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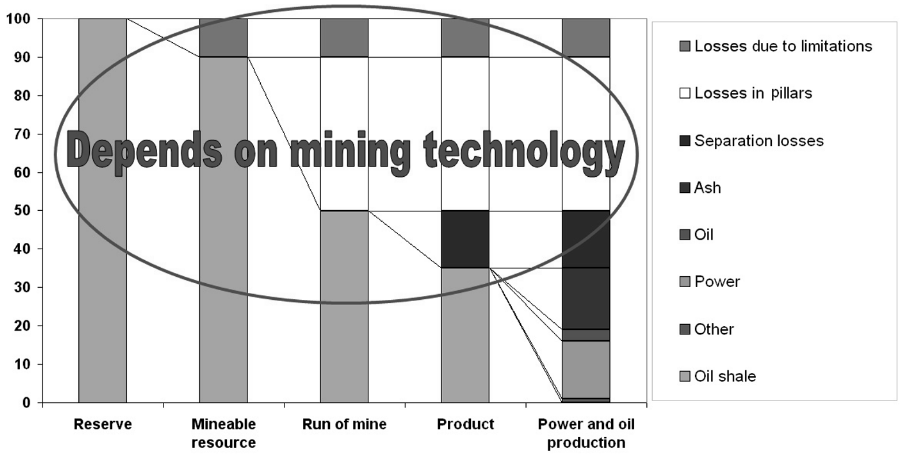
EDITOR'S PAGE

OIL SHALE MINING-RELATED RESEARCH IN ESTONIA

Finally the long-announced changes arrived, caused by environmental, geological and technological changes in oil shale mining sector. In addition, the biggest change has occurred with alteration of professionals' generation. In most of the countries, the institutions dealing with mining are facing difficult questions – to continue or not to continue, and if, then how. Research, development and teaching work are facing a low at the moment.

The biggest section in oil shale business in which saving and effectiveness could be achieved is the mining sector. It includes social and environmental restrictions in deposits, losses in pillars and separation of products and waste rock. Losses are closely related to backfilling and waste rock usage. Much smaller sections include production of oil, electricity and chemicals in which most of the research and development is performed today.



Efficiency of oil shale usage depends manly on mining technology.

Current urgent topics for investigating, testing and developing of oil shale mining related questions are backfilling, mechanical extracting of shale and digital modelling of mining processes.

Estonian oil shale mining industry with its 90 years of history has been a test polygon for equipment manufacturers, geologists and mining engineers from Germany, Soviet Union, Finland and Sweden.

These are the reasons why Estonia has recently hosted in average one international mining-related conference per year and is going to host the most important and highest level of the conferences – Annual General Meeting of the Society of Mining Professors "Innovation in Mining" (SOMP AGM 2010, http://mi.ttu.ee/somp2010).

Mining research concerning Estonian oil shale deposits

Several mining-related factors, such as changes in environment, underground conditions, landscape and property, tend to awoke public resistance. In order to create sustainable mining conditions, research on the natural environment and experiments conducted in mines and mined areas are required. Together with physical experiments, computer modelling is a widespread method in mining engineering. The principal task of modelling is to choose criteria and constraints satisfying all involved parties, as well as ways of presenting. In reaction to this, various restrictions for mining (mainly environmental ones) are created. In most cases, their argumentation is one-sided, often subjective. As a result, it is not possible to exploit a large part of deposits due to environmental restrictions, but also due to expiration of evaluation criteria of the supplies of resources. Part of the problems is caused by miners that do not apply environmentally friendly mining technologies.

Mining environment is understood as the entity including resources (deposits and groundwater), land (agricultural and housing land), engineering and technology. Research has shown that ground and landscapes changed by mining can afterwards be of better quality than before. If reclaiming is planned skilfully, the soil, landforms, forest, water bodies and agricultural land can be more valuable than before mining. All this is the basis for developing acceptable, environmentally friendly mining.

Acceptable mining requires engineering research concerning both natural and technogenic environment, e.g. modelling and pilot projects. As such research is voluminous, computer modelling has become the principal tool in solving problems related to all sorts of developments, technologies and effects. The key issue is defining **criteria** and **restrictions** that satisfy all the involved parties. Creating models and estimation criteria requires mining-related expertise and a database acquired from measurements, experimenting and laboratory testing. Modelling is followed by laboratory and industrial experiments, which require profound know-how. The experiments include e.g. chronometry of technological productivity, geometric and geological measurements, and measurements of rock quality. The parties that compose mining plans, development plans and estimations of environmental effects have acquired planning and modelling software for various purposes, which causes some problems: the geological database requires skilful treatment; data exist in several geodetic coordinate systems and include partly obsolete stratigraphic terminology. Unfitting coordinate systems disturb the usage of cross-use of spatial data in various geoinformation databases (digital maps, border files, land registers, building registers, databases of technological networks of enterprises, etc.). This creates further problems related to mined areas. Most environmental restrictions, which have to be taken into account in mining and building, are not based on real measurements. Usually the restrictions are two-dimensional and do not take into account the structures of the geological environment. Such vagueness does not support precise engineering calculations or modelling. Basic modelling systems that are designed in developed mining countries are principally meant for deep deposits. However, in Estonia there are blanket deposits, which cause wider environmental effect of mining. Because of that, imported systems have to be adapted.

Mining is possible in any circumstances, provided that sustainable mining environment has been created. In other words, with the proper choice of mining technology, the effect of mining has been damped below the level that the nature and man can tolerate. The methodology and criteria for planning, designing, modelling and accepting of sustainable mining environment will provide the basis for mineral raw material that the economy requires, both in the near and far future.

The principal direction of developing mining technology is filling the mined area. This provides control over majority of environmental effects. For instance, filling the workings decreases the loss of resources and land subsidence, and at the same time provides usage for stockpiling. Filling the berms of surface mine decreases dewatering; harmless waste can be used for filling open mines and in this manner offer new building land.

Local land subsidence related to mining may extend also to technological networks. It is possible to find out deformation parameters by geodetic monitoring. Taking these parameters into account enables to model further the extent and effect of the deformation.

Modelling, including digital planning, is aimed at gaining and creating the following: mining indicators needed for making decisions, future scenarios of mining oil shale and building material, support for development planning at state and regional level, technological solutions that take into account all possible environmental effects and social reactions, new output: project solutions, theme maps, inquiries, zoning, evaluations of crises or risks, optimal methodology for gaining, storing and using information, having in mine requirements for various purposes and levels, more effective usage of geological, technological and spatial information, additional functionality of the database.

The optimal solution is obtained by modelling. The most general but also dominant **criteria** are: minimal effect on man and nature, minimal amount of residual and waste, maximal economic profit, also in other fields not only in the mining industry. The problem includes several criteria, and its solving requires both theoretical and computational solutions. Principal methods are related to introducing sensors, measuring equipment and mining condition experiment, matching structures of various data and modelling based on them. The methods are: mapping the modelling criteria, indicators and processes of the mined areas; experimenting the possibilities of application, compatibility and results of mining software; applying laboratory experiments and fieldwork in modelling; creating models for blanket deposits (methodology in modelling MGIS, i.e. mining geoinformation system, models of new mines, changes in ground conditions, environment (modelling and analysis of groundwater dynamics, effects of dust, noise, etc.), geotechnological models in mined areas); applying seismological methods for developing theory for collapse risk, analysis methods for creating spatial models from geodetic spatial information, studies on material properties for developing theory for criteria for rock breakage, dendrochronologic studies for monitoring changes caused by collapses and changes in the water regime.

As a result, conditions for creating mining environment satisfying all involved parties (industry, state, public, decision makers) will be developed, applicable for any deposit of any resource. A system of criteria of evaluating the mining environment will be designed.

This research provides for **mining science** a new level of digital modelling of blanket deposits, basing on long-term experiments and modern digital planning. The research results will be applied in compilation of the **state** development plan, planning mined areas, as well as in teaching and science.

The results are relevant principally for users of land and ground (builders, geologists, hydrogeologists, hydrologists, mining engineers and reclaimers).

The results provide better understanding between the **public** and the miners, and further a basis for well-argumented communication and promotion for economy in the manner that satisfies both parties. In recent years, there has been a world-wide initiative for research, creating the concept of sustainable mining, using relevant indicators and making decisions based on them. MMSD (Mining, Minerals, and Sustainable Development), SDIMI (Sustainable Development Indicators for the Minerals Industry) and other international networks emphasize the need for creation of a concept for regional sustainable mining, relevant for local conditions. At the same time, modelling systems are being built and usage of non-traditional fuels is being started.

About three decades ago oil-shale mines of the former USSR including Estonia did not use the progressive mining methods with continuous miner, which are most suitable for the case of high-strength limestone layers in oil-shale bed. Therefore, oil shale mining with blasting has been used as a basic mining method in Estonian minefields up to now while continuous miner was tested for roadway driving only. As for cutting, the installed power of coal shearers and continuous miners has increased enormously since the original work. The actual state of the market has changed, and a wide range of powerful mining equipment from well-known manufacturers like DOSCO, EIMCO, EICKHOFF, etc. is available now. Estonia has 30 years of experience in cutting with longwall shearers which were not capable of cutting hardest limestone layer inside of the seam. Tests with road headers have been carried out in the 1970s. Additionally Wirtgen surface miners have been tested (SM2100 and SM2600) for two years as well as SM2200 and Man Tackraf surface miner, and currently the testing of Wirtgen surface miner SM2500 for high selective mining in an open cast mine is being performed.

The main field to be developed in addition to mine backfilling is mechanical extraction of oil shale. Potentially this allows increasing oil yield, decreasing CO_2 pollution, decreasing ash amount, decreasing oil shale losses, avoiding vibration caused by blasting, avoiding ground surface subsidence (in the case of longwall mining), increasing drifting and extracting productivity compared with current room and pillar mining, increasing safety of mining operations. The final aim of the research is to use BAT (best available technology) for underground mining in areas with arduous conditions of coal and oil-shale deposits. The main problems to be solved are: selective cutting of oil shale (15 MPa) and hard limestone (up to 100 MPa), roof support at the face, stability of the main roof, roof bolting, pillar parameters, backfilling with rock or residues (ash) from oil production, water stopping and pumping in problematic environment (30 m^3/t expected).

Currently room and pillar mining with drill and blast technology is used underground. Supporting is done with bolts. Mining production is in total around 14 Mt/y, including 7 Mt/y underground. Total raw material amount underground is 12 Mt/y. Tests are made for opening new mines, with total production 15 Mt/y.

Continuous miners keep playing a major role in the underground industry in over fourteen countries worldwide. Estonia's oil-shale industry is at the beginning of introducing modern fully mechanized continuous miner systems, which could increase productivity and safety in the underground mines.

A longitudinal cutting head-type miner was first introduced in the former Soviet Union by modifying the Hungarian F2 roadheaders and in the 1970s in Estonia by modifying the Russian coal roadheader 4PP-3. Evaluation of breakability was performed by a method developed by A. A. Skotchinsky Institute of Mining Engineering (St Petersburg, Russia). For this purpose over a hundred samples produced by cutting of oil shale and limestone, as well as taken in mines by mechanical cutting of oil shale were analysed. Evaluations were made for using coal-mining equipment for mining oil shale. Comparative evaluations were made by the experimental cutting of oil shale in both directions – along and across the bedding, including also mining-scale experiments with cutting heads rotating round horizontal (transverse heads) and vertical axes (longitudinal heads). In both cases the efficiency was estimated by power requirement for cutting. The feasibility was shown by breaking oil shale in direction of cutting across the bedding by using cutting drums on horizontal axis of rotation. The research also evidenced that the existing coal shearers proved low endurance for mining oil shale. Therefore, there arose the problem of developing special types of shearers for mining oil shale or modifying the existing coal shearers.

It was further stated that the better pick penetration of the longitudinal machines allows excavation of harder strata at higher rates with lower pick consumption for an equivalent-sized transverse machine. It was reported that with the longitudinal cutting heads the dust forming per unit of time decreases due to smaller peripheral speed. The change in the magnitude of the resultant boom force reaction during a transition from arcing to lifting is relatively high for the transverse heads, depending on cutting head design. Specific energy for cutting across the bedding with longitudinal heads is 1.3–1.35 times lower which practically corresponds to the change of the factor of stratification.

These are the questions waiting for answers in the near future for effective oil shale extraction in Estonia and in similar mining conditions. In spite of current economic problems, still everything begins with mining.

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