltijos serijos paplitimo riba

urian shales-carbonates, Devonian terrigens-carbonates. The Mesozoic rocks occur in the southern part of Lithuania. The sedimentary cover is toped by Quaternary succession.

DATA

An inventory of 161 wells drilled through the Cambrian Blue Clays was performed. The GEOLIS database (Geological Survey of Lithuania) was used. This database contains original stratigraphic and litholgical subdivisions provided by different geologists during the past decades of drilling activities. Descriptions of wells had to be unified. The definition of the base of the Baltija Group is sometimes not correct due to lithological similarity of the basal sandstones to the underlying Vilkiðkës Formation of the Upper Vendian (Ðliaupa, 2002) (Fig. 1). The Ignalina NPP area was analysed in detail. Besides the lithological description, the individual layers were correlated using gamma ray, spontaneous potential, resistivity logs. The clay content variations were calculated from gamma-ray logs:

$$CLAY = (GR- GRsand) / (GRclay-GRsand),$$

where CLAY is the fraction of clay, GRsand is the gamma-ray of sandstone, GR is the measured gamma-ray, GRclay is the gamma-ray of clay.

Eighteen clay samples of the Baltija Group were collected from seven wells of east Lithuania for X-ray diffractometry to determine clay minerals following standard procedures such as oriented mounted fraction <2 mm, non-treated, ethylene-glycolated and heated to 350 and 500 °C.

The isopach and depth maps of the Baltija Group were compiled using corrected well database and GIS tools (MapInfo program).

RESULTS

Lithology

The top of the Lower Cambrian Baltija Group succession occurs at a depth of 204–1014 m, growing in depth to the west. The thickness of the Baltija Group reaches 115 m in the easternmost part of Lithuania (Fig. 2).

The well correlation indicates increasing percentage of sandstone bodies westwards, towards the palaeoshore of the sea (Figs. 3, 4). The tracking of the individual clay and sandstone layers suggests a lens-type architecture of the Baltija Group. Nevertheless, some regional-scale clay layers can be identified, which are most prospective of RW disposal (profiles I–I' and II–II', Figs. 3, 4).

The thickness of the Baltija Group in south ranges from 80 m in the east to 4 m in the west. The section is quite heterogeneous, composed of clay and sandstone intercalations (Fig. 3). Thick individual clay layers, which could be a promising medium, are rare

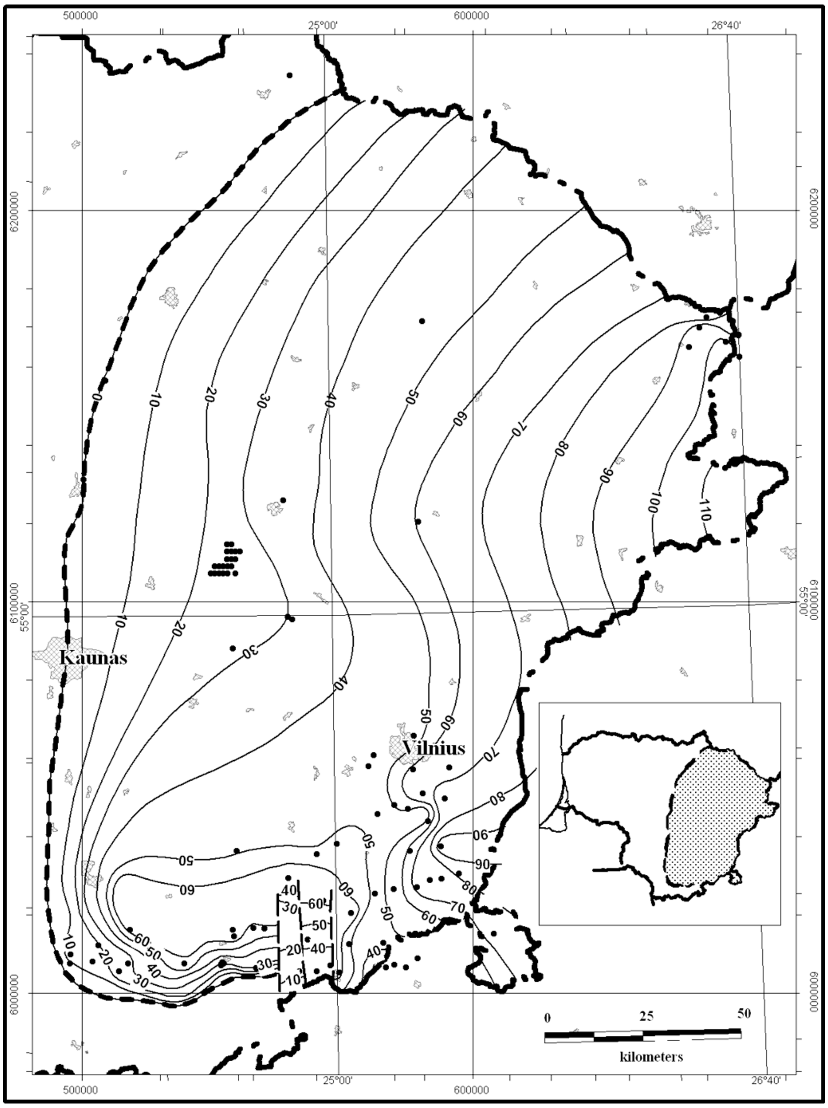

Fig. 2. Map of thickness of the Baltija Group (original scale 1:400 000)
2 pav. Baltijos serijos storiø þemëlapis (originalus mastelis 1:400 000)

and distributed only in the eastern part of the basin (Fig. 3). The thickness of the clay layers is up to 8–10 m, *i.e.* not enough for RW host media. Intercalations of clay and sandstone dominate. The sandstone layers up to 8 m thick are common in the central part of SE Lithuania (the Balninkai-408 well) and are accumulated in the local depression. Sandstone with clay predominate in the lower and middle parts of the section (usually 10–16 m thick, increasing up to 25 m in the Poškos-75 well).

The thickness of the Baltija Group in NE Lithuania ranges from 115 m in the east to 10 m in the west. Compared to SE Lithuania, the section is more clayey. Sandstone with clay intercalations dominates the Rudamina Formation (lower part of the Baltija section). Upwards, clay with sandstone intercalations occur in the western part of the section (Fig. 4). Furthermore, the northern part of the Baltija basin is more clayey than that in the south. This trend is inherited from the Upper Vendian time which was related to shedding terrigenous material from the Belarus High (Grodno) (Ðliaupa, 2002). The thickest homogeneous (15 m) clay layer is confined to the top of the Molëtai Subformation. A 22-m layer of clay with sandstone intercalations occurs below this prospective clay. It gives

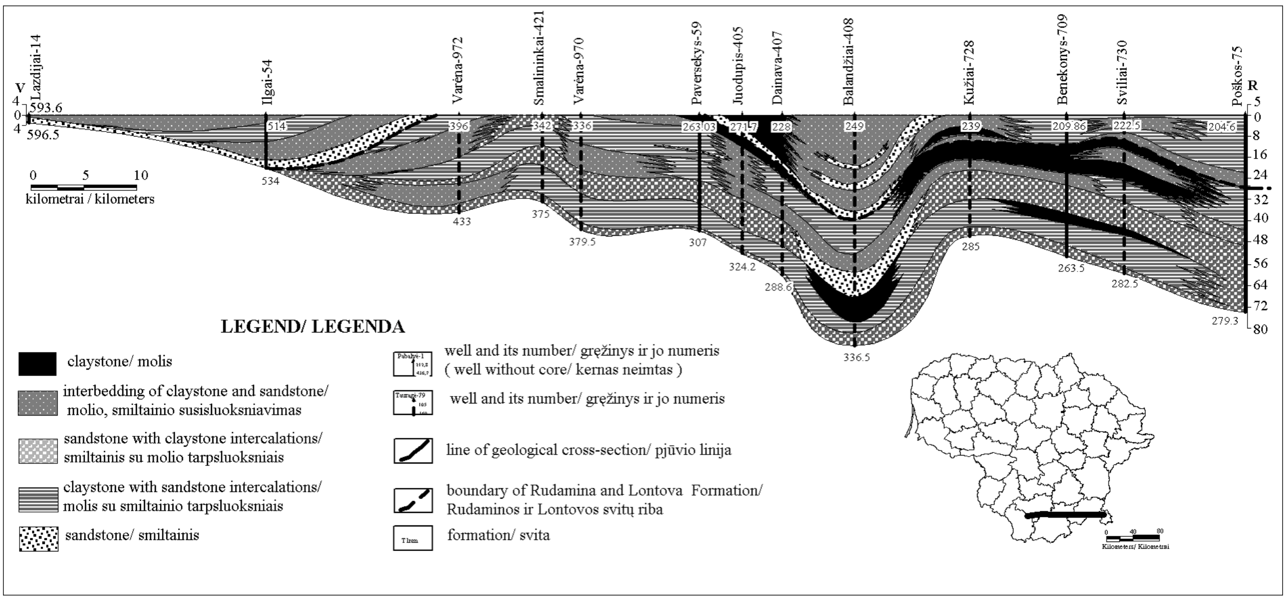

Fig. 3. Geological cross-section I–I' of the Baltija Group
3 pav. Baltijos serijos geologinis pjûvis I–I'

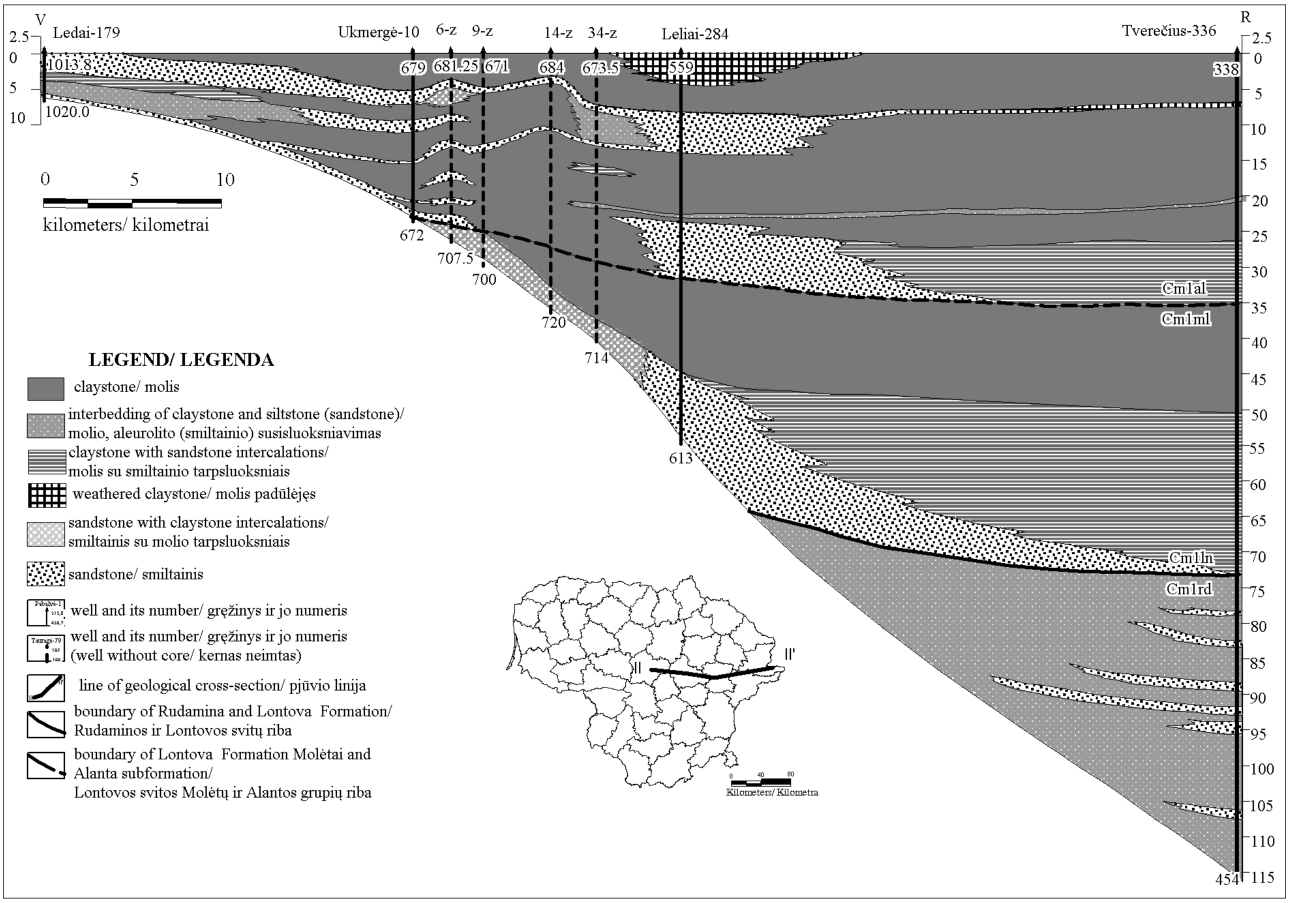

Fig. 4. Geological cross-section II–II’ of the Baltija Group
4 pav. Baltijos serijos geologinis pjûvis II–II’

way to sandstone and sandstone with clay interlayers to the west. Above the prospective clay layer there lies a 8-m clay layer with sandstone intercalations; it grades into sandstone to the west. The basal portion of the Alanta Subformation is composed of 10 m thick sandstones or clays with sandstone interlayers. Upwards it passes into 25 m thick clay package containing thin sandy layers. The Leliai-284 and 34-z wells show increased amounts of sandstones and siltstones.

Based on the lithological correlation of the lowermost Cambrian, the eastern part of the basin is considered as a prospective area, essentially the transgressive part of Molëtai Subformation. Some prospective areas occur also on the western flank of the basin, as indicated by wells 9-z and 14-z. Moreover, the nearby well 6-z indicates that drastic lithofacial changes take place on the local scale, which increase the exploration risk. The lithofacies are more favourable in the north than in the south. The quantitative assessment of clay content in the Baltija Group using gamma-ray logs clearly indicates the domination of clay in the northern section, whereas sandy clay and clayey sand are most abundant lithologies in the south (Fig. 5).

The Ignalina area is considered to be most attractive for disposal of RW owing to proximity to the NPP and favourable lithologies. The deep wells drilled in a small area indicate, however, lithological variations (Figs. 6, 7). The Kazimirovo-6 well is composed of the most clayey succession, the homogeneous clay layers reach 15 m in thickness. Clay layers of similar thickness are mapped in the Visaginas-5 and Šaškiai-2 wells, but here clay is more silty. The Navikai-1 well is rather sandy, correlating with a smaller thickness of the Baltija Group (Fig. 6).

Petrophysical properties and mineral composition

Petrophysical properties of the Baltija clays are scarcely studied, as the main studies have been so far focused on the Cambrian reservoir of west and central Lithuania (e.g. Laškova, 1979; Šliaupa et al., 2001).

The density of the Baltija clays ranges from 2.10 to 2.25 g/cm^3, the porosity changing from 28% to 17%. Following a few available laboratory measurements, the Baltija clays are rather weak (Pusch, 2004). The compressive strength is in the range of 0.7–1.2 MPa, *i.e.* lower than the expected tangential stress at tunnel walls, which may cause serious engineering problems. Furthermore, the swelling pressure of the clay is high (5–8 MPa), therefore the tunnelling would require engineering enforcement, for which strong rock support would be needed. On the other hand, the weakness of the Blue Clays reduces

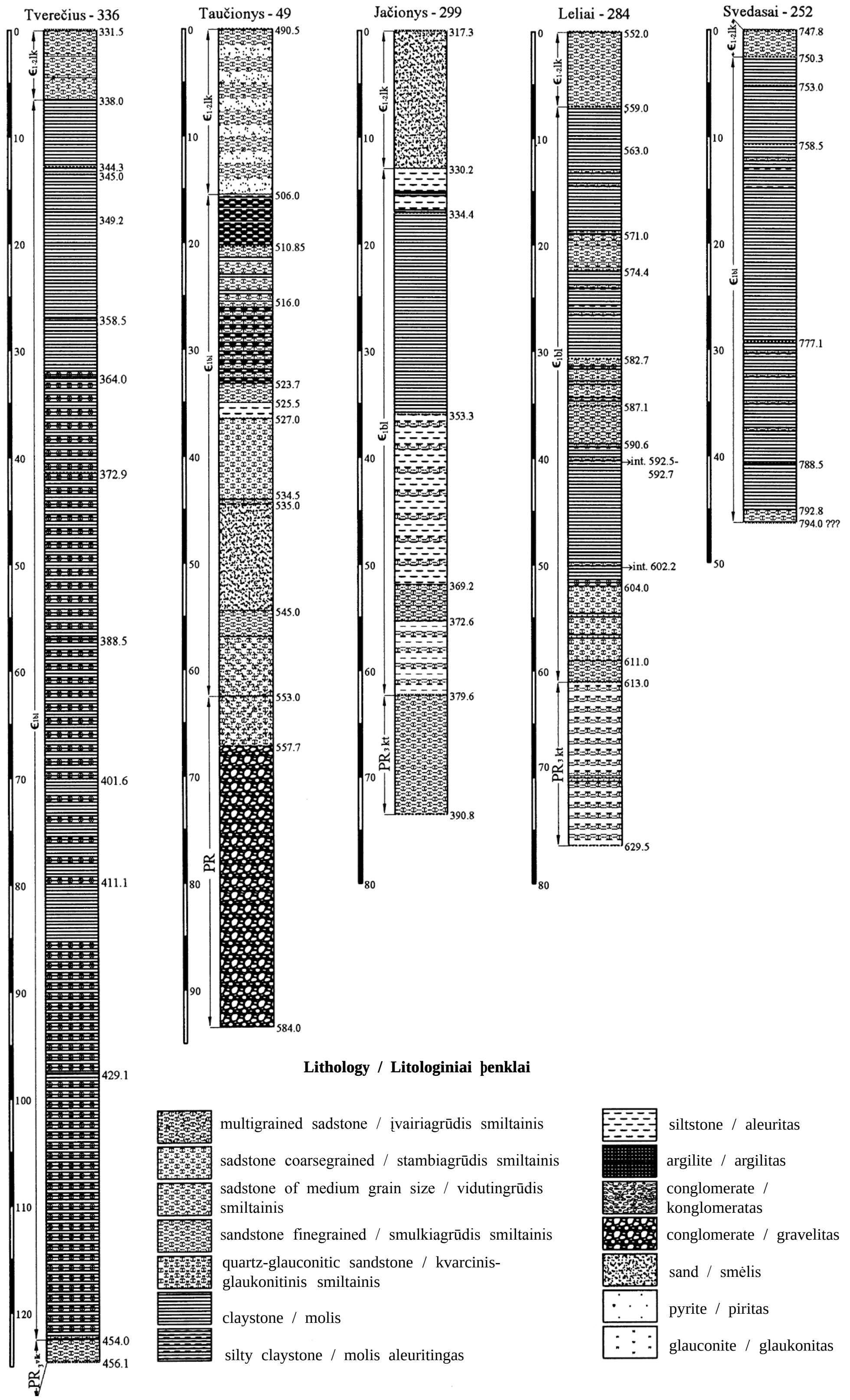

Fig. 5. Lithology of the Baltija Group in representative wells of Southeast Lithuania
5 pav. Tipiniai litologiniai Baltijos serijos pjûviai Pietryèiø Lietuvos græþiniuose

the excavation-disturbed zone (EDZ) problems. It should be taken into consideration that measurements were performed on drill-core samples, which are partially damaged; therefore, the measured values should be considered rather critically.

The mineralogical composition of the Baltija clays was studied in the Vilkiškiai-68, Schedai-3, Leliai-284, Tvereèius-336, Svedasai-252, Visaginas-5 and Kazimirovo-6 wells (Table). Illite is the dominant clay mineral composing about 60% of the clay volume; the rest is represented by kaolinite (30%) with a minor amount of smectite and chlorite (Fig. 8). The kaolinite content decreases from 40–65% to 25–35% up the section (Zinovenko, Abramenko, 2004). The high content of illite is explained by a long-term, though rather shallow, burial as the illite-smectite transformation is dependent not only on the temperature, but also is time-controlled. The high content of kaolinite may be related to the proximity of the denudation area.

Hydrogeology

The Blue Clays represent a regional aquitard which separates the Vendian and Cambrian aquifers (Mokrik, 1997). The Baltija Group is overlain by highly permeable upper Lower Cambrian sandstones a few dozens of meters thick. The porosity of sandstones is in the range of 20–30%, their permeability being more than 1000 mD (Šliaupa et al., 2001). The aquifer plunges to the west. The hydraulic head of the Cambrian aquifer changes from +180 m in the southeast to +20

Fig. 6. Lithology of the Baltija Group of the representative wells of Northeast Lithuania (Ignalina NPP area). See Fig. 5 for legend

6 pav. Tipiniai litologiniai Baltijos serijos pjûviai Ðiaurrytinës Lietuvos græþiniuose (Ignalinos AE apylinkës). Legendà þr. 5 pav.

in central Lithuania, implying a water flow towards the Baltic basin centre (Fig. 9A). The gradient of the hydraulic head is 0.6 m/km and significantly increases along the western limit of the Blue Clays where the hydraulic head changes from +100 m to +20 m within a zone of 40 km wide; the gradient is accordingly 2 m/km. The latter boundary represents the major hydrogeological feature, variations in the hydraulic head are miserable to the west of it (hydraulic head is in the range of +30 to +20 m in the western half of Lithuania) here TDS changes from 0.5 to 120 g/l in the east, being rather stable (120–150 g/l) in the western half of Lithuania (Fig. 9C).

An important parameter for prediction of the vertical fluid flow across the clayey formation is the hydraulic head difference between the overlying and underlying aquifers. The available data (though rather scarce) indicate that the hydraulic head of the Vendian aquifer is higher than that of the Cambrian aquifer (Fig. 9B). The difference increases from 0.5 m close to the western Baltija Group margin to 16 m in the northeast. This trend is related to (i) the increasing thickness of the Blue Clays and (ii) the increasing isolation parameters (more clayey composition in the east). The difference in hydraulic heads implies an upward fluid migration through the clay package.

The Vendian sandstones and conglomerates are of low permeability due to cementation by clay and iron hydroxides (Marfin et al., Varëna Iron Ore exploration report, unpublished). The hydrodynamic tests for underground gas storages indicate that Blue Clays have good isolation properties, the Cambrian and vendian aquifers are not connected, except the western part.

Also, the faulted pathways may pose some risk by increasing the permeability of the damaged clays. Some implications are based on the distribution of the hydrochemical anomalies mapped above the Baltija aquitard (Šliaupa, Monkevièius, 2004). The

Table. **Mineralogical composition of the Baltija clays** (J. Èyþienë et al.)
Lentelë. **Baltijos molio mineraloginë sudëtis**

Well ID	Sample ID	Depth, m	Illite	Chlorite	Kaolinite	Smectite
Kazimirovo-6	N-32	459	+	–	+	–
Kazimirovo-6	N-34	477	+	–	+	–
Kazimirovo-6	N-35	470,2	+	+	–	–
Leliai-284	N-02	592,4	+	+	+	–
Leliai-284	N-14	576,4	+	–	+	–
Leliai-284	N-18	559,9	+	–	+	–
Leliai-284	N-24	568,6	+	–	+	–
Svedasai-252	N-06	784,2	+	+	+	–
Svedasai-252	N-20	760,2	+	+	+	–
Svedasai-252	N-22	752,1	+	+	+	+
Tvereèius-336	N-04	393,1	+	–	+	–
Tvereèius-336	N-13	373,4	+	–	+	–
Tvereèius-336	N-17	437,6	+	+	+	–
Tvereèius-336	N-21	350,1	+	–	–	–
Visaginas-5	N-19	508,5	+	–	–	–
Visaginas-5	N-26	503,5	+	+	+	–
Schedai-3	A-1	527	+	+	+	+
Vilkiškiai-68	A-2	241,8	+	–	+	+

sedimentary cover of east Lithuania is locally damaged (Fig. 9D) along the tectonic zones. The hydrochemical anomalies are grouped along the Neris River and the western margin of the Baltija basin. The latter supports the hypothesis of the tectonic control of the Baltija Group deposition in the west; this is also corroborated by the above-described pore-water chemical composition and hydraulic head changes. The rest few hydrochemical anomalies are related to some separate faults (*e.g.*, the easternmost anomaly is confined to the W–E trending Polotsk tectonic zone).

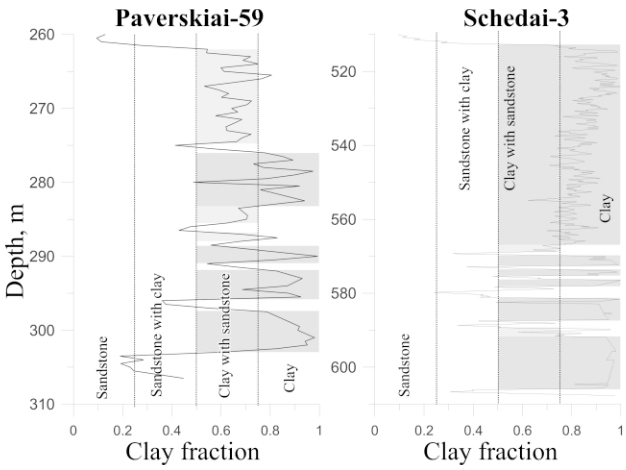

Fig. 7. Clay content calculated in the Baltija Group from gamma-ray logs in wells Paversekys-59 (southeast Lithuania) and Schedai-3 (northeast Lithuania)
7 pav. Molingumas apskaièiuotas pagal gama metodo geofizines kreives Paversekio-59 (Pietryèiø Lietuva) ir Schedø-3 (Ðiaurrytinë Lietuva) græþiniuose

DISCUSSION

Clayey rocks generically have favourable characteristics, such as low permeability, retardation, self-sealing. Natural phenomena show that such properties may ensure a long-term isolation of radioactive waste. There are several aspects of advantages and disadvantages of the Lower Cambrian Blue Clays as a medium for high-level waste repository.

Positive factors

The Blue Clays have a low permeability. A comparison of the well sections of the Blue Clays basin shows some distinct regional trends. The clay content increases to the east towards the centre of the palaeobasin. Furthermore, the northern areas show a more clayey composition than those in the south. The former trend is related to the distance from the palaeoshore, whereas the latter was inherited from the Vendian time and is related to the Belarus uplift shedding terrigenous material from the south. Accordingly, the northern part of the Baltija basin is more prospective for the siting. The Ignalina NPP is located within this first-priority area. Following experience of the other countries, the public acceptance is a key factor to be considered, often forcing to abandon the geologically best sites and to look for the sites showing good enough geological conditions and accepted by local community. The local community of the Ignalina area is used to the nuclear power, whereas the other counties of Lithuania are intuitively suspicious about everything related to nuclear sources.

The damage of the formation by fault fracturing is minor in east Lithuania as suggested by the scarceness of hydrochemical anomalies, mainly concentrating along several large-scale tectonic zones.

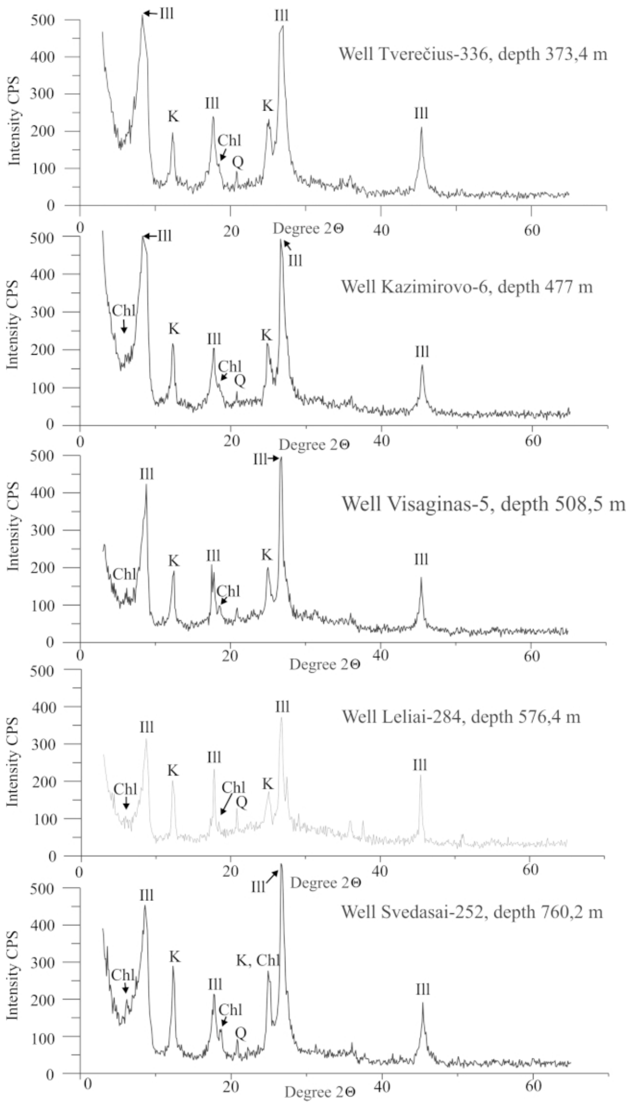

Fig. 8. Baltija Group clay mineral associations containing illite, kaolinite and chlorite from XRD analysis. In addition, there are traces of quartz. Main peaks are labelled: Chl – chlorite, Ill – illite, K – kaolinite, Q – quartz

8 pav. Baltijos serijos molio mineraloginë sudëtis (ilitas, kaolinitas, chloritas, kvarco apraiðkos), nustatyta rentgenostruktûriniu metodu (XRD). Pagrindiniai pikai paþymëti ðiais simboliais: Chl – chloritas, Ill – illitas, K- kaolinitas, Q – kvarcas

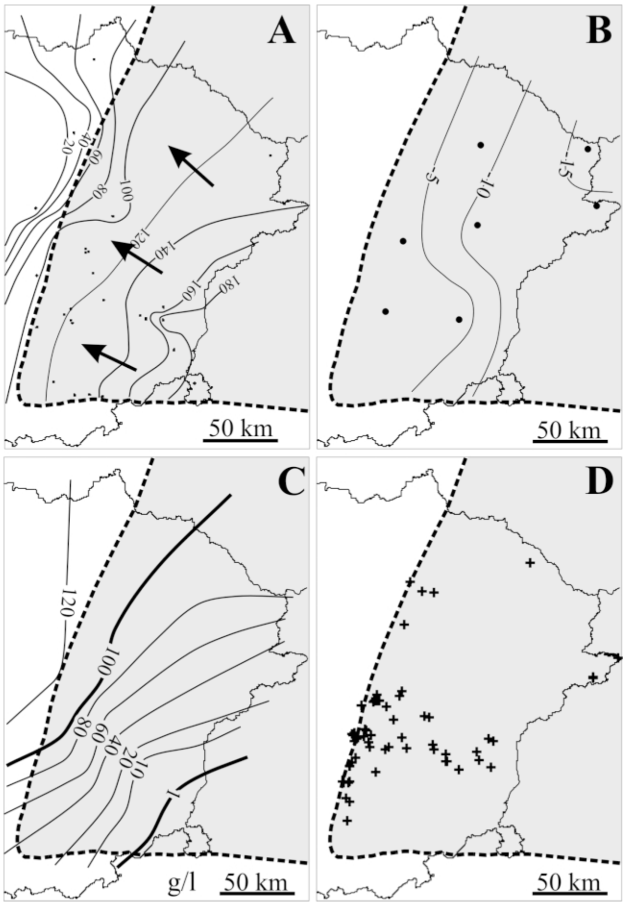

Fig. 9. Hydrogeological maps. *A* – hydraulic head (m) of the Cambrian aquifer overlying the Blue Clay. Arrows indicate water flow direction; *B* – difference of Cambrian and Vendian hydraulic heads (m), negative values indicate a higher hydraulic head of the Vendian aquifer than that of the Cambrian aquifer overlying the Blue Clay; *C* – salinity (g/l) of the Cambrian aquifer overlying the Blue Clay; *D* – hydrochemical anomalies (stars) mapped in shallow aquifers (depth 30–250 m) above the Blue Clay

9 pav. Hidrogeologinis þemëlapis. *A* – kambro vandeningo horizonto, slûgsanèio virð „mëlynøjø" moliø, pjezometrinis lygis (m; rodyklës nurodo vandens srauto kryptá); *B* – kambro ir vendo pjezometrinio lygio (m) skirtumas (neigiamos reikðmës rodo didesná negu kambro vendo vandeningo horizonto pjezometriná lygá); *C* – kambro vandeningo horizonto druskingumas (g/l); *D* – hidrocheminës anomalijos (paþymëtos þvaigþdutëmis) virð „mëlynøjø" moliø negiliame (gylis 30–250 m) vandeningame horizonte

The depth of the Blue Clays is sufficient for RW repository. The thickness of the formation (80–110 m) is rather marginal.

The low strength and high swelling pressure of the clay may be considered as an indirect indication of the high self-sealing potential which reduces the EDZ risk factor. A damaged zone is an evolving zone experiencing geomechanical and geochemical modifications of the state and material properties, which might have a negative effect in terms of operational (stability) and long-term (radionuclide confinement and transport) safety due to the construction, operation, closure of the repository and the post-closure phase.

Negative factors

The Baltija Group is rather heterogeneous in terms of the lithological composition. In general, it can be described as a clay package containing varying proportions of sandstone and siltstone interlayers, which may serve as conduits for fluid migration. A correlation of the well sections indicates that individual thick layers can be traced for a long distance, whereas thin layers are laterally isolated. The available drilling materials are too scarce to construct the reliable hydrodynamic model of this system.

Of all clay groups, bentonite has particularly favourable properties due to its water absorption capacity with simultaneous volume increase (swelling). In addition, it has a high sorption capacity, which leads to a long-term retention of radionuclides. Claystones with a high smectite content have similar properties. The mineralogical composition of the lowermost Cambrian clays is therefore considered as not favourable due to predominance of illite and kaolinite with only minor amounts of smectite.

The lowermost Cambrian clays provisionally have unfavourable mechanical-engineering properties. The weakness of the clays has to be compensated by a strong engineering tunnel support. Only a few measurements have been performed on drill cores so far. They cannot be considered reliable, as the drilling and long storage of the rock inevitably lead to rock damage and weakening.

The hydraulic head difference is 10–15 m, it drives the convective fluid flow upwards across the Blue Clays. They are overlain by a highly permeable Cambrian aquifer. On the other hand, the latter is well isolated by Ordovician and Silurian carbonates and shales.

CONCLUSIONS

In terms of lithology of the Baltija Group, the Ignalina area is considered as the most attractive for RW disposal. Some factors such as the depth and thickness of the clayey formation, low permeability of clays and location close to the Ignalina NPP are considered as advantageous for the high- and intermediate-level radioactive waste repository. Nevertheless, some negative parameters such as the limited thickness of homogeneous clay layers and the weakness of clays are considered. A detailed lithofacies analysis showed changes of the lithological composition of sediments both in the vertical and lateral directions. The Lower Cambrian formation shows a rather unfavourable mineralogical composition of clayey sediments as illite in content prevails over smectite; also, the mechanical-engineering properties of clayey sediments are rather weak.

The problem of geological repository is of primary economic importance, because the developments of new nuclear energy initiatives are possible only in the presence of radioactive waste disposal solutions.

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APATINIO KAMBRO BALTIJOS SERIJOS MOLIO TINKAMUMO RADIOAKTYVIØJØ ATLIEKØ GILUMINIO KAPINYNO ÁRENGIMUI RYTØ LIETUVOJE PRELIMINARUS ÁVERTINIMAS

S a n t r a u k a

Ágyvendinant Lietuvos Radioaktyviøjø atliekø tvarkymo strategijos reikalavimus, 2001–2004 m. buvo pradëta panaudoto branduolinio kuro ir ilgaamþiø radioaktyviøjø atliekø laidojimo galimybiø ávertinimo programa. Programoje pirmiausia numatyta iðanalizuoti bei apibendrinti geologinæ informacijà ir parinkti giluminiam kapinynui geriausiai tinkanèià geologinæ formacijà (formacijas).

Lietuvoje yra kelios perspektyvios geologinës formacijos ir viena ið jø – apatinio kambro Baltijos serijos molis. Strategijoje numatytas formacijos storis turëtø bûti maþiausiai 70 m, o slûgsojimo gylis – ne maþesnis kaip 200 m. Ðiuos reikalavimus atitinka Baltijos serijos molis. Jo storis siekia 115 m rytinëje Lietuvos dalyje, o kraigo gylis kinta nuo 204,6 iki 1013,8 m. Perspektyviø kapinyno konstrukcijai homogeniðkø molio sluoksniø storis siekia iki 15–20 m, vietomis ir daugiau.

Radionuklidø migracija priklauso nuo molio sorbciniø savybiø, kurias nulemia mineralinë sudëtis. Baltijos serijos molyje vyrauja ilitas, sudarantis apie 60% molio, kaolinitas – apie 30%, tuo tarpu smektito yra labai nedaug, ir tai gerokai maþina bendras molio sorbcines savybes.

Geotechninës savybës iki ðiol maþai iðtirtos. Retø tyrimø duomenimis, kambro molis yra silpnas, jo brinklumo slëgis yra aukðtas, ir tai apsunkina poþeminës galerijos inþinerines sàlygas. Preliminarus apatinio kambro Baltijos serijos molio ávertinimas rodo, jog bûtina tolimesnë hidrogeologiniø, mineraloginiø ir ypaè uolienø mechaniniø savybiø analizë.

Éîëàíòà ×èæåíå, Ñàóëþñ Øëÿóïà, Þðãà Ëàçàóñêåíå, Àðòóðàñ Áàëþêÿâè÷þñ, Éîíàñ Ñàòêóíàñ

ÏÐÅÄÂÀÐÈÒÅËÜÍÀß ÎÖÅÍÊÀ ÃËÈÍ ÁÀËÒÈÉÑÊÎÉ ÑÅÐÈÈ ÍÈÆÍÅÃÎ ÊÅÌÁÐÈß ÊÀÊ ÂÎÇÌÎÆÍÀß ÔÎÐÌÀÖÈß ÄËß ÃËÓÁÎÊÎÃÎ ÇÀÕÎÐÎÍÅÍÈß ÐÀÄÈÎÀÊÒÈÂ-ÍÛÕ ÎÒÕÎÄÎÂ Â ÂÎÑÒÎ×ÍÎÉ ËÈÒÂÅ

Ð å ç þ ì å

Ñîãëàñíî ñòðàòåãèè èçoëÿöèè ðàäèîàêòèâíûõ îòõîäîâ â Ëèòâå â 2001–2004 ãã. íà÷àòà ðåàëèçàöèÿ ïðîãðàììû, öåëü êîòîðîé – îöåíèòü âîçìîæíîñòü çàõîðîíåíèÿ èñïîëüçîâàííîãî ÿäåðíîãî òîïëèâà è äîëãîæèâóùèõ ðàäèîàêòèâíûõ îòõîäîâ. Ïðîãðàììîé ïðåäóñìîòðåíû àíàëèç è îáîáùåíèå ãåîëîãè÷åñêîé èíôîðìàöèè, à òàêæå âûáîð ãåîëîãè÷åñêîé ôîðìàöèè (ôîðìàöèé), íàèáîëåå ïðèãîäíîé äëÿ ãëóáèííîãî çàõîðîíåíèÿ ðàäèîàêòèâíûõ îòõîäîâ.

Â Ëèòâå åñòü íåñêîëüêî ïåðñïåêòèâíûõ ãåîëîãè÷åñêèõ ôîðìàöèé, îäíà èç íèõ – ãëèíû Áàëòèéñêîé ñåðèè íèæíåãî êåìáðèÿ. Ñòðàòåãèåé ïðåäóñìîòðåíà ìîùíîñòü ôîðìàöèè íå ìåíåå 70 ì, à ãëóáèíà çàëåãàíèÿ íå ìåíåå 200 ì. Ãëèíû Áàëòèéñêîé ñåðèè ñîîòâåòñòâóþò ýòèì òðåáîâàíèÿì, èõ ìîùíîñòü äîñòèãàåò 115 ì â âîñòî÷íîé ÷àñòè Ëèòâû, a ãëóáèíà êðîâëè – îò 204,6 äî 1013,8 ì. Ìîùíîñòü ïåðñïåêòèâíûõ ñëîåâ ãëèí äëÿ êîíñòðóêöèè çàõîðîíåíèÿ äîñòèãàåò 15–20 ì, ìåñòàìè áîëüøå.

Ìèãðàöèÿ ðàäèîíóêëèäîâ çàâèñèò îò èçîëÿöèîííûõ ñâîéñòâ ãëèí, êîòîðûå â ñâîþ î÷åðåäü çàâèñÿò îò ìèíåðàëüíîãî ñîñòàâà ïîñëåäíèõ. Â ãëèíàõ Áàëòèéñêîé ñåðèè ïðåîáëàäàåò èëèò, ñîñòàâëÿþùèé 60% ãëèíû, êàîëèíèò – îêîëî 30%, à ñìåêòèòà î÷åíü ìàëî, ÷òî ñíèæàåò aáñîðáöèîííûå ñâîéñòâà ãëèí.

Ãåîòåõíè÷åñêèå ñâîéñòâà ïîäðîáíî íå ðàññìàòðèâàëèñü. Äàííûå íåìíîãèõ èññëåäîâàíèé ãëèí êåìáðèÿ ïîêàçûâàþò, ÷òî îíè ñëàáûå, äàâëåíèå ðàçáóõàíèÿ – î÷åíü âûñîêîå, ÷òî îñëîæíÿåò èíæåíåðíûå ñâîéñòâà ïîäçåìíûõ ãàëåðåé. Ïðåäâàðèòåëüíàÿ îöåíêà ãëèí Áàëòèéñêîé ñåðèè íèæíåãî êåìáðèÿ ïîêàçûâàåò, ÷òî íåîáõîäèìî ïðîäîëæàòü èçó÷åíèå ãèäðîãåîëîãè÷åñêèõ, ìèíåðàëî-ãè÷åñêèõ è îñîáåííî ìåõàíè÷åñêèõ ñâîéñòâ ïîðîä.