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EDITOR'S PAGE

MORE OUT FROM OIL SHALE?

In a very broad meaning, oil shale is defined as a fine-grained sedimentary rock containing organic matter that yields economic amounts of oil and combustible gas upon destructive distillation. In many cases oil shale contains valuable metals. Some of metal-enriched organic-rich shales are known as black shale and used for extraction of metals. During the last decade, organic-rich sedimentary rocks, commonly shales, have been targeted for shale gas extraction; this trend seems to be still increasing.

It is well known that the world oil shales range widely in mineral composition, organic matter content and oil yield. The deposits range from Cambrian to Tertiary in age and greatly vary in layer thickness and lateral size. Thus, the thickness of oil shale beam can reach up to 700 m and the largest deposits occupy several thousands of square kilometers. This variability is created by differences in original depositional environments and other conditions.

There are more than 600 known oil shale deposits around the world. A large number of deposits need more geological exploration to determine their potential as reserves. The most known large deposits, which can be classified as reserves, include the Green River in the United States, a deposit in Queensland, Australia, the El-Lajjun deposit in Jordan, some deposits in Syria and Israel, Brazil, China, and Russia. At present it is expected that these deposits would yield at least 40 liters (0.25 bbl) of shale oil per metric ton of shale, using the Fischer Assay. Commercial grades of oil shale, usually determined by their oil yield (and calorific value), range from about 100 to 200 liters per metric ton of rock. The US Geological Survey has defined a lower limit to be about 40 l/t for classification as US oil-shale lands. This lower limit is well depending on the available technology and market price for oil and gas, but also in some cases for electricity.

It has usually been much less recognized that in many cases oil shale is a source of a number of metals and useful elements. For example, some Jordan oil shales, apart from excellent oil yield, contain high concentrations of many metals. Molybdenum in the Jordan oil shale from some deposits is reaching more than 1500 ppm, zinc – 2500 ppm; vanadium, nickel, chromium, selenium and some other elements can be in high to very high concentrations. These geochemical anomalies should draw attention as a valuable co-product in shale oil or electricity production. This possibility has not been widely addressed in oil shale business yet, mostly due to the lack of knowledge and economic technologies. An alternative will be leaving behind vast piles of metal-enriched waste after shale oil or electricity has been produced; the latter may be potentially harmful to the surrounding environment and health for decades.

The Estonian kukersite, a specific type of Estonian oil shale, is low in metals. However, there is another type of oil shale in Estonia known as graptolite argillite (the older term Dictyonema shale). Graptolite argillite is a kind of black shale of sapropelic origin, which is characterized by high concentrations of a number of trace elements, including metals. On a regional scale, graptolite argillite belongs to the wide but patchy belt of Middle Cambrian to Lower Ordovician black shales extending from Lake Onega district in the east across Sweden (alum shale as a local name in Scandinavia) to the Caledonian front, Oslo region and Jutland Peninsula in the west. It is a low-energy oil shale. The thickness of the Estonian graptolite argillite reaches occasionally more than 7 m and it covers a major part of Northern Estonia. The Estonian graptolite argillite is characterized by high to very high concentrations of U (up to 1200 ppm), Mo (1000 ppm), V (1600 ppm), Ni and other heavy metals, and is rich in N, S and O. During the Soviet era, graptolite argillite was mined for uranium production at Sillamäe, Northeast Estonia, between 1948 and 1952. A total of 22.5 tons of elemental uranium was produced during that period.

Although the reserves of graptolite argillite (about 70 billion tonnes) surpass those of Estonian kukersite (4.7 billion tonnes), it is of a quality too poor for energy production at the present stage of technological development. The calorific value of graptolite argillite ranges from 4.2–6.7 MJ/kg and the Fischer Assay oil yield is 3–5%. Thus, considering it as a low-grade oil source, its potential oil reserves are about 2.1 billion tonnes. However, keeping in mind the high metal concentrations, it can be considered as a complex future mineral resource. The GIS-based metal content calculations, based on more than 400 Estonian drill cores, provide us approximate total amounts of elements. For example, the total amount of U_3O_8 under the Estonian mainland is about 6.68 million tonnes, ZnO is 20.58 million tonnes, and MoO_3 is 19.15 million tonnes. Western Estonia has the highest potential, especially for U and Mo production. However, since a simple, environmentally friendly and economic technology has yet to be developed for the co-extraction of most of the enriched elements (and oil/energy) from graptolite argillite, its economic value remains theoretical. In any case, graptolite argillite has to be carefully considered as a future two-fold mineral resource and therefore thoroughly studied. At the moment it seems that the present Estonian Government has no intention to allow such kind of geological explorations, neither is this rock listed in the national mineral resources database.

Significant reserves of good to very good quality kukersite (a specific type of Estonian oil shale) and nearly a century of experience in using this resource make possibly Estonia's oil shale industry the most developed in the world. The extracted rock from open-pit or underground mines is directly used in power plant for electricity generation or for shale oil production; the latter can be refined into gasoline, diesel or other fuel and chemical products. However, oil shale, due to still incomplete technologies, tops the list of the most polluting fossil fuels.

The active geological reserve of Estonian kukersite is about 1.31 billion tonnes, the passive reserves add another 3.4 billion tonnes (2013). Compared to world reserves – about 690 gigatonnes (2008) – the Estonian oil shale reserve forms just a fraction of it. Most likely, the global total resource is even somewhat bigger since the data on many Asian deposits are scarce. According to the 2010 World Energy Outlook by the International Energy Agency, the world oil shale resources may be equivalent to more than 5 trillion barrels (790 billion cubic metres) of oil in place of which more than 1 trillion barrels may be technically recoverable. According to John Dyni, Estonian in-place shale oil resource is 16 290 million barrels (2010).

Having in mind Estonia's long and successful experience in using oil shale, it might be wise to merge the existing geological, technological, environmental and social knowledge into an organization, for example something like National Institute of Oil Shale. The main problem with Estonian R&D organizations is a lack of critical mass of researchers and engineers in most of the institutions. Very commonly basic and applied research is diffused and there is little communication between different small groups working on similar topics. National and commercial funding is limited and also diffused. Oil shale research is not different in this meaning. Today, Estonia still has a potential by creating this type of new integrated research organization, to be the world leader in oil shale developments. As kukersite is quite well as a government business (not to say monopoly!), the foundation of the National Institute of Oil Shale is depending on the country's political will and pragmatic vision. At the moment there is a deficit in both of them.

In the frame of an increased global awareness of environmental protection, climate issues and sustainable development, the rising technical and socio-economical question is how to use oil shale in a cleaner, more sustainable manner in production of more efficient and economically valued products. Is the direct combustion of oil shale in power plants economically and environmentally plausible, or are there better ways of gaining more value out of this resource? Is it fear by all meanings to have defined annual upper limit for oil shale mining? At the moment and for the next decade the limit has been set to 20 million tonnes per year. Is this a reasonable amount, or should the country mine much more of the resource when there is a distinctive demand for oil shale products in the market? Today, about 30% of this resource is lost during mining. Is this acceptable? Most likely not! What causes more harm to the environment, keeping the 20 M t limit or mining out larger quantities and limit thus the exploitation time of the resource? What is the best product, oil or chemicals, or simple power generation by burning oil shale in the oven? There is no single and unanimous answer to those, increasingly critical questions yet, though research has been done in order to plot the "right" course for the Estonian oil shale sector.

In the present political situation, where owning energy resources becomes more and more a critical factor in defining a nation's independence, Estonians most likely will soon be happy again about their burning shale. It is really the ultimate time for the EU to work out very concrete plans how to engage the Union's oil shale reserves to soften Europe's energy dependence on Russia. The "East-controlled" energy dependence has fossilized several crucial economic and technological, resource-based developments in Europe during the last several decades. In case of Estonia, this dependence can be avoided by a better use of the country's oil shale resources, which could provide in addition to electricity, also oil products (diesel, etc.) and secure a major part of Estonia's energetic needs. Graptolite argillite may provide the basis for metal production in the future, which copes with the EU's increasing demands for some critical metals.

It is just the time to look with a new and clearer vision at oil shale, keeping in mind that there are very different ways of using this long-known rock type in a more economic and sustainable way. A good start for this new revision is a detailed global updating of geological resource information databases and advancing technologies for different kinds of oil shales of the world by using modern approaches and achievements, for instance, in nanotechnology and material science.

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