# MINING OF OIL SHALE

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## Summary

In Estonia, oil shale has had a long history of commercial production since 1018. Until the end of the1990s, oil shale mines annually produced about 12 to 13 million tons. Almost half of the oil shale is exploited in surface mines with open cast technology; the other part is produced from underground mining.

About 85% of oil shale mined is used for burning in oil shale power stations; 12% for retorting for obtaining shale oil; about 3% for cement factories.

In Russia, the production of oil shale in the Leningrad mining area has dropped to about 2 million tons annually in recent years. It is mined underground.

In China, the Fushun open pit mine has been operated for more than 70 years, mainly for coal production and also for oil shale, as a byproduct, which lies on the upper layer of the coal bed. Part of the oil shale mined is used for retorting for producing shale oil. Maoming oil shale mine started operation in the 1960s, and stopped in the 1990s due to the shutting down of the Maoming retorting plant.

In Brazil, open pit mining has been carried out for producing oil shale, about several thousand tons daily, for Petrosix retorting.

In USA, oil shale was exploited, but only used for pilot plant or prototype retorting tests.

## 1. Introduction

Usually oil shale is at first mined out, and then it is pyrolyzed in retorts or burnt in boilers. Oil shale may also be retorted or gasified in-situ underground, thus obviating the mining process; however, underground retorting or gasification was only tested on a prototype scale in the USA, and in the former USSR in the past but this technology has not continued in commercial production.

Just like coal, oil shale can be mined underground in the case of deep buried reserves; and oil shale can be mined aboveground, too.

Oil shale deposits have now been exploited in Estonia, Russia, China, USA, Brazil, Israel, Germany, etc.

## 2. Oil Shale Mining in Estonia and Russia

### 2.1 Mining Location

In the area of the former Russian Empire and USSR there are two regions where oil shale has been exploited.

The first, the Baltic oil shale area, located at the Republic of Estonia and the Leningrad Province of Russia, near the Gulf of Finland, covers about fifty thousand square kilometers, which is the largest and the best known. The main oil shale, from the Middle Ordovician age, is named kukersite oil shale. The Baltic area includes the Estonian and Leningrad deposits and Tara occurrences, of which the first two are commercially exploited. The Estonian deposit is one of the largest commercially exploited oil shale deposits in the world with its total resources exceeding five billion tons of oil shale. The Leningrad deposit includes a small kukersite occurrence in Weimarn near St. Petersburg.

The second known region is the Volga oil shale area, which exploits deposits located in Saratov province.

The organic matter content of kukersite oil shale in Estonia ranges from 23% to 52%, making it one of the highest-grade oil shales in the world. Kukersite is carbonaceous and has a high organic content and low sulfur content.

## 2.2 Mineable Reserves

In 1946, after previous investigations, the estimated oil shale resources in Estonia were one billion tons and in 1960 were 3.3 billion tons. The increase can be explained by the larger area for which the resources were calculated. Until 1998, the size of the Estonia oil shale reserves was determined on the basis of three characteristics: thickness, average calorific value, and depth of the mineable bed. The regulation concerning the geological exploration of the mineral, resources and the establishment of mineral reserves provided that oil shale could be regarded as a mineral resource if the calorific value of the bed is equal to or more than 6.1 Mj kg$^{-1}$.

The bed thickness should not be less than 0.5 m at the overburden thickness of up to 10 m or bed thickness is not less than 1.4 m at the overburden thickness of over 10 m. Estonia and Leningrad oil shale constituted basic mineral fuel resources for the USSR northwestern region, which required massive reserves. Thus a low criteria were established for the determination of oil shale reserves. The Soviet criteria proved unsuitable under new economic conditions. Furthermore, the characteristics applied in the eastern and central Baltic resource proved inadequate in the western area.

The best criterion determining Estonia’s resources of kukersite oil shale is the energy rating of the bed in GJ m$^{-2}$, implying the sum of the products of thickness, calorific values and densities of oil shale layers and limestone interlayers in all A-F beds.

Estonian mining fields have an energy rating from 36.5 to 46.3 GJ m$^{-2}$, with an average of 42.2 GJ m$^{-2}$. The resources of the Estonian deposit consist of mineable or active reserves and additional or passive resources. The active reserve is defined as oil shale layer with energy rating equal to or exceeding 35 GJ m$^{-2}$. If energy rating of a bed is below 35 GJ m$^{-2}$ (about 10 MWh m$^{-2}$), at the time suitable for surface mining, then auxiliary criteria are used.

Auxiliary criteria include the total thickness, without limestone interlayers, of selectively mineable oil shale layers. A reserve block is formed to register the active reserves, within which the average calorific value of mineable oil shale layers exceeds 11 MJ m$^{-2}$, and their summary thickness is over 10% of the burden thickness.

The average energy rating of the bed in the oil shale exploration block registered as passive resources should be at least 25 GJ m$^{-2}$. The reserves of the operating mines and open casts of Estonian oil shale deposits approximate 0.6 billion tons plus the reserves of exploration fields. According to the criteria, the active reserves of exploration fields exceed 2 billion tons of oil shale rock with limestone interlayers over 17 EJ of energy and passive resources amount for over 4 billion tons of oil shale rock or over 30 EJ of energy.

Based on energy point of view, Estonian oil shale minefields have approximately one billion tons of proved reserves and the exploration fields have double these reserves. The Estonian oil shale resources are twice as large as the oil shale that has been mined out to the present time. The resources of oil shale rock in all exploration fields form 6.3 billion tons, and the energy resources amount to 48.6 EJ. Russian oil shale resources at the Leningrad deposit that occurs by the Narva River have an energy rating below 35 GJ $m^{-2}$. The conclusion for data of Russian Leningrad and Estonian Baltic active oil shale deposits are 1 billion and 3.94 billion tons respectively.

The second oil shale in the Baltic oil shale basin is Dictyonema shale from Cambrian age; analogous mineral in Sweden and Norway is named Alum shale. The peculiarity of the shale is the low content of organic matter and high content of sulfur, along with the metal content: Vanadium 1100 g $t^{-1}$, Molybdenum 350 g $t^{-1}$, and Uranium 300 g $t^{-1}$. In Estonia and in Sweden, these particular shales have been raw materials for uranium production.

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