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SUSTAINABLE MANAGEMENT OF MINERAL RESOURCES, SOIL COVER AND GEOSITES IN ESTONIA

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Abstract. Nature conservation and protection of geological heritage have long traditions in Estonia. Already in 1910 the first nature reserve was established, and in 1935 the first nature protection law approved. In 1995, the Parliament of Estonia adopted the Act of Sustainable Development and in 1996, the Estonian Environmental Strategy was approved by the Government. Although small in area, Estonia is relatively rich in mineral resources (oil shale, phosphorites, peat, building materials, *etc*.), which together with large forested areas (about 50% of the territory) and high productivity agriculture have been and will be the basis for economy, and account for a substantial share in the Gross National Product. During the Soviet occupation, the soil cover of Estonia was subjected to severe degradation. About 1.9% of Estonian territory was used for military objects and these sites are still highly contaminated. Sharp increase in the exploitation of mineral resources has caused ever worsening impact on the environment. In the independent Republic of Estonia, nature conservation and mineral wealth protection gained importance of the first rate and the situation has improved.

Key words: sustainable management, mineral resources, soil cover, military objects, geological heritage, nature conservation, rational land use.

Abstrakt. Konserwacja przyrody i ochrona dziedzictwa geologicznego mają już długą tradycję w Estonii. Pierwszy rezerwat przyrody został ustanowiony w 1910 r. W 1935 r. przyjęto pierwszą ustawę o ochronie przyrody. W 1995 r. parlament Estonii przyjął ustawę o zrównoważonym rozwoju, a w 1996 r. rząd zatwierdził Estońską Strategię Środowiskową. Chociaż niewielka, Estonia jest stosunkowo bogata w zasoby mineralne (łupki bitumiczne, fosforyty, torf, materiały budowlane itd.). Surowce te, wraz dużymi obszarami leśnymi (około 50% terytorium kraju) oraz wysoko produktywnym rolnictwem, będą podstawą gospodarki i wniosą duży wkład do dochodu narodowego. Podczas okupacji sowieckiej gleby Estonii poddane były poważnej degradacji. Około 1,9% terytorium Estonii wykorzystywane było na obiekty militarne. Tereny te są nadal silnie zanieczyszczone. Silny wzrost wydobycia surowców mineralnych także spowodował niekorzystny wpływ na środowisko. W niepodległej Republice Estonii konserwacja przyrody i ochrona bogactw mineralnych uzyskały pierwszorzędne znaczenie i ich sytuacja uległa poprawie.

Słowa kluczowe: zrównoważone zarządzanie, zasoby mineralne, gleby, obiekty mineralne, dziedzictwo geologiczne, konserwacja przyrody, racjonalne wykorzystanie ziemi.

INTRODUCTION

Estonia is rather rich in mineral resources, some of which were utilised long before written records appeared. Human activities have spoilt natural landscapes on about 8% of the Estonia territory. As a result of oil shale mining alone, the area of quarries covered with waste rocks and with ash from thermal power stations increased every year by several hundred hectares.

In the last century Estonian agriculture passed several revolutionary stages. The number of farms in Estonia was highest at the beginning of the 19th century, when only 14% of inhabitants

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lived in towns; thereafter it started to be reduced. Nevertheless, Estonia continued for a long time to be a typical agricultural country (Kahk ed., 1992). Since the 1950s, the urban population has been rapidly increasing, reaching in 1987 its highest value – 71.5%. In 2000, it was a little bit less – 67.4% that indicates not only the reorientation of Estonian economy but also differences in assessment of urban population.

MAIN MINERAL RESOURCES AND HISTORY OF MINING

Several mineral resources of Estonia have been used for millennia. Erratic boulders were taken into use during the Mesolithic period, when prehistoric man learnt to make tools and weapons from them. At around 6000 BP, it was discovered that good earthenware could be made of clay. About 5000-4000 BP carbonate rocks were applied to the building of townlets and fortified settlements. The birth of local metallurgy – smelting of iron from bog ore – goes back to at least the beginning of our era. Since 1230, lime has been widely used as binder, and bricks made of local clays have served as building material for strongholds and churches. The manufacture of glass from surface sands was introduced in the 17th century. By the end of the 18th century, travertine and lake chalk had found an application as fertilisers, and peat as a fuel. The first evidence of the use of curative muds dates to this period, too.

The kukersite oil shale is the most important mineral resource in Estonia. The mining of kukersite oil shale began in 1916. At present, of the total 10–12 million tonnes mined per year, slightly over 80% is burnt directly in thermal power plants as pulverised fossil fuel. The chemical industry uses about 15% of the mined oil shale for oil recovery, and about 3% goes to the cement industry. The Estonian deposit is the largest commercially exploited oil shale deposit in the world; its total reserves exceed 7 billion tonnes of oil shale. Reserves of the prospective Tapa deposit are in order of 2.6 billion tonnes (Bauert, Kattai, 1997). In the 1980s, the maximum annual output exceeded 30 million tonnes which is sixteen times higher than in 1940.

In 1920, the first phosphorite mine was opened at Ülgase and in 1939–1991 an open pit operated at Maardu. It was closed down for economical and ecological reasons. Commercial phosphorite reserves have been studied at Maardu, Raasiku, Kehra, Tsitre, Toolse, Aseri and Rakvere deposits (Fig. 1). The thickest phosphorite layers (average 5 m) are located in the vicinity of Rägavere and Assamalla, Lääne-Viru county. According to present forecasts, the Rakvere field may hold the largest phosphorite reserves in Europe. Resources of the deposit are estimated at about 750 million tonnes of phosphate ore, i.e. *c*. 1–2% of the total supply in the world (Raudsep, 1997).

In the 1940s, production of uranium concentrated on local dictyonema-argillite (alum shale) was undertaken at Sillamäe (Fig. 1). The reserves of alum shale have not yet been precisely evaluated but they are expected to amount up to 60 billion tonnes. The rock contains about 20 valuable elements, including vanadium, molybdenum, strontium, uranium, thorium, *etc*. The average content of uranium in the Toolse phosphorite deposit was 192 g/t (up to 850 g/t), thorium 13 g/t (up to 500 g/t) and yttrium 45 g/t. In 1948 in Sillamäe, a top secret facility was built, originally for processing alum shale from Estonia, and afterwards uranium ore from eastern Europe. At the beginning of 1970s, the plant switched to processing of loparite, rich in niobium, tantalum and other rare earth metals. In total, during 1948–1977, more than 4 million tonnes of uranium ore and about 140,000 tonnes of loparite were processed at the plant.

The waste from uranium processing was conveyed to the first marine terrace of the Päite Cape near the plant. The pile has been reshaped a couple of times, and in 1969–1970 it was expanded to its present size with an overall area of some 350,000 m^2 and a height of about 25 m above sea level. It contains *c*. 12.4 million tonnes of various waste, including 6.3 million tonnes of waste from processed uranium ore and 6.1 million tonnes of oil shale ash mixed with waste from loparite processing. The depository includes some 1,830 tonnes of uranium, 850 tonnes of thorium and 7.8 kg of radium, and exhales radon emissions into the atmosphere (Putnik *et al*., 1996). The waste is stored under the open sky at the waterfront of the Gulf of Finland and was for a long time one of the most dangerous objects in Europe due to the erosion of the shoreline and possible sliding to the sea. In 1999, with the help of international organisations, the work aimed at strengthening the protecting embankment and covering the waste with engineered cover of linear system was started; it will be completed in 2006.

In Estonia, there are more than 900 sand and gravel deposits for road and industrial building, and unlimited Cambrian, Devonian and Quaternary clay deposits, used mainly as a raw material in the ceramics and cement industries. The unlimited resources of limestone are used as a raw material in producing lime, cement and building stone, but also in glass, chemical, pulp and paper industries. Dolomite is suitable for glass and facing stones, used in the chemical industry and as road and industrial building material. There are also large resources of curative mud, mineral water and different minerals of local importance, as lake chalk, ochre, glauconite, etc.

Estonia has big peat resources (Fig. 1) and nowadays peat is an important export article. Peatlands occupy 10,091 km^2 or 22.3% of the Estonia territory. Within Estonia as a whole there are 165,000 mires and peatlands with an area over 1 hectare, of which 1626 are of commercial importance. At present, total peat reserves are estimated at 2.37 billion tonnes or 15.24 billion cubic metres. Economically exploitable resources constitute 1.52 billion tonnes because 0.85 billion tonnes occur under fields and meadows. 69 mires (156,562 ha by area) or 16% of mires are under conservation (Orru, 1997). The greatest thickness of peat (16.7 m) was measured in the Võllamäe bog in south-eastern Estonia. As the natural accumulation of peat in mires is slow and natural sites for its accumulation are dwindling rapidly, the Government of the Estonian Republic has adopted the regulations of sustainable use of peat which enacts annual output quotas for every county.

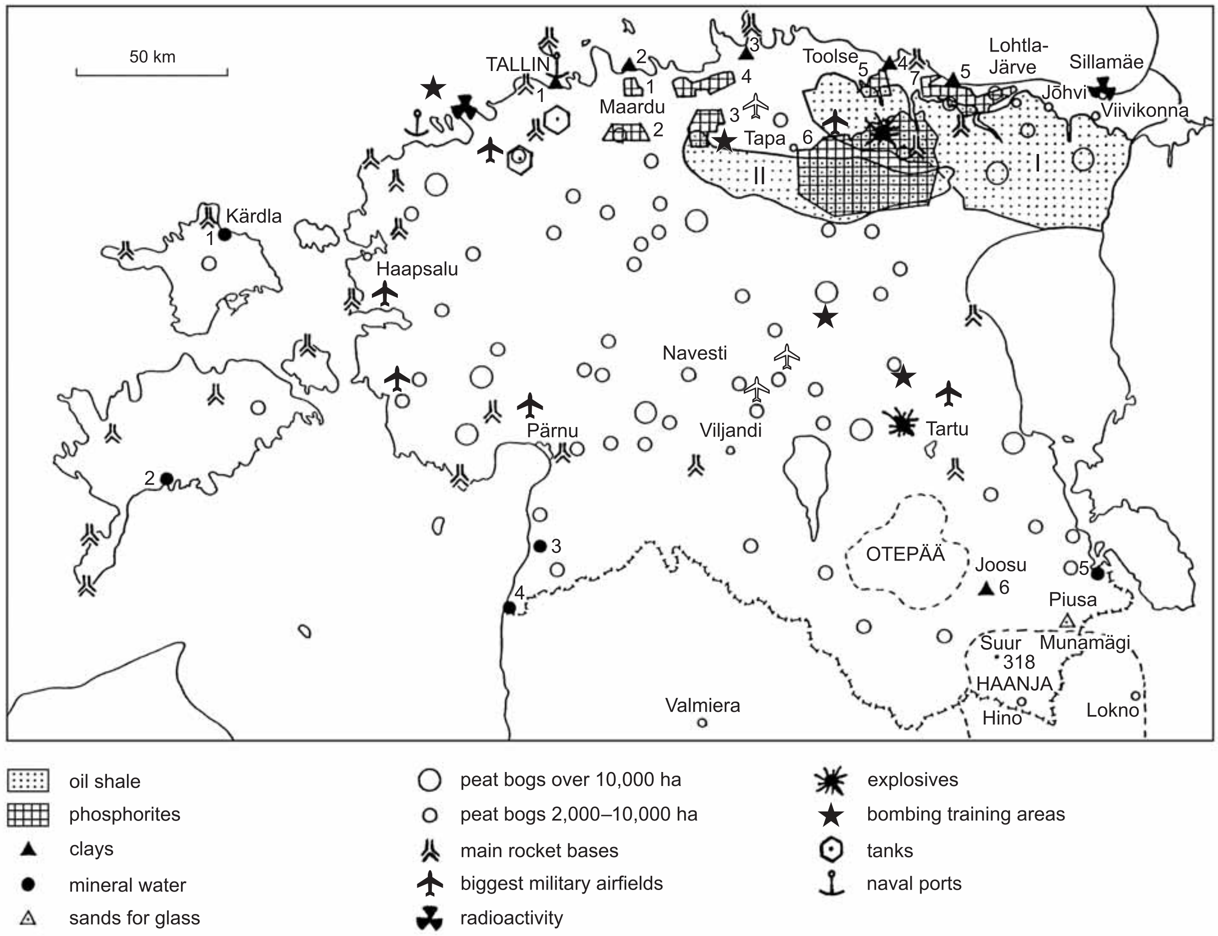

Fig. 1. Main mineral deposits and former military areas of Russia within Estonian territory

Oil Shale: I — Estonian Deposit, II — Tapa Deposit; **phosphorites**: 1 — Maardu, 2 — Raasiku, 3 — Kehra, 4 — Tsitre, 5 — Toolse, 6 — Rakvere, 7 — Aseri; **clays**: 1 — Kopli, 2 — Kallavere; 3 — Kolgaküla, 4 — Kunda, 5 — Aseri, 6 — Joosu; **mineral waters**: 1 — Kärdla, 2 — Kuressaare, 3 — Häädemeeste, 4 — Ikla, 5 — Värska; **sands for glass**: Piusa

IMPACT OF MINING ACTIVITIES

The vigorous intensification of agriculture and industry during the Soviet occupation was accompanied by a sharp increase in the exploitation of mineral resources and by still worsening impact on the environment (Raukas, 1994). In Soviet time, the population of Estonia increased some 1.4 times, the number of workers and employers 3.8 times, industrial output 4.2 times, the production of mineral resources 15 times, and the generation of electric power 100 times. Human activities have spoilt the natural landscapes on about 8% of the territory of Estonia. At the end of the 1980s, annual exploitation in the mining industry alone exceeded 70 million tonnes of solid mineral resources, which made up more than 50 tonnes per capita. Moreover, it should be noted that these figures did not include the sand used as ballast material and the overburden removed from open pits.

As a result of oil shale mining alone, the area of the quarries covered with waste rocks and ash fields from thermal power stations increased every year by several hundred hectares. Serious environmental problems were caused by some 300,000 tonnes of dust emitted into the atmosphere annually, approximately 200,000 tonnes of which originated from the chimneys of the power plants processing the oil shale and containing mostly oxides of alkali and alkaline-earth metals. Besides, fly ash contains heavy metals, including toxic ones, in relatively high concentrations. For instance, some 50 tonnes of lead, 30 tonnes of mercury, 30 tonnes of zinc and 20 tonnes of copper were emitted annually.

Old lime- and dolostone quarries contain often stratotype sections (Fig. 2), and are, therefore, taken under nature protec-

Fig. 2. Stratotype section of Ordovician Caradocian Pääsküla beds near Tallinn is often visited by geologists (*Photo by A. R*õõ*musoks*)

tion. Many other mining objects (semicoke hills, open-cast mines, entries and adits) are protected as industrial heritage. In an old mine at Kohtla, near the town of Kohtla-Järve (Fig. 1), an underground mining museum was opened. Visitors are introduced there to underground mining passages and miner's profession. It is possible to drive by an underground train and watch mining devices at work. Old caves of glass-sand mine at Piusa (Fig. 1) are one of the most popular objects of interest for tourists.

MANAGEMENT OF THE MINERAL RESOURCES

The Land Act (Article 26) adopted on October 10, 1919, vested all mineral resources occurring in the Earth's crust in the Republic of Estonia with the State. On March 17, 1927, the Mining Law of Estonia was adopted by the Estonian Parliament. It was amended and changed twice: in 1932 by the Parliament and in 1937 with the decree of the President of the Republic. The right to explore for mineral resources was acquired by an application to the Ministry of Economics. The law prohibited explorations at public sites, in the cemeteries and on the roads open for public transport. In orchards, yards, below the buildings, and in the distance of 60 metres around the dwellings, the research was allowed only with the consent of the owner or possessor of the real property. The exploration permit indicated the mineral to be studied, the location and dimensions of the area necessary for the exploration, the terms of the exploration, and other obligations and rights of the permit holder. The size of the claim was limited to 2,000 hectares and the agreement fixed the lower limit of the yearly extraction (Paalme, 1996).

The principles which regulated the exploitation of the Earth's crust in Estonia during the first years under Soviet occupation were based on the Act of 1927. In 1977, the Earth Crust Code of the Estonian SSR was adopted, which as a matter of fact was the translation of the Bases of the Earth's Crust Legislation in the Soviet Union and the Union Republics. While in the Soviet Union, the ownership of all mineral resources was vested in the State and practically all mining was conducted by Soviet Government organisations (to a negligible extent also by some co-operative enterprises), the law enacted only the jurisdiction and activities of enterprises and institutions. The management of mining industry was completely subordinated to Moscow`s control.

However, in regulating the use of the Earth's crust, Estonia gained independence well before the restoration of the independent Republic of Estonia. On December 25, 1989, the Supreme Council of the Estonian SSR adopted the law which fixed the order of the usage of the environment and mineral resources. It also enacted that the permit of mineral reserves extraction would be granted according to the orders fixed by the Government of the Estonian SSR (26.09.1990; 17.01.1991).

On November 9, 1994, the Parliament of the Estonian Republic adopted the Earth's Crust Act and on September 19, 1995, the Law on Amending and Supplementing the Earth's Crust Act was passed by the Parliament. Besides the regulation of geological explorations, extraction of minerals, and mining operations, which is normally the subject of mining laws, the Estonian Earth's Crust Act regulates also the right to mine earth material, the exploration and usage of the Earth's crust in setting up the constructions not connected with the mining of minerals and earth material and geological investigations. The exploration of the minerals is allowed on the basis of the exploration permit. The only privileged person in receiving the exploration permit is the owner of the real property on the exploitation territory. The extraction tax for the right to exploit the state minerals is fixed by the Government of the Republic. Most of the tax is paid into the local budget, and a small part into the Environmental Fund.

On February 22, 1995, the Parliament of the Republic passed the Act of Sustainable Development which established the principles of the national strategy of sustainable development to guarantee that the environment meets human needs but also provides the resources necessary for economical development without causing significant damage to the environment and without depleting biological diversity. There were clear obligations to use renewable and non-renewable natural resources. The stock of renewable natural resources was divided into critical and usable reserves. The critical reserve of renewable natural resources was the smallest quantity which guarantees the natural balance and renewal, implementation of protection regimes as well as the maintenance of the biological and landscape diversity.

The excess of a natural resource over the critical reserve of renewable natural resources as determined by the Government of the Republic of Estonia would be the usable reseserve of a renewable natural resource. In planning economical activity, this usable reserve could not be exceeded. The extent of the usable reserve and the allowable annual rate of use should be determined by the Government taking into account natural growth. In planning the use of non-renewable resources, the following main conditions should be taken into account: the adequacy of exploited reserves in the longest possible term, the possibility of switching to products made of renewable natural resources or to inexhaustible energy sources and the possibility of substituting non-renewable resources with waste or other secondary raw materials. Annual allowable rates of use of non-renewable natural resources should be determined by the Government and the procedure for their use was established by law. In exploitation of a usable natural resource, associated natural resources would be either utilised or preserved suitable for using in a quality as close to the unused state as possible.

PROTECTION OF GEOLOGICAL HERITAGE

When in 1935 the first nature protection law was passed, a number of areas and nature monuments were declared under protection (Fig. 3). In 1994, the Parliament of Estonia adopted the Act of Protected Natural Objects, which enacted the procedure of taking such objects under protection and determines the rights and obligations of landowners. The Ministry of Environment has distributed computer databases with the corresponding interface and together with the county environmental departments is compiling the register on protected nature objects. The main types of protected objects are:

1. Natural parks comprising interesting geological structures.
2. Different types of reserves for protecting picturesque landscapes, valleys, hills, cliffs, meteorite craters, etc.
3. Single geological objects, which include isolated features of landscape, as river banks, erratic boulders, stratotype sections, outcrops with protected fossils, etc. Researchers of the Institute of Geology at Tallinn Technical University are working on the monograph “Estonian Ancient Natural Monuments” which includes the most significant geological and landscape features in Estonia. Ten booklets of Natural Heritage of Estonia have already been published.

Fig. 3. Kaali meteorite craters were taken under nature protection already in 1938 (*Photo by A. Raukas*)

Estonian geoscientists are actively participating in ProGEO (The European Association for the Conservation of the Geological Heritage) projects. In 1997, the Second Assembly and Scientific Conference of ProGEO was organised in Estonia. The preliminary list of Estonian geosites for including into list of European geosites was compiled in 2002.

DEGRADATION OF THE SOIL COVER

During the Soviet occupation, there was a great degradation of the soil cover in Estonia (Kokk, 1995; Reintam, 1996). Large-scale collectivisation in 1949 changed the agrarian structure; land use was entirely aimed at growing monocultures. About 542,900 hectares of land were endangered by wind erosion, especially on marine sandy terraces. Erosion-endangered areas with an inclination of terrain greater than 3 degrees made up 105,800 hectares or 10.1% of arable land. Eroded soils on the terrain with an inclination greater than 10 degrees (Fig. 4), accompanied by the corresponding deluvial formations, cover an area larger than 4000 hectares. In the hilly topography of Võru, Valga and Põlva counties (SE Estonia), erosion endangered areas account for 36, 29 and 28% respectively (Reintam *et al.*, 2001).

Fig. 5. A former Russian missile base at Keila-Joa attracts a great number of tourists visiting Tallinn (*Photo by A. Raukas*)

Fig. 4. Soil erosion in the hilly topography of South-East Estonia (*Photo by A. Raukas*)

After the liquidation of state large-scale agriculture in the Estonia, the area of deflation risk fields has essentially decreased. At the same time, the last decades have witnessed a rapid growth of towns and town-like rural settlements at the expense of fields, and large areas with fertile soils are under buildings or covered with asphalt. As a result, ecosystems have been destroyed on more than 200,000 ha of productive arable soils. Recently, a map of soil vulnerability and degradation has been compiled showing soil pollution with heavy metals, soil acidification and alkalisation, fertility decline and reduced organic matter content, soil compaction, and urban and industrial land conversion (Reintam *et al*., 2001). A serious problem is also turning soils into marshes with the wide distribution of weeds. More than 50% of the drainage systems are 20–25 years old and require urgent reconstruction. However, it seems that there will be no need for highly productive fields any more after Estonia has joined New Europe.

There were 1,565 military objects of the former Soviet Union in Estonia covering 1.9% of the Republic's territory (Fig. 1). Thousands of hectares of land were under military airfields and missile bases (Fig. 5). Almost all the sites once in the possession of the military units of the former Soviet Union and Russia are heavily contaminated by oil products, chemicals, demolished buildings and domestic wastes (Raukas ed., 1999). Now the situation in the former military areas has improved but the migration of pollutants from such sites is still actual. According to the Estonian National Environmental Strategy, by the year 2005 we should stop migration of pollutants from former military sites, from currently operating industrial waste depositories and municipal landfills into the soil and into surface and groundwater and by the year 2010 we should ensure isolation of all past pollution sites which are of enhanced environmental risk.

CONCLUSIONS

Main outlines of the protection of mineral resources, soil cover and geosites in the Republic of Estonian are presented in the Estonian National Environmental Strategy (1997) and National Environmental Action Plan (1998). The Act on Sustainable Development was adopted by the Estonian Parliament (Ratas, Raukas, 1997), and Estonia has signed the association agreement of EU and EC member countries which contained articles on agricultural management and environmental protection. In order to balance economical activities in sectors with the greatest impact on human and natural environment, national programmes are drawn for the period of 10–20 years. Spatial plans and development plans of the national, county, commune and towns level, national programmes of important sectors, as well as development plans of the most threatened regions, give hope for better management of mineral resources and soil cover in coming future.

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