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HISTORICAL REVIEW

OIL SHALE IN ESTONIA IN THE 19TH CENTURY – FROM REDISCOVERY TO USAGE

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Abstract. *The purpose of this paper is to provide a historical overview of what was known about oil shale in Estonia in the 19th century and reveal some background political and economic processes in this country, Russia and the world as a whole that framed oil shale studies in those days. We specify how oil shale was rediscovered in Kohala estate by Gregor von Helmersen in 1838. We also bring to light how oil shale was independently detected by Paul Georg Alexander Petzholdt in 1850. Finally, we describe the peculiar chain of events that led to oil shale studies and usage on Kukruse estate in the 1870s.*

Keywords: *oil shale history, Helmersen, Petzholdt, Schmidt, Kohala, Kukruse.*

1. Introduction

Although oil shale is Estonia's most important mineral resource, the history of its discovery and research in the country has been somewhat poorly studied. Instead, a certain traditional narrative has developed in handling the history. However, as it was revealed in our previous study [1], that story contains several mistakes and misinterpretations.

In the previous paper [1], we analysed issues of oil shale studies in the 18th century. Oil shale was accidently discovered in the 1780s in Kohala estate and was scientifically analysed and described in 1789 by Johann Gottlieb Georgi, a chemist of the Free Economic Society of Saint Petersburg. On the other hand, Tammiksaar [2, 3] analysed in detail plans made in Estonia at the beginning of the 20th century to exploit oil shale. The aim of the present study is to fill the gap in information left by articles [1] and [2, 3]. Namely, we look into what was actually known about oil shale in Estonia in the 19th century, how this rock was rediscovered on several

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separate occasions and how it was used as a natural resource for the first time.

In the current paper, we also follow and analyse the traditional narrative which is widespread in Estonian popular science literature and which we discussed in our earlier study [1]. In general, the 19th century's events have been quite truthfully echoed in the narrative, i.e. there are no fundamental differences in facts between the story and, for example, archival materials. However, as this narrative is mostly unknown to the international public, we shed light on some facts and uncover the background of certain political and economic processes having taken place in Estonia, Russia and also other countries which shaped oil shale studies at that time.

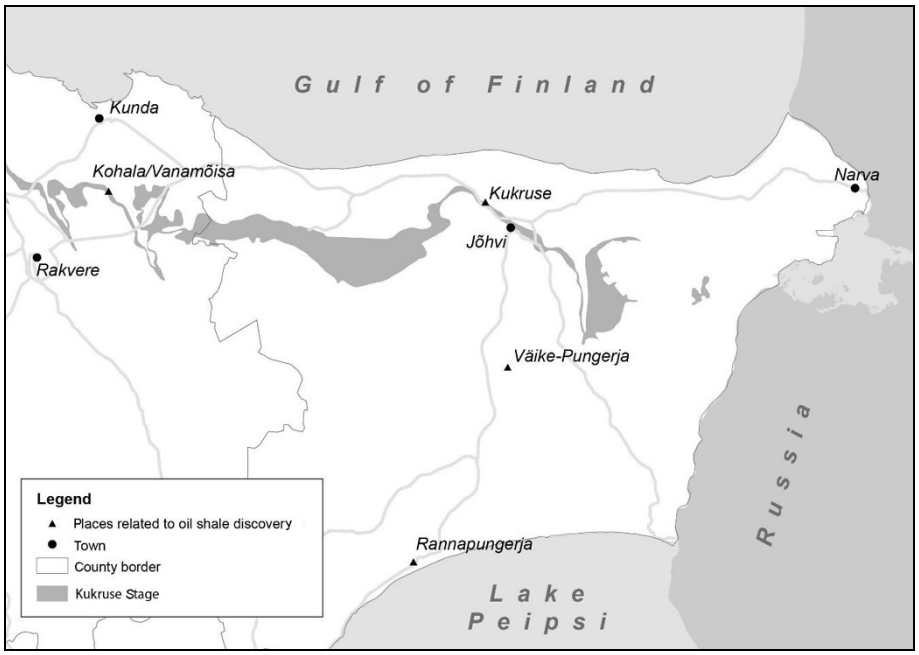

Figure. Places related to oil shale discovery in Estonia and the outcrop area of the Kukruse Stage.

2. Gregor von Helmersen

In the context of articles on the history of oil shale chemistry and quarrying in Estonia [4–10], the scientific research of oil shale began with the studies by the geologist Gregor von Helmersen (1803–1885) in 1838. Unlike the 18th century's oil shale researchers who were usually encyclopaedists [1], Helmersen, member of the St. Petersburg Academy of Sciences, was a scientist who clearly specialised in geology. Thereat, his scope as a geologist was still tremendous. Hydrogeology, coastline processes, the geology of

Lake Peipsi and the Narva River, landforms and sediments formed by the last ice age – this is only a short list of Helmersen's subjects of interest in Estonia. The gold and coal deposits he discovered in Russia made him an influential and well-known scientist-practitioner [11].

Thus, almost half a century after oil shale was discovered in Kohala estate (German: Tolks) [1], the "burning stone" was found again in the same area in June 1838[1] [Fig.]. However, half a year earlier a similar inflammable mineral was unearthed in the estate of Keila-Joa (German: Fall)[2]. That information and the "burning stone" (German: *brennbarer Stein*) samples from both places reached the Corps of Mining Engineers in Saint Petersburg. The Corps where Helmersen served was subordinate to the Russian Ministry of Finance. Several tests were conducted on the discovered rock in Saint Petersburg under the guidance of Hermann Heinrich Hess (1802–1850), member of the Academy of Sciences in applied chemistry, and it was found that "/.../ the best application for the mineral would be as a burning material in some enterprises that require great heat" [12]. The matter deserved further investigation and Helmersen, who had already proved himself as a talented geologist, was sent to Estonia in the middle of June 1838. Helmersen presented his preliminary related report to the Corps of Mining Engineers on 18 July 1838[3]. Later he also drew up two detailed reports on the geology of the Estonian northern coastline: the first, written in Russian, on 1 August 1838[4], and the second was published in German on 19 January 1839[5]. The latter report contained a map of the study area and also assessment of the profitability of the "burning stone" as a fuel. Based on the mentioned reports, Helmersen published several articles [12–15] in German, Russian and French in 1838–39.

G. von Helmersen started his field studies of the 1838 summer in Keila-Joa and classified the "burning stone" discovered there as graptolitic argillite which had no industrial value [12]. Next, Helmersen went to Kohala to meet the landlord, Reinhold Johann von Wrangell (1789–1865), who told him that brown oil shale (German: *der braune Brandschiefer*) was found at the foot of a terrace near Vanamõisa village (located between the modern Aresi, Kohala and Jäätma villages) by accident. Then he specified that "/.../ the discovery was made [in the autumn of 1837 while digging a well] second time /.../, since it [the mineral] was already known, but no attention was

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1 Note over the discovery of oil shale in the estate of Kohala, 1 June 1838. On the command of major von Helmersen to the Gouvernement Estland for geognostical investigations of the oil shale, Russian State Historical Archive (RSHA), 44-2-593, s 10.

2 Benckendorff, Alexander Graf to Konstantin V. Chevkin, estate Fall 26. April 1838. RSHA, 44-2-593, s. 2–2v.

3 Helmersen, G. von. Preliminary report on my geognostical trip to the estates Fall and Tolks, 18. July 1838. RSHA 44-2-593, s. 24–24v.

4 Helmersen, G. von. Detailed report on my geognostical trip to the estates Fall and Tolks, St. Petersburg, 1. August 1838. RSHA, 44-2-593, s. 28–31 (in Russian).

5 Helmersen, G. von. Second detailed report on my geognostical trip to the estates Fall and Tolks, St. Petersburg, 19. January 1839. RSHA, 44-2-593, s. 38–52 (in German).

further paid to it" [12]. In the Russian version of the article [13] it is said that oil shale was already known [to peasants], but this bit of knowledge was not imparted [to the landowner]. The burning properties of the stone were discovered thanks to some village boys who were around at the time of the well digging. They made a fire ring and accidentally used pieces of oil shale for that.

It should be noted that the ownership of Kohala estate had changed twice[6] since Georgi's studies in 1789 [1] and that is why information about oil shale was new to the landlord, Reinhold Johann von Wrangell. Still, the rediscovery seems to be somewhat odd. The fact is that the estate ownership changed inside the family, and as most Baltic-German landlord families were closely related to each other, it is natural to suppose that this information should have been known to the Wrangell family.

Helmersen established that two kinds of oil shale could be found near Vanamõisa village: one burnt better than the other [12]. On the basis of that information, Helmersen suggested that oil shale with better burning properties could be used in enterprises, while the other could be used for extracting oil. On his initiative and with the help of the neighbouring landlords, 10 prospect holes, i.e. trenches, were established on the lands of Kohala estate [13], in order to map the oil shale distribution area. However, no oil shale was found in Kohala then. At the same time, the rock was found in the neighbouring estates of Andja and Uhtna.

As mentioned, Helmersen also analysed potential profits from oil shale. But he found that it would be too expensive to export oil shale to Saint Petersburg compared to English coal, "/.../ but the locals could profit considerably from using the mineral" [12, 13]. At the same time, Helmersen clearly paid only formal attention to the matter. He asked the locals at a small nearby port of Kunda for the price of transporting a pood of goods to Saint Petersburg, multiplied the figure with the quantity of oil shale needed for heating the city and reached a logical conclusion that it was cheaper to import coal from England.

Nevertheless, Estonian landlords did not find application for oil shale, although a thorough article was published on Helmersen's studies and the properties of the discovered rock in a popular Baltic-German weekly magazine *Das Inland* in 1838 [16]. Estonia lacked industrial enterprises that would have required high heat. Extracting oil from oil shale, however, was troublesome and economically futile for an estate that was specialized in agricultural production. Nor was oil shale of use to peasants, as there was no shortage of firewood in Estonia. Saint Petersburg got its coal from either England or the mainland of the European part of Russia where namely Helmersen conducted large-scale exploration in order to discover coal deposits in the 1830s and 1840s [11]. Helmersen's work enjoyed extra-

[6] Land registers. Kohala estate. National Archives of Estonia: EAA.4187.1.816; AM.104.1.1157; AM.31.1.1. http://www.ra.ee

ordinary success that, in turn, made the oil shale of the province of Estonia unnecessary for the state and its existence was forgotten once again.

It should be emphasised that Helmersen's expedition to study oil shale was not his private scientific "joy". As is mentioned in [13], Helmersen was ordered to survey oil shale deposits in Keila-Joa and Kohala by the Head of the Corps of Mining Engineers, who at that time was the Minister of Finance, Count Yegor Frantsevich Cancrin, Georg von Cancrin (also spelled Kankrin) (Russian: *Егор Францевич Канкрин*) (1774–1845). In that perspective Helmersen's expedition can be seen as part of a campaign of boosting Russian economy led by the Minister of Finance. Cancrin was known in Russia as an arrogant, yet devoted and hard-working politician and economist, who was best known for his spearheading and successful reforms in the Russian financial system [17, 18]. However, his views on the industrialisation of Russia are considered controversial. Cancrin was politically very conservative and his credit policy was anti-industrial, but with regard to technical education and the system of high protective tariffs he was apparently pro-industrialist [17]. Similarly, his policy to boost the mining industry was full of controversies and eventually an overall failure [19]. On the one hand, Cancrin's father and grandfather were mining scientists and thus, he himself was somewhat personally connected with mining industry matters. Cancrin urged to find and take into use new mineral deposits, especially gold and combustible materials [18, 19]. As a result, the production of precious metals and coal more than doubled in Russia during his term of office, 1823–1844. On the other hand, Cancrin centralised and militarised state owned mining companies and restricted free enterprise. This resulted in Russia's overall economic backwardness as its mining volumes remained far behind those of the United States and Great Britain [19]. The side effect of this backwardness was that the capital of Russia, Saint Petersburg, became increasingly dependent on coal exported from foreign countries, mostly Germany and England. This dependence suffered a painful setback during World War I when the sea route to England was cut off, Saint Petersburg was threatened by the imminent energy crisis, and the import of oil shale from Estonia became topical again [2, 3].

3. Georg Paul Alexander Petzholdt

We learnt from the above that oil shale was discovered in Kohala estate on two separate occasions. But there was one more independent story of oil shale discovery and in quite an unusual location. The news of a new burning rock found in the province of Estonia was published in a weekly magazine *Das Inland* in 1850 [20]. Georg Paul Alexander Petzholdt (1810–1889), professor of agriculture and technology at the University of Tartu (1846–1872), describes how he discovered a light brown, narrow-layered, light and easily breakable burning mineral between the layers of Silurian (as is known,

the Ordovician was separated from the Silurian in 1879) in the area between the coach stations of Rannapungerja and Väike-Pungerja (Figure). If the rock is broken along the layers, one can see the skeletons of various prehistoric animals. Petzholdt also conducted chemical tests and determined that the mineral consisted of organic material to the extent of 65.6%. He tried to extract gas as well and produced 555 cm^3 of gas from 5.5 kg of rock. Petzholdt concluded that the rock was less valuable as a burning material than high-quality coal by 1/4, and better than birch by 1/3, and assumed that it could be found all over North Estonia. Professor Petzholdt also published the results of his study in several science magazines [21, 22]. Three weeks after publishing the news in *Das Inland*, Petzholdt wrote a new article [22] which included additions to his earlier article as in the meanwhile, he had seen Helmersen's study published in 1838 [12]. Petzholdt concluded that the rock he had discovered was probably the same mineral Helmersen had found in Kohala, and believed those deposits to be connected not isolated.

However, the main point of doubt in Petzholdt's study arises in connection with the location of oil shale discovery – the area between the coach stations of Rannapungerja and Väike-Pungerja. Surrounding Iisaku, this is the area where oil shale layers are located at a depth up to 100 metres due to the general gradient of the sedimentary basin of Estonia. Because of the depth of oil shale layers, it is impossible that Petzholdt found the rock in an artificial cavity – quarry, drainage ditch or well. It is plausible that Petzholdt provided wrong place names. But the articles contain indirect references which refute that possibility, namely that the location is approximately 60 versts (ca 64 km) from Kohala and north of the coast of Lake Peipsi. There remains the most likely option that the oil shale Petzholdt discovered was located in a rock monolith or large pieces of gravel carried south as a raft during the ice age. It is known that the moraine of Iisaku-Illuka eskers contains pieces of oil shale [24].

This story is not part of the traditional narrative of oil shale discovery in Estonia although Petzholdt is not a complete stranger for the history of oil shale. For example, Carl Schmidt [25] considered namely Petzholdt's article of 1850 the first writing to reveal the history of oil shale research. In his list "The special literature of Baltic oil shale", Vitali Levykin [26] has referred to Petzholdt's articles. Agu Aarna [27] has abstracted Petzholdt to a great extent, presenting him as an example of the early interest in oil shale among the scientists of the University of Tartu and claiming his article to be the first study to characterize the chemical properties of Estonian oil shale. However, the issue of the location where Petzholdt discovered oil shale has never been discussed.

Petzholdt's role in Estonian oil shale research is limited to those few articles [20–23] only. As far as we know, he did not study the subject further, which is why oil shale research is not mentioned in the thorough article about his biography [28].

4. Guano formations in Kukruse?

The last case of oil shale discovery to be discussed is probably the most intriguing. In the spring of 1869, a man called Carl Funk visited Estonia. He was most likely a Russian German since his residence was in the village of Vichenky of the Chernigov Guberniya [29] that was known as an important centre of Russian Germans. However, he worked as a chemist in Berlin at the end of 1869, but for many years prior to that as an agronomist for Russian landlords [29]. Sometime in the mid-1860s he received a piece of unknown mineral from a Mister Pollack from Estonia. Funk sent the piece to the laboratory of Carl Scheibler (1827–1899), a chemist in Berlin. Scheibler's answer delighted Funk as it said that 17.4% of phosphorus compounds were found in the rock. Thus Funk concluded that the mineral must have been guano [29, 30].

It should be emphasised that guano was considered as a strategic mineral wealth in the 19th century. Some types of guano have been historically used not only as a fertiliser but also as a raw material to produce gunpowder. As is known from the history, there was the Chincha Islands War between Spain and a Peruvian-Chilean alliance in 1864–1866 in which control over guano played a central role. In a situation where the prices for guano were very high and rose quickly [31] and world resources of this valuable fertiliser were thought to get depleted [32], the discovery of a new deposit in Estonia would have meant a significant financial gain.

Consequently Carl Funk travelled to Estonia and looked for guano in the high grounds surrounding Tallinn, but with no success. Then he asked Pollack where the mineral came from. According to Pollack, it came from a peasant from Undla estate of Kadrina Parish. Funk went to the estate and attempted to rent the place, but to no avail. After that, purely by chance, he visited a pharmacy in Tallinn and during the conversation with the apothecary asked him where else the rock could be found. To the pharmacist's knowledge, similar rocks had been discovered in Kukruse [29] where the landlord, Robert von Toll (1802–1876), had performed drainage works since 1850. Four kilometres of drainage ditches had been established there by 1870 [33]. In Kukruse, Funk found the surroundings to resemble those in Undla and attempted to rent or buy that estate. But he was refused again because Kukruse estate was not subject to rent or sale, according to law. Still, Funk notified von Toll of the mineral resources located in his grounds and asked the landlord to continue taking samples so that the costs Funk himself had made would have been paid off [29]. Since von Toll was not interested in the matter, Funk decided to put pressure on him by informing both the civil Governor of Estonia and the Ministry of State Assets of his findings, and by publishing an article [30] where he presented quite detailed calculations of the profit the mining of this phosphorus-rich mineral might have yielded.

Funk's article got a lot of feedback from all over Russia and was quoted in various magazines, e.g., in *Revalsche Zeitung* 17./29. July 1869. Estonian newspaper *Eesti Postimees* published the news on the fertiliser deposits found in Virumaa (the north-eastern part of Estonia) on 30 July 1869. Although misleading, this is the first known reference to oil shale in Estonian printing press.

However, the note on the discovery of guano deposits aroused suspicion in the famous palaeontologist, Carl Friedrich Schmidt (1832–1908), who had general knowledge about the mineral composition of the soil of North Estonia [34]. Schmidt in person visited Kukruse in 1869 and took samples of the material that had emerged from the ditches. He wrote a special comment in *Baltische Wochenschrift*, the only agricultural journal that was appearing in Russia's western provinces at that time. In his answer to Funk, Schmidt noted that it had been proven long ago that the mineral discovered in Kukruse was oil shale (German: *der Brandschiefer*) not guano. Also, Schmidt accused Funk of deliberately replacing the rocks [25], i.e. of forgery.

In his answer Funk tried to defend himself but had to admit that the test he had performed in Saint Petersburg proved that the rock found in Kukruse did not contain as much phosphorus as he had expected [29]. So, he had failed and neither the expected profit had been gained nor the expenses paid off. It is most likely that the mineral Funk received was indeed phosphorite, and the apothecary in Tallinn had misled him by accident.

It is virtually impossible to ascertain who the mysterious Mister Pollack was or whom of the five pharmacists operating in Tallinn at that time [35] Funk happened to visit. However, the link between apothecaries and oil shale is probably not entirely accidental. It is known that Oscar Ferdinand Seiler, an apothecary in Jõhvi since 1862, brought a load of oil shale from Kukruse to his pharmacy for experiments or just for heating. Unfortunately, fire broke out in Jõhvi on June 23, 1868 and the pharmacy together with many other buildings burned down. The load of oil shale continued to burn for several days and this fire accident was widely reported in the press [36]. However, it is also likely that apothecaries actually knew each other in person and communicated tightly as the community of pharmacists working in Estonia in the 1860s was very small [35].

Despite his failure Funk's activity proved very useful to the beginning of oil shale usage in Estonia. Schmidt noted in his answer to Funk [25] that Richard Hehn (born in 1846), a chemistry student, was going to analyse the oil shale from Kukruse under his guidance. Schmidt was especially interested in the oil content of oil shale "as a future basis of its technical implementation" [25]. Hehn published the results of his dry distillation research in 1871 [37]. At the same time, Hehn's article includes a footnote where a D. R. writes: "Since this oil shale is located in the traffic area of the currently active Baltic railway, further work may be suitable for commencing and enhancing the technical advancement of the railway" [37].

Already before Hehn's study was published, Schmidt's student Aleksander Shamarin (German: Schamarin), Master of Chemistry, published an overview of the chemical properties of oil shale of Kukruse [33]. Shamarin also compared the heating value of oil shale with that of coal, peat, brown coal and birch. Although the heating value of oil shale was the second highest after coal, Shamarin did not consider oil shale more valuable than birch due to the large amount of burning residue generated. At the same time, he found that "/.../ the most rational implementation area of Estonian oil shale (especially that of richer bottom strata) is producing combustible gas and using oil shale as heating material" [33].

Although this fact has not been proven, it is possible that the magistrate of Estonia, Baron Robert von Toll, started using oil shale as a heating material namely seized on Shamarin's study. Von Toll should be regarded as the first user of oil shale in Estonia. It is known that he mined about 3000 poods (50 tonnes) of oil shale per year as a by-product of limestone. He used small quantities of oil shale along with firewood in his fireplace and vodka plant [38].

By the 1870s, information on oil shale and its possible importance had reached Estonian landlords. When establishing drainage ditches in Kohtla, Erra, Purtse and Jõhvi estates and between the Opolye and Koporye coach stations in the Petersburg Guberniya, as well as during the construction works of the Baltic railway [38], the findings of oil shale greatly contributed to that. In 1878, the mining engineer Pavel Aleksejev (1817–1881) published a longer article on oil shale from around Saint Petersburg, paying special attention to Estonian oil shale that he had personally studied on the spot. He wrote: "The locals fully realise the importance of oil shale as a heating material and a source material of gas and oil. But due to the narrow strata of oil shale deposits near the ground and the random nature of their discovery, no one mines it for personal use." [38]. Aleksejev was convinced that thicker layers of oil shale could also be discovered, but it required geological exploration that was manageable for state or large private companies only. In any case, oil shale would bring significant economic advantages [38]. Yet it took almost another 50 years before Estonian oil shale found wider industrial use.

5. Conclusions

While oil shale was discovered in Estonia in the 1780s, it was only in the 1830s that oil shale studies began again due to the interest of Russian government to obtain high-quality heating material. Gregor von Helmersen's studies on oil shale were already so profound that in addition to chemical consistency and heating value, they also determine the profitability of the mineral, finding this to be low. It can be admitted that oil shale was forgotten again, mainly as far as its usage was concerned.

Another independent discovery of oil shale was made by Georg Paul Alexander Petzholdt in 1850. His findings originate from the area around Iisaku where oil shale, however, was located at a depth of 100 m. Still, the descriptions leave no room for doubt that the substance analysed was oil shale. In such, we can consider it as the third case of discovery of oil shale, which, however, was not followed by any further research again, let alone usage.

Since the middle of the 1850s, the main researcher of the geology of North Estonia was Carl Friedrich Schmidt. Although his activity was not directed to oil shale per se, we can regard him as a scientist who placed oil shale in a concrete geological system by his study of Silurian, constructing a basis for further research. Still, the narrative of oil shale discovery offers another surprising turn of events. Carl Funk, who had an agronomical background, presumed in 1869 that the mineral deposited in Kukruse was guano (although most probably he had received a piece of phosphorite), and hoped that it was his key to great wealth. However, by that time knowledge of oil shale was already quite profound so that Funk's dream fell to dust. At the same time, it can be said that Funk's activities had raised oil shale research to a new level as several scientific studies appeared in the 1870s and oil shale was used as a heating material for the first time.

In conclusion, it can be said that oil shale was discovered in Estonia on several occasions in the 18th and 19th centuries, while the obtained knowledge was forgotten in the meanwhile. Or, more precisely, the pertinent information was not sufficiently widely spread. This may be explained by the fact that oil shale is not a very convenient material to use as a burning material in households. Also, there has always been an abundance of firewood and peat in Estonia. And, last but not least, one should not neglect the extremely poor transport facilities of that time either.

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