Jyrki Huhtaniska & Minttu Merivirta (eds.)

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Mine Your Own Business

Improving English Language Skills for Mining Engineering Education at Lapland UAS

PUBLICATIONS OF LAPLAND UAS
Publication series B. Reports 29/2015

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Jyrki Huhtaniska

Introduction: Improving English language skills enables effective teaching

Mineral-based materials, products and structures are used either directly or indirectly in almost every area of our life. Prosperity, security and the opportunity for self-fulfillment, which are closely related to higher living standards and wellbeing, are likewise based on the utilization of minerals in many ways. (Finland's Minerals Strategy 2010, 3.)

Modern society requires the use of mineral-based products in the construction and maintenance of housing and other buildings, earthen structures, railroads, road networks, power lines, pipelines and other infrastructure. Industrial production and manufacture of machinery, equipment, vehicles and ICT technology are largely based on the utilization of mineral-based materials. Mineral fertilizers and agricultural machinery are also vital to food production. (Finland's Minerals Strategy 2010, 3.)

The Ministry of Employment and the Economy in Finland has pointed out some key challenges that the minerals sector is facing these days. For example, one challenge is greater volatility in the demand for minerals, which means that recycling is not enough, we have to mine minerals. Also, deposits are of a lower grade or are located at a greater depth. This is true especially in Finland. We have ore bodies that can only be utilized with new technologies and solutions. Another problem is legislation and public opinion, which can jeopardize mining projects. It is possible that extractive operations are limited by competing forms of land use and access. The public opinion can affect permitting procedures. The procedures can become more complex, and processes become longer when demands are growing. One key challenge is that it will be increasingly difficult to recruit expert consultants and skilled labor. This means high demands for universities in the field. New exploration and beneficiation technologies must be developed when the industry is dealing with high demands from the public, environment, health and safety. The industry must be prepared to decrease water and energy consumption and at the same time emissions and waste need to be minimized. (Finland's Minerals Strategy 2010, 13.)

All the above facts and challenges demand professional education in general and professional English language skills in particular.

GLOBALIZATION DEMANDS BETTER LANGUAGE SKILLS

This publication is based on the English course that strengthened the language skills of the teachers in the School of Industry and Natural Resources at Lapland University of Applied Sciences. The background of this English course is long-term cooperation between Kajaani University of Applied Sciences (KAMK) and Lapland University of Applied Sciences (Lapland UAS) concerning mining engineer education. KAMK and Lapland UAS are working together in a cooperation project called Northern Mining Network (NMN), and this course was funded by the project. The network has developed engineer education and also acts in the field of R&D expertise. The importance of being able to communicate and teach in English can most easily be explained from the project point of view.

KAMK and Lapland UAS have created a new approach to engineering education including a curriculum: network-based engineer education. This is done by several projects, of which NMN is the last ongoing project. The project is funded by the Ministry of Education and Culture and executed during December 1, 2013–December 31, 2015.

The next phase in this cooperation is to expand the activities to the national level and further, to the international level. The industry in Finland consists mainly of global players; only the Talvivaara and Kemi mines are domestic. For example, First Quantum Minerals (Kevitsa mine) and Agnico-Eagle (Suurikuusikko mine) are Canadian companies. R&D demands networking with domestic and foreign partners from Canada, North America and Latin America (especially Chile) and England, Sweden and Norway.

The aim of this project is to create an exchange network for both professionals and students and new R&D-based partnerships to ensure international funding. A further aim is to bring international partners to domestic teaching and to develop the competence of educational staff. This is carried out by means of a series of expert lectures, creating a continuing education program for the teaching staff and improving the conditions for international exchange. All these activities demand good professional language skills. Mining is a global business, and the language of mining is English. The project has six work packages described below, explaining why it was important to design an English course for the staff.

NORTHERN MINING NETWORK DEVELOPS INTERNATIONALIZATION

In the first work package of the NMN project, the activities deal with international cooperation and networking. The tasks in the work package are national university cooperation, international university cooperation and exchanges periods for the staff. All these activities demand good language skills in general and in the field of mining in particular. KAMK is the partner responsible for this work package.

In the second work package, the activities deal with strengthening mining professional expertise in universities of applied sciences. This means that it is necessary to plan and implement exchanges between the industry and universities. The second task is to plan and implement a lecture series in mining and mineral technology. The third task is to plan and implement R&D seminars. This work package also concentrates on curriculum development. The partners have designed the content of the common 45 credits of mining-specific studies. These studies are also planned to be offered in English, which is why it is necessary to train professionals and the staff, too. Lapland UAS is the partner responsible for this work package.

In the third work package, the activities deal with sorting out expertise export opportunities. The tasks are analyzing the needs of training, providing product training and describing the business model and piloting. KAMK is the partner responsible for this work package.

In the fourth work package, the activities deal with project applications. The aim is to create international project applications. Lapland UAS is the partner responsible for this work package.

In the fifth work package, the activities deal with the development of English teaching materials and utilization of the existing international teaching materials. The tasks are to develop and expand the choice of English teaching materials and courses, to purchase and develop simulation-based programs to support education, to model mine environments and to plan and implement a virtual environment to be productized. Effective international student exchange in the field and increasing the expertise require English teaching materials. There are several different e-learning platforms in the field internationally, in which businesses and universities provide training materials. Lapland UAS is the partner responsible for this work package.

In the sixth work package, the activities deal with further education and the development of adult education. KAMK is the partner responsible for this work package.

All these acts aim for international-level know-how in the mining industry, further development in R&D and beyond – and adult education.

THE RESULTS OF THE ENGLISH COURSE SPEAK FOR THEMSELVES

The English course organized by the NMN project was a suggestopedic intensive course. The participants were teachers, senior lecturers, principal lecturers and project workers from R&D in Lapland UAS. A total of ten people participated in the course. The course included three three-day sessions. The target was to be prepared to give lectures in English and to be able to participate in international projects. The course concentrated on mining-specific vocabulary on the one hand and general language skills on the other.

The final assignment for the language course was to write a presentation of the chosen area of expertise in the field. This publication gathers together articles written during the course. All the articles are based on the vast expertise of their authors and their long careers in the industry. The articles include presentations of the current state of the mining industry, teaching, laboratories at Lapland UAS, projects, etc. In addition, each article is accompanied by the writer's reflection of the benefits and learning outcomes of the course. The personal insights offer a more personal view on the advantages of the English course in the NMN project.

The course was a success. The results, namely being able to speak and learning mining-specific vocabulary, developed decisively. All participants were grateful for the opportunity to develop their language skills, and Lapland UAS is planning to continue having these kinds of courses and education for the staff. This series of articles is also one result. All the work done by the participants and the best practices in the course can be utilized in the next course.

SOURCES:

Finland's Minerals Strategy 2010. Geological Survey of Finland. Ministry of Employment and the Economy. Retrieved December 9, 2015. http://projects.gtk.fi/export/sites/projects/minerals_strategy/documents/FinlandsMineralsStrategy_2.pdf

Results of the English Language Course

Jyrki Huhtaniska

Finland's minerals strategy and education

This article is about Finland's mineral strategy reaching to 2050. In this vision, Finland is a global leader in the sustainable utilization of mineral resources and the minerals sector is one of the key foundations of the Finnish national economy. The other aspect is what the strategic objectives and the themes of action proposals are and how education can be part of this vision. The third part of this article is to introduce Lapland University of Applied Sciences' solution, the KaiVi project. In this project, Lapland UAS is developing a new way of teaching and learning via a virtual learning environment in mining. The project aims to produce new, innovative teaching methods for mining education, because today's engineer students need more and more hands-on practice and education based on real-life situations. Currently, the students get hands-on experience and essential skills mainly during their practical training. The students need training environments where professionals guide them. Scenario-based learning cases for a virtual environment are developed with the teachers, representatives of the industry and experts – those who represent the real-life experiences that the students will face.

FINLAND'S MINERAL STRATEGY AND THE SIGNIFICANCE OF MINERALS

Efficiently managed and sustainable utilization of our mineral resources secures the long-term supply of raw materials at a national level, while creating the preconditions for stable regional development far into the future.

Expertise in the minerals sector also enables Finland to effectively promote the responsible and sustainable management of mineral resources within a global environment, in addition to generating opportunities for new international business activities (Finland's Minerals Strategy 2010).

VISION 2050

The vision for 2050 is that Finland is a global leader in the sustainable utilization of mineral resources and the minerals sector is one of the key foundations of the Finnish national economy (Finland's Minerals Strategy 2010). This vision means that education is an important tool to achieve this goal. Education can participate in this vision in the following objectives (Finland's Minerals Strategy 2010):

Strategic objectives:	**Education**
Promoting domestic growth and prosperity	can participate
Solutions for global mineral chain challenges	can participate
Mitigating the environmental impact	can participate
The themes of the action proposals:	
Strengthening the minerals policy	
Securing the supply of raw materials	can participate
Reducing the environmental impact of the minerals sector and increasing its productivity	can participate
Strengthening R&D capabilities and expertise	can participate

THE SIGNIFICANCE OF MINERALS

Mineral-based materials, products and structures are used either directly or indirectly in almost every area of our life. Prosperity, security and the opportunity for self-fulfillment, which are closely related to higher living standards and wellbeing, are likewise based on the utilization of minerals in many ways. (Finland's Minerals Strategy 2010, 3.)

Modern society requires the use of mineral-based products in the construction and maintenance of housing and other buildings, earthen structures, railroads, road networks, power lines, pipelines and other infrastructure. Industrial production and manufacture of machinery, equipment, vehicles and ICT technology are largely based on the utilization of mineral-based materials. Mineral fertilizers and agricultural machinery are also vital to food production. (Finland's Minerals Strategy 2010, 3.)

For example, the EU estimates that together with metals manufacturing and the construction industry, the production based directly and indirectly on the minerals sector accounts for approximately 40% of the gross domestic product (Finland's Minerals Strategy 2010, 3).

MINERALS SECTOR CHALLENGES

The Ministry of Employment and the Economy in Finland has pointed out some key challenges that the minerals sector is facing these days. For example, one challenge is greater volatility in the demand for minerals, which means that recycling is not enough, we have to mine minerals. Also, deposits are of a lower grade or are located at a greater depth. This is true especially in Finland. We have ore bodies that can only be utilized with new technologies and solutions. Another problem is legislation and public opinion, which can jeopardize mining projects. It is possible that extractive operations are limited by competing forms of land use and access. The public opinion can affect permitting procedures. The procedures can become more complex, and processes become longer when demands are growing. One key challenge is that it will be increasingly difficult to recruit expert consultants and skilled labor. This means high demands for universities in the field. New exploration and beneficiation technologies must be developed when we are dealing with high demands from the public, environment, health and safety. We must be prepared to decrease water and energy consumption and at the same time emissions and waste need to be minimized. (Finland's Minerals Strategy 2010, 13.)

In addition to these, the Ministry lists the following challenges (Finland's Minerals Strategy 2010, 13):

- A decline in the availability of aggregates in proximity to locations of greatest use.
- The utilization of by-products and replacement materials must be enhanced.
- Automation in the mining industry must be encouraged.
- The use of rehabilitated sites after mine closure needs to be promoted.
- The general acceptability and perception of the industry must be improved.
- Finnish ownership must be increased.

THE ROLE OF EDUCATION

Research and education are in a key role to provide new information and wider knowledge in the mining sector. Education is needed to spread the knowledge and best practices in the field. The challenges, like lower grade ore, demand new expertise in the processes and totally new methods. With ordinary technologies you may have a pile of rocks, but new technologies can change the situation so that you have ore.

Education is also essential to provide skilled labor for the mining sector. Mines are demanding places to work and that is why we need to teach students to be skilled and responsible employees for the mining industry.

Research and education can be a solution to an energy-efficient mine. Bioenergy and water-saving methods and technologies are more and more important in the field. Environmental issues demand new solutions for emissions and waste. We are also participating in a project that is creating new solutions for waste treatment.

Promoting domestic growth and prosperity means to us that education must provide workers and experts for mining companies. Knowledge means efficiency and efficiency means profitable business opportunities. Opportunities mean possible mining operations. Foreign companies can operate in Finland if the political climate is suitable. We cannot much affect this climate, but we can provide experts who understand the special features of mining. With expertise and knowledge, education is the key element to promote new ideas and spread new best practices in the field. This expertise can create solutions for the field nationally and internationally. Knowledge in mitigating environmental impacts is essential. Education is the tool to make best practices and development in the mining sector widely known.

Education is the main tool to make a quick difference in making sustainable mining widely known in the field. A certain new development in some area of mining can easily be spread in the field with the help of education. Mining is obliged to earn the social license to operate.

We are developing a new tool for education, a virtual learning environment in mining. It is a game-based environment. Since 2007, the mining industry has been developing intensively. Increasing mining operations call for skilled and professional workforce. This is particularly crucial as many experienced professional mine workers are currently getting retired. Moreover, the multidisciplinary work environment in the mining companies needs a wide variety of professionals from various fields of engineering.

KAIVI – THE VIRTUAL LEARNING ENVIRONMENT IN MINING

Today's engineer students need more and more hands-on practice and education based on real-life situations. Currently, the students get hands-on experience and essential skills mainly during their practical training. The students need training environments where professionals guide them. Scenario-based learning cases for a virtual environment are developed with the teachers, representatives of the industry and experts – those who represent the real-life experiences that the students will face.

The purpose of the virtual learning environment is to function as a training environment for engineer students. They can use this training environment to practice real-life situations and processes such as accidents and other extraordinary circumstances within various scenarios either by themselves or in groups. Virtual learning and training environments enable the students to practice leadership and decision-making skills wherever and whenever they choose. This improves the readiness and occupational safety knowledge of graduates.

The objective of the KaiVi – Virtual Mining project is to respond to the needs and challenges set by today's mining industry and technical expertise through developing virtual and network-based education. The project aims to produce new, innovative teaching methods for mining education. Furthermore, it will assist individuals from different operational fields of engineering to become employed in the mining industry. (Kaivosalan virtuaalinen oppimisympäristö 2015.)

New mines are situated in Eastern and Northern Finland, supporting the development of these regions. The critical factor in the mining sector is to ensure the supply of skilled labor. Training organizations will react in anticipation of educating versatile expertise for the industry. Developing the content and methods of mining education provides students with expertise that is needed in the industry and also to enable access to education in sparsely populated areas. Lapland and Kajaani Universities of Applied Sciences have worked together to develop engineer education in the mining sector for many years. The cooperation has confirmed Lapland's and Kajaani's role as key providers of engineer education in Eastern and Northern Finland.

The last act in the interregional cooperation to develop the mining sector education is KaiVi – the virtual learning environment for mining. The key part of the project is to combine information technology skills and mining industry professional expertise in the learning environment. The KaiVi project will create a virtual learning environment where the students can act in different roles in the virtual mining environment at the same time. The result is a new learning environment that allows for the visualization of the activities and decision-making cause-effect relationship in mines that are difficult or impossible to observe without a virtual environment. The simulation based on game-like learning environment develops the students' readiness to operate in the real-life mining environment.

Mining sector engineers need more training that is practical and based on real-life problems. Students need real training situations in which they are guided to operate correctly. Scenario-based exercises and game-like assignments give students the opportunity to practice real situations in the virtual learning environment developed. The contents are defined in cooperation with mining industry experts, business representatives and teachers, so that they are as authentic as possible. Software Systems Laboratory pLAB in Lapland University of Applied Sciences and the CSE simulation center in Kajaani University of Applied Sciences are responsible for the development of the virtual and scenario-based environment.

MULTIDISCIPLINARY WORKPLACE

The mining sector needs various technical experts. The virtual learning environment is a platform for students in various fields of training tasks. The training environment can be utilized in various fields of education, such as infrastructure, maintenance, mechanical engineering, construction engineering, electrical engineering and automation. The students will learn to work together in a multidisciplinary mining environment during their studies. This will improve the students' readiness for working life and mine safety. The virtual learning environment and online teaching give the opportunity to practice in a flexible and versatile game-like environment. The virtual learning environment will be widely utilized in higher education.

The main result of the project is a virtual learning environment in mining that enables a flexible education system and is suitable for many different exercises, regardless of time and place. Scenario-based teaching and exercises as well as the development of e-learning teaching methods are also among the results of the project. The virtual learning environment and scenario-based exercises are utilized in teaching at Lapland and Kajaani Universities of Applied Sciences. The intention is to create a virtual environment also suitable for vocational education in Finland as well as international mining education.

The implementation period of the ESF-funded KaiVi project is June 1, 2015–May 31, 2018. The project is co-financed by North Ostrobothnia Centre for Economic Development and Lapland Centre for Economic Development.

CONCLUSIONS

The mining industry and universities have mutual challenges. One challenge is greater volatility in the demand for minerals, which means that recycling is not enough, we have to mine minerals and deposits that are of a lower grade or are located at a greater depth. New exploration and beneficiation technologies must be developed when we are dealing with high demands from the public, environment, health and safety. This means that universities must offer studies in these subjects to improve recycling, discover new technologies and solutions for mining to make it profitable. In the near future, it will be increasingly difficult to recruit expert consultants and skilled labor. This means high demands for universities in the mining field. Mining sector engineers need more training that is practical and based on real-life problems. Universities must develop new solutions for mining education to ensure the development of good practices in the mining industry.

SOURCES:

Finland's Minerals Strategy 2010. Geological Survey of Finland. Ministry of Employment and the Economy. Retrieved December 9, 2015. http://projects.gtk.fi/export/sites/projects/minerals_strategy/documents/FinlandsMineralsStrategy_2.pdf

Kaivosalan virtuaalinen oppimisympäristö 2015. Project description of KaiVi – Virtual Mining project. Lapin AMK hanketietojen haku. Lapland UAS. [In Finnish.] Retrieved December 9, 2015. http://www.lapinamk.fi/fi/Tyoelamalle/Tutkimus-ja-kehitys/Lapin-AMKin-hankkeet?RepoProject=521818

REFLECTION

I had two main expectations for this English course. The first was to improve my speaking. I wished that after the course I would be able speak English fluently when I'm communicating with English-speaking partners. This is quite important, because we have ongoing international projects. We had also several projects whose objectives were to create cooperation in education with foreign institutes. The cooperation included curriculum development. The other objective was to learn mining-specific vocabulary. I think both objectives were developed very much thanks to our teacher, whose preparations, methods and teaching skills were excellent and served the objectives exactly.

Dominic Landon's way of teaching is based on suggestopedic learning. The idea of the course was to act as an encouraging and inspiring push to speak English. The idea worked perfectly for me. I actively participate in conversations, and I think this is a key factor why I managed to improve my speaking. The other thing is that I helped the teacher to select important words and vocabulary. This helped me very much, because I was much more prepared for the course itself.

The course included three three-day intensive course sessions. We were away from our daily working lives in a bit remote, backwoods hotel. Our teacher's goal was to pull students from their everyday lives just to concentrate on speaking English and English only. This started first thing in the morning. Our teacher was among us during breakfast and we started to speak English at 7:45 am and continued to speak English during lessons, songs, exercises and tales and also during lunch, afternoon classes and dinner. We were speaking English even in the sauna late at night before bedtime.

The best progress I made was definitely my courage to speak and not to be afraid of making mistakes. My mining vocabulary is now also more active than it used to be. We are developing a new mining engineer training program in English, and after this excellent course and preparations I'm more ready for the task.

– Jyrki Huhtaniska

Laila Kaikkonen

Mineralogy laboratory samples

This text covers an example of laboratory works in which students can explore different methods of enrichment. The images were photographed in the laboratory of the Vocational College Lappia. The students of the Lapland University of Applied Sciences have also had the opportunity to use this laboratory. There is the separate laboratory equipment, as well as the continuous and automated concentrator, which have been planned together with mining companies. This text deals with flotation in a laboratory, which is one theme in the basics of concentration course.

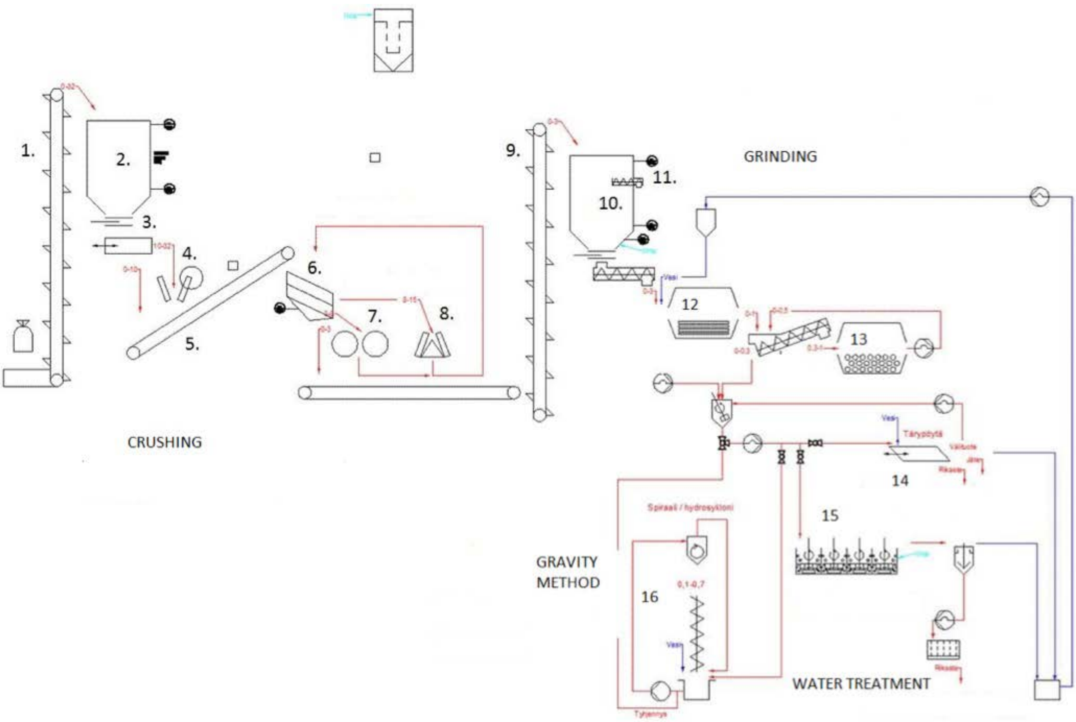


Figure 1. Process description of Lappia.

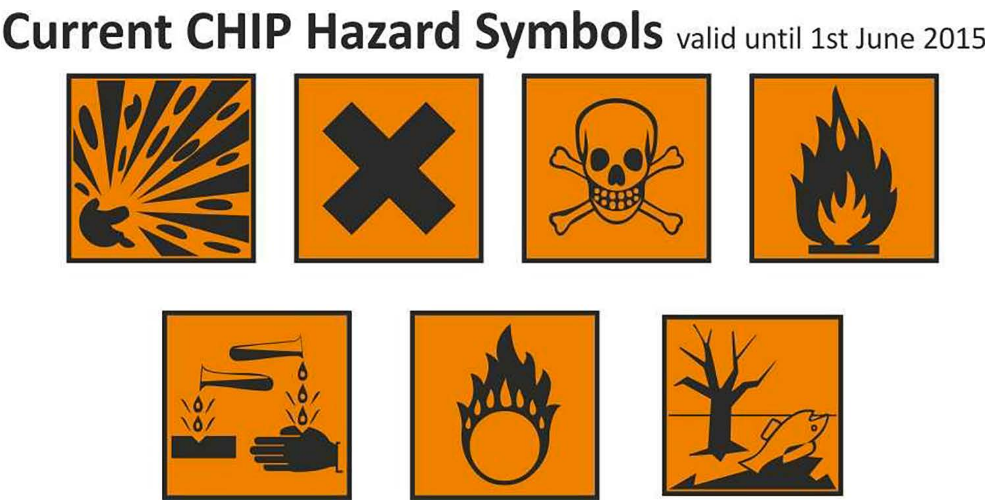
In the laboratory of the Vocational College Lappia, there are many appliances including a jaw crusher, ball mill, vibrating screen, flotation cell and ultrasonic washing machine. In the continuous process, there are the cup conveyor (1), feed silo (2), screen (3), jaw crusher (4), conveyor belt (5), vibrating screen (6), roll crusher (7), cone crusher (8), screw conveyor and silo for the product (10). There are also the rod mill (12), ball mill (13), shaking table (14), flotation cells (15) and spiral separator (16). (Figure 1.)

COMMON PRACTICES IN THE LABORATORY

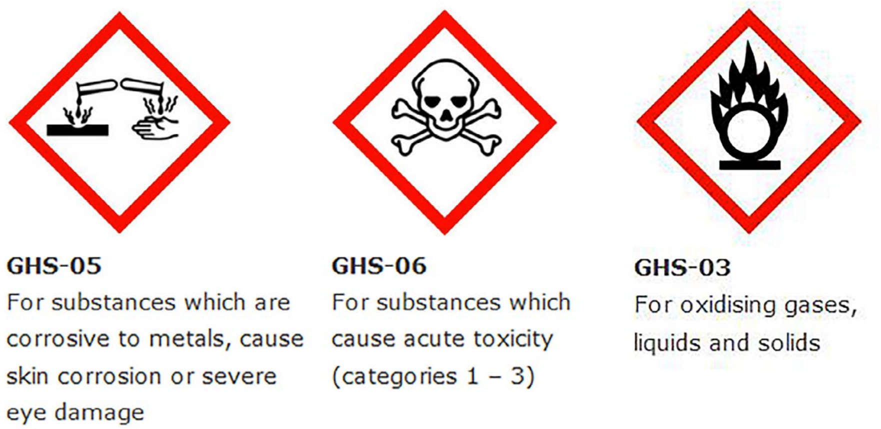
First, it is important to explore the safety data sheet and what kind of safety equipment is needed in the work. In general, at least safety glasses and gloves are needed.

An SDS (safety data sheet) is a widely used system for cataloging information on chemicals, chemical compounds and chemical mixtures. SDS information may include instructions for the safe use and potential hazards associated with a particular material or product. These data sheets can be found anywhere where chemicals are being used.

There is also a duty to properly label substances on the basis of physico-chemical, health and/or environmental risks. Labels can include hazard symbols, such as the European Union standard black diagonal cross on an orange background, used to denote a harmful substance (Picture 1). A black saltire set in an orange square is the hazard symbol for irritants or harmful chemicals. It indicates a hazard less severe than skull and crossbones, used for poisons, or the corrosive sign. Examples of new symbols are provided in Picture 2.



Picture 1. Hazard symbols until June 1,2015 (Stickylabels 2015)



Picture 2. Examples of current EU hazard labels (Stickylabels 2015)

SIGNIFICANCE OF FLOTATION TESTS

Laboratory flotation tests provide the basis to design, although they do not closely simulate commercial plants, as they are batch processes. The data provided by the tests includes, for example, the optimum grind size of the ore, quantity of reagents and location of addition points, pulp density and temperature.

The optimum grind size depends not only on the grindability of the ore but also on its floatability. Some readily floatable minerals can be floated above the liberating size of the mineral particles. In that case, the limit to size is the size where the bubbles can physically lift the particles to the surface. The lower size limit for flotation is important, as the problems of oxidation and other surface effects can occur.

Pulp density is important in determining the size and number of flotation cells. The denser the pulp, the less cell volume is required in the commercial plant, and also the less reagent is required, since the effectiveness of most reagents is a function of their concentrations in the solution. Pulp temperature affects the reaction time. Usually, however, water at room temperature is used. The laboratory tests are used to explore the corrosion and erosion qualities of the pulp, and this produces data to determine the materials which can be used for constructing the plant.

It must be noticed that in batch flotation tests the pulp density varies continuously, from beginning to end, as solids are removed with the froth and water is added to maintain the cell pulp level. This continuous variation changes the concentration of reagents as well as the character of the froth. Most commercial flotation circuits include some cleaning stages, in which the froth is refloated to increase its grade. In batch tests in the laboratory, cleaner tails are not recycled and hence the tests do not always simulate commercial plants.

In practice, the ore has variations in hardness, grindability, mineral content and floatability. It is important to investigate these things so that the variations can be accommodated in the design. (Wills & Napier-Munn 2006, 291–292.)

EXAMPLE OF FLOTATION

The flotation process is illustrated in Figure 2. The laboratory flotation cell is similar to this in many ways. The differences are that the cell is usually a closed container without separate feed and tailings pipes. There is no concentrate launder either, although the concentrate is scraped to a separate container.

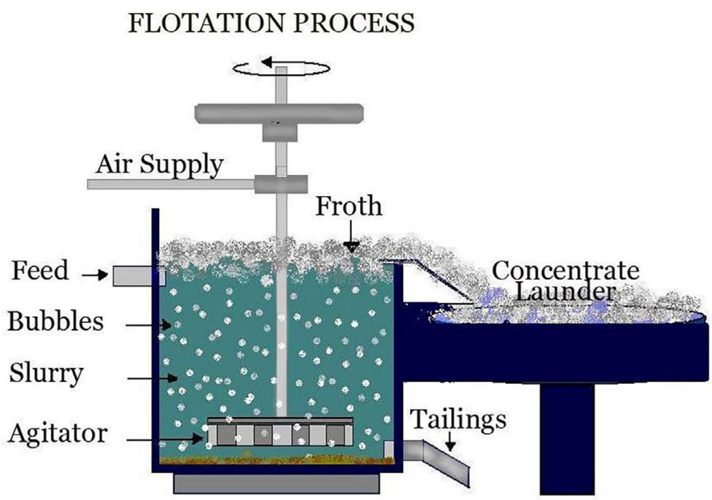


Figure 2. Flotation cell.

This example covers the concentration of talc by floating soapstone (Picture 3) in a flotation cell in the laboratory. The feed consists of soapstone from Mondo Minerals in Sotkamo. The concentrate will be talc, and the tailings are magnesite, $MgCO_3$ and nickel sulfide, NiS. The frother used is Montanol, which also acts as a collector (Figure 3).

Picture 3. The soapstone.

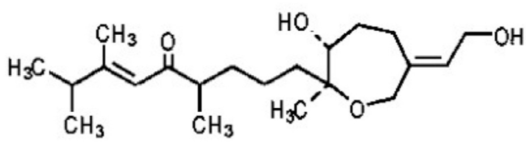
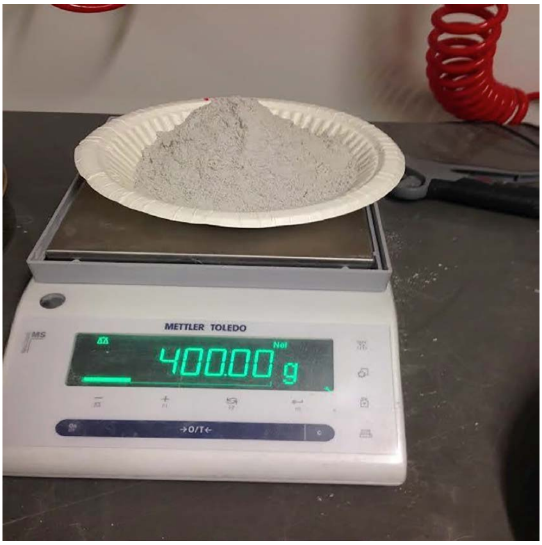


Figure 3. The frother.



Picture 4. Precision scales.

Precision scales are used for weighing in the laboratory (Picture 4). It is important to remember that weighing has an influence on the result of the analysis. This means that the scales have to be checked before weighing: the scales have been tared and cleaned carefully.

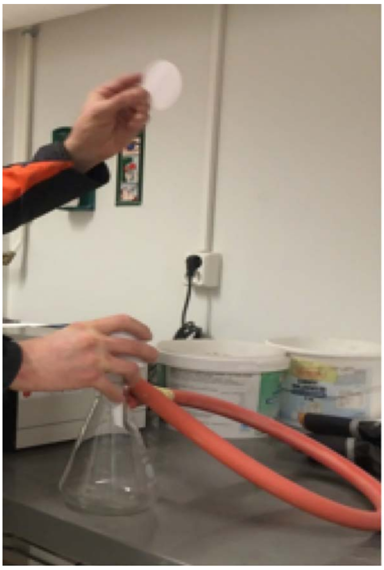
In this example, the feed is about 400 g soapstone and the other elements needed are water and the frother. The frother has the trade name Montanol and it acts as both collector and frother. Montanol is not outstandingly toxic and hence it is quite safe to use in the college laboratory. The frother should be measured out about 50 g per metric ton, which in this case means about 0.5 g for the cell.

First the weighed rock material is put in the container and after that water and the frother are added. The pulp is mixed, and the so-called conditioning time is about one minute. The agitator is set to 1,500 rpm. The flotation time is four minutes in this work.

Picture 5. The flotation test in the laboratory of Lappia.

The flotation begins after conditioning when the air valve is opened and the froth begins to form. The feed of air is adjusted by looking at the bubbles and the target is to get a lot of small bubbles. The froth is scraped by a spatula to the pot. (Picture 5.)

When the froth has been collected, it is filtered by a suction or pressure filter. In this phase, the principles of different filters can be compared. For example, the filtering time is shorter by pressure filter than by suction filter. (Pictures 6 and 7.)



Picture 6. The suction filter.

Picture 7. The pressure filter.

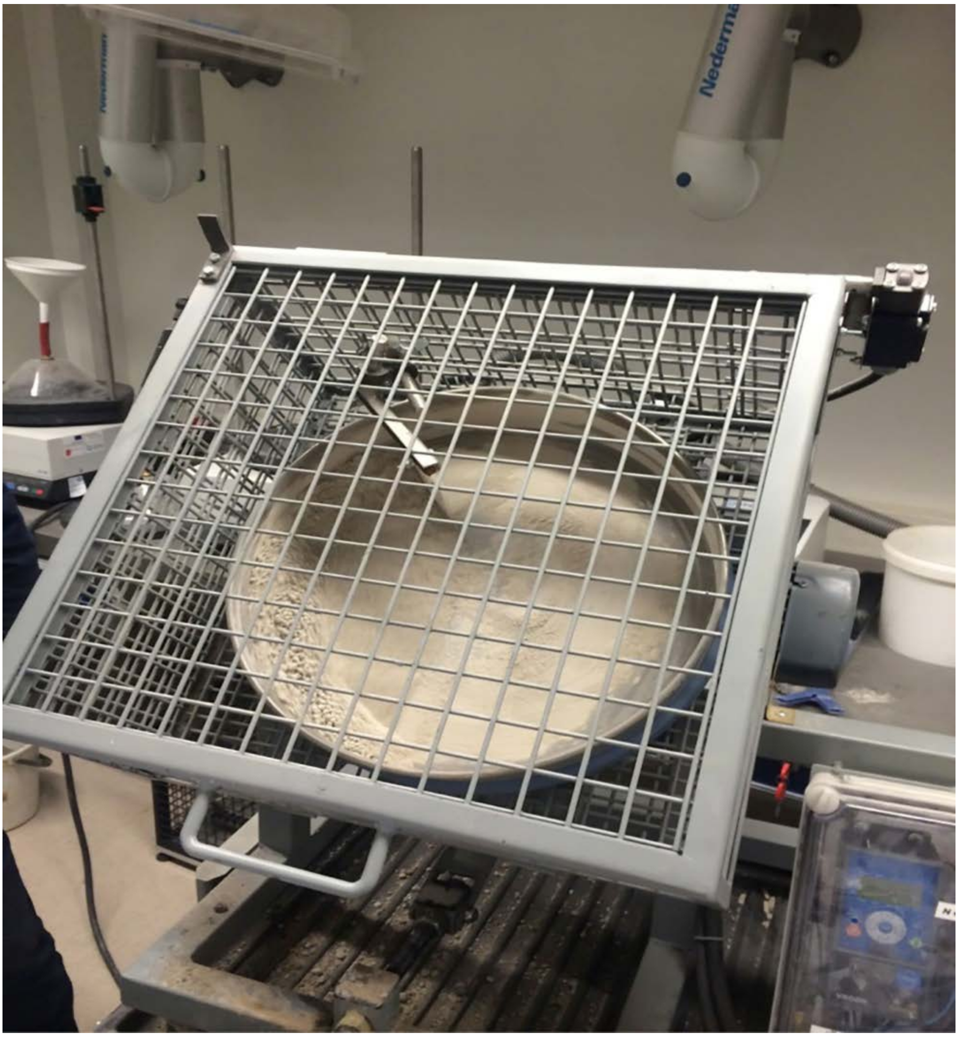
After filtering, the concentrate is collected in a pot, which is heat-resistant. It is dried in the oven for about one hour in the temperature of 200°C. Depending on the next exploration, the concentrate (Picture 8) can be, for example, granulated by the disc granulator.

Picture 8. Dried concentrate.

Picture 9. Grinding in the ball mill.

Before granulating, the concentrate is grinded in the ball mill (Picture 9). The material and adhesive are added to it. In this case, the adhesive can be, for example, a fertilizer such as Green Care.

After grinding, the material is put in the granulator, whose angle of heel can be adjusted (Picture 10). The ground concentrate rotates on the plate, and water is added by spraying intermittently. After some minutes, grains begin to form.



Picture 10. The disc granulator.

The purpose of granulation is to get bigger grains, which do not make dust and are both easier to transport and suitable for the next exploration.

Exploring how well talc was formed in this exercise is another project, and this can be made, for example, by a separate analyzer. Lapland University of Applied Sciences has an RDI department (Research, Development and Innovation) which is specialized in different measuring technologies. They have also planned to invest in geological and mineralogical gauges.

CONCLUSIONS

In this exercise, students can see what kinds of machines there are in the laboratory, because similar machines are used also in the laboratories of concentrating plants. They will get to know some of the laboratorian's tasks.

The most important lesson in this example is to see how flotation is performed and what the crucial factors are in this process. Another important thing is to know how chemicals are handled and stored. The students also prepare a report of the exercise and create a learning diary, which helps them to remember and analyze the different things they see and test in the laboratory.

About twenty students of Lapland University of Applied Sciences spent two days in the laboratory during the study module and worked in groups of three or four. They tested different devices one after another and got an impression of the different machines that are needed in concentration. After this, they can get deeper knowledge in advanced courses.

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REFLECTION

I participated in the English course organized in the spring semester of 2015. It was carried out in periods of three days and lasted nine days in its entirety. The studies were very intensive and we talked English from the morning to the evening. The subjects were sometimes unfamiliar to me because my hobbies are very different than the hobbies of the other participants, who were all men.

On the basis of the name of the course, I expected to learn words and things which are linked to mining. At the same time, I wanted to improve my skills in the English language and be able to speak and pronounce English better. The course lived up to my expectations in this respect.

The teacher had prepared the course material very creditably and the methods used were versatile. I liked the different kinds of games and discussions. The words became familiar in the process. I especially liked the teacher's way of bringing up mining words in a fun story which was handled in different ways.

Writing this article was challenging, because the theme about which I wrote was not so familiar. I have taken part in the laboratory work with the students, but the laboratory is not our own laboratory, in which I could have tested and prepared the measurements. During the course, I gave a presentation on this theme and I think that both speaking and writing were very useful for my vocational knowledge.

The course developed my skills in reading and writing English texts and speaking with foreign people. Therefore I think it was very useful to me as we should become international, go abroad as an exchange teacher and invite guests from other academies here to Lapland.

– Laila Kaikkonen

Rauno Toppila & Jukka Joutsenvaara

Mineralogical sample preparation as a part of mineralogical studies

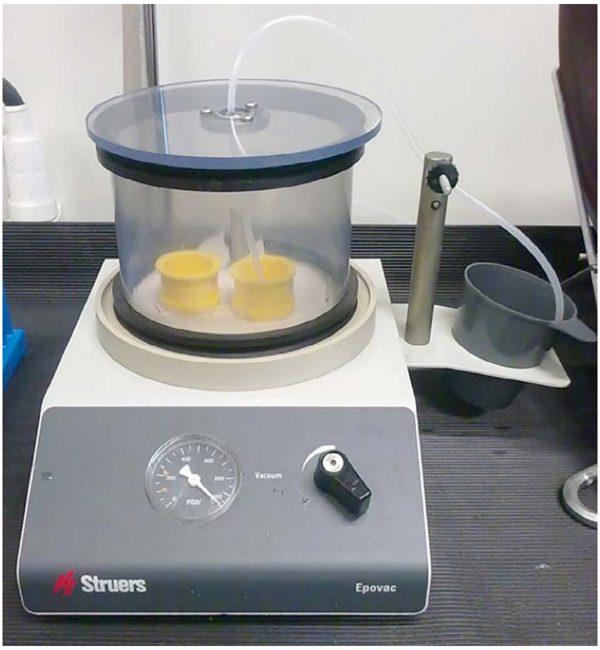
The mining industry needs plenty of different kinds of information to support decision-making for investments. The information could concern facts about location, logistics and soil geology. Naturally, geological investigations are laying the foundation for further studies and explanations. Without verified anomalies and proven concentrations, there cannot be valid information to make the feasibility studies for new mines.

Lapland University of Applies Sciences has the group ASM (Arctic Steel and Mining), which is in charge of this research area with a close connection to education. ASM is working in close cooperation with Luleå University of Technology and Kemi-Tornionlaakso Municipal Education and Training Consortium Lappia, which are widening the educational basis from practice to theory.

The following article concentrates on describing the process of preparation of the samples used to study geological anomalies. This article aims to explain the different phases of research to give an informative package for education and research.

TYPICAL WORKFLOW FOR GEOLOGICAL SAMPLE MAKING

First, a work order is made and an order number is assigned to it for tracking and cataloging purposes. The received mineral samples are cataloged with an internal sequential number for traceability which corresponds to the work order number. Typically, the arriving samples are pre-ground, so that the preprocessing is not so laborious.



Picture 1. Epovac – Epoxy casting of a sample in vacuum.

With thin section samples, the process is a bit different, because they are made from solid rock by cutting and grinding. This process is briefly mentioned later in this document.

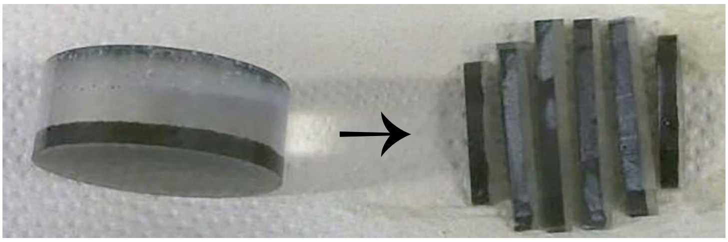
After arrival at the laboratory, the mineral samples are divided with a sample divider, provided that there is enough material to divide. Dividing is required in order to get a statistically valid but smaller sample, so that it consists of all the grain sizes as in the original sample.

After dividing, the samples are placed in a numbered mold based on the original sample number and cast in epoxy in vacuum with Epovac. Epovac equipment holding the samples is shown in Picture 1.

Finer grain samples are mixed with graphite powder for added quality. Adding the graphite decreases the surface tension of the resin so that mixing is easier with the flour-like samples.

The cast samples are then left to harden for 12 hours. This time is enough to ensure that the resin is hardened thoroughly. After complete hardening, the mount is removed from the mold and the mount is marked by engraving the corresponding work order and sample number. The backsides of mounts are then ground to level and the edges are rounded by grinding. After this, the mount is ready for grinding or polishing of the test surface.

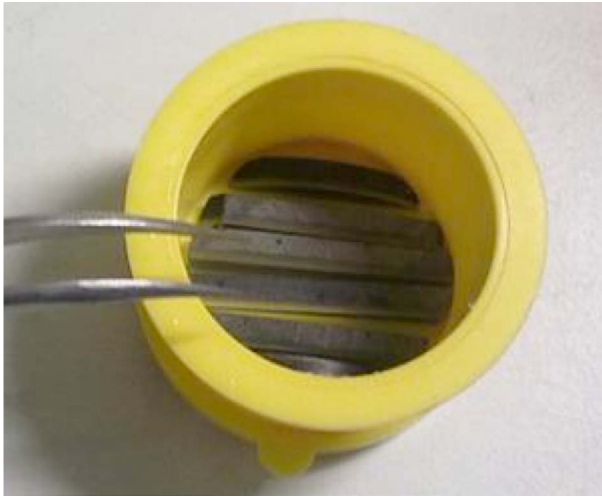
Double section resin mounts are used to inspect variation thru-the-thickness of the original sample. This gives more detailed information on the sample than an inspection of a surface sample. For making a double section resin mount, the previously cast mounts are sliced with a cutter into slices and extra epoxy is removed



Picture 2. Sliced resin mount.

from the slices. The slices rest on one side so that the thru-the-thickness is visible. The original sample and the resulting slices are shown in Picture 2.

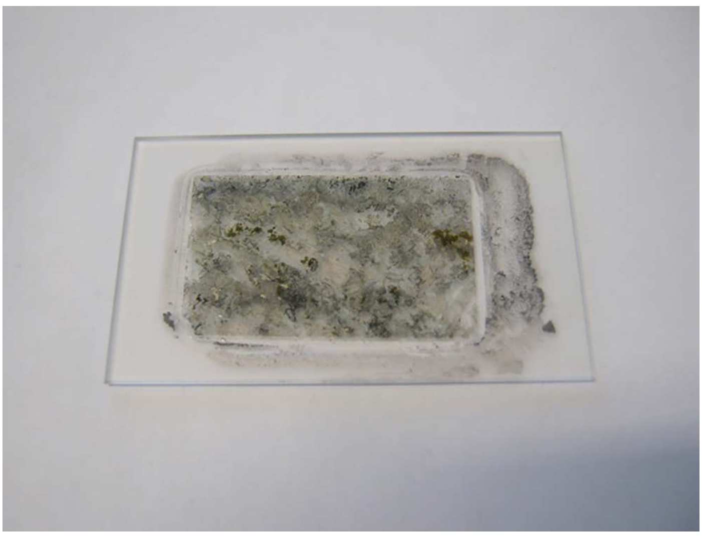
The slices are then set at the bottom of a new cast mold for re-casting, as shown in Picture 3. After re-casting, the mount is left to harden again for 12 hours as with the normal samples. After complete hardening, the mount is processed in similar manner as with the surface mount samples.



Picture 3. Positioning of sample slices for re-casting.

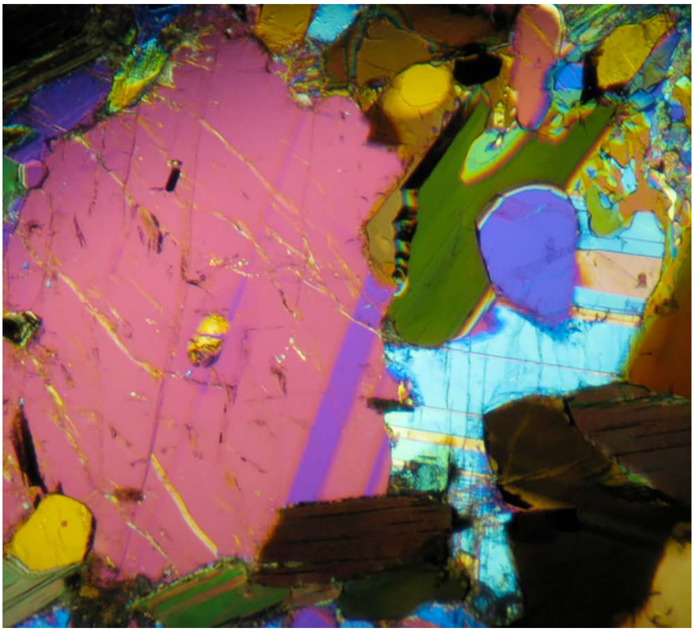
The polished resin mount and a double section resin mount are ground and polished with a Struers Tegramin polishing machine. The relevant settings, i.e. feed rate and rotational speed, are selected for the sample material in question. The settings vary because of the hardness of the sample material. The samples are ground with diamond discs and polished with polishing cloth according to the requested grit. In addition, various diamond suspensions are used to ensure the quality of polishing. After the polishing, the samples are typically ready for further inspection or analysis.

For thin section samples, the workflow is a bit different as the samples are typically cut from rock at the laboratory. The rock sample is cut to a rectangular shape and then glued to a specimen glass for further cutting and grinding procedures. The target thickness for the samples is 30 micrometers. A finished thin section sample is shown in Picture 4.



Picture 4. Geological thin section sample.

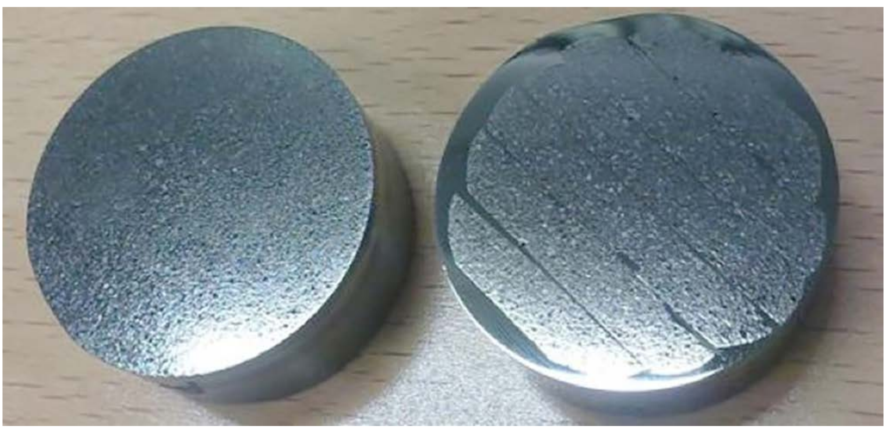
Thin section samples are normally analyzed with a polarization microscope for geomorphological information. Typical, and most often seen, images from polarization microscope analysis show a vividly colored sample with clear grain boundaries. Here, an acquired analysis image is shown in Picture 5.



Picture 5. Image from polarization microscope.

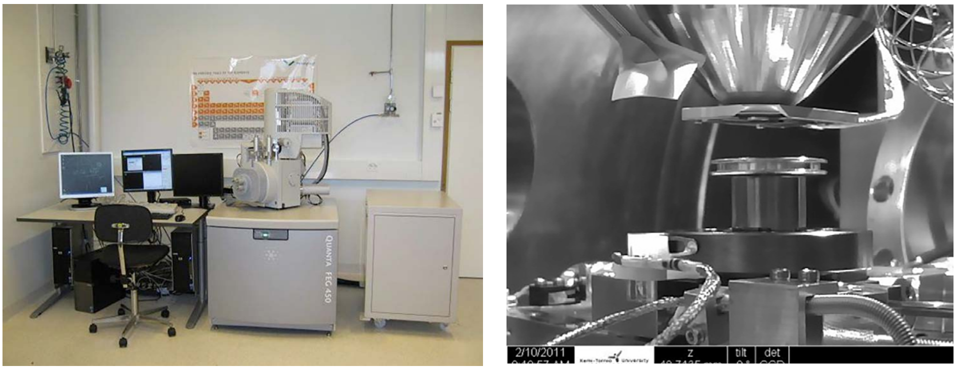
If more detailed analysis is needed, the next step is to analyze the sample with Quanta FEG450 FE-SEM (Field Emission Sweeping Electronic Microscope) EDS (Energy Dispersive Spectrometry).

Typically, samples could be analyzed in FE-SEM directly after polishing, but sometimes the samples are sputter-coated in vacuum with a carbon sputter coater. The coating enhances the resolution for the SEM analysis. An example of a sputter-coated polished resin mount and a double section resin mount is seen in Picture 6.



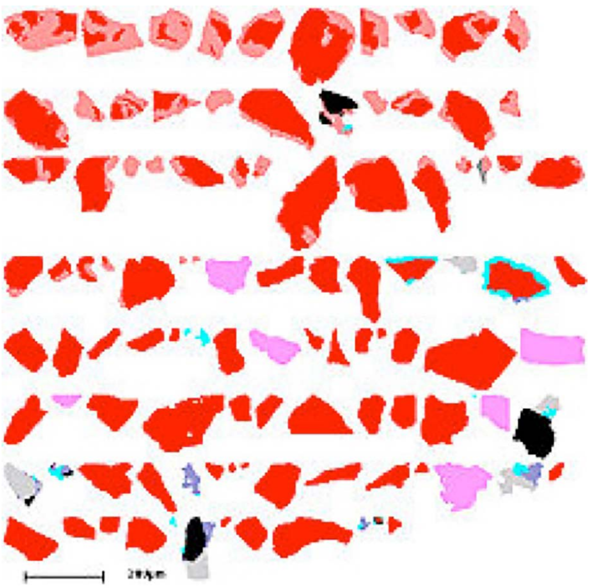
Picture 6. Sputter-coated polished resin mount and a double section resin mount.

FE-SEM and a typical view of the controlling computer is shown in Picture 7. The usage of this machine is only allowed for certified personnel.



Picture 7. Quanta FEG450 FE-SEM.

FE-SEM with the MLA software is used to do a Mineral Liberation Analysis (MLA) of samples or normal spot analysis of base elements. In order to produce a relatively pure concentrate, it is necessary to grind the ore fine enough to liberate the desired minerals, which is roughly interpreted as a liberation analysis. Picture 8 shows a typical MLA result that separates the recognized minerals. Different minerals are shown in different colors.



Picture 8. Different minerals separated with MLA software.

Picture 9. Gold.

For example, in Picture 8, the red particles are arsenopyrite, which can be used as an indicator mineral for gold. The old-fashioned way of finding and refining gold is shown in Picture 9.

CONCLUSIONS

This article is a brief introduction to sample making for mineralogical studies. Several specimen types and their workflows are mentioned for an overview. There are also some examples of the equipment needed for the preparation and analysis of the samples. This article is a small part of the future educational content of studies given to engineering students.

REFLECTION

The overall expectations for the course were to get more vocabulary for the mining industry and mineralogy in both spoken and written English. My personal goal was to be able to use the language in everyday discussions and to understand scientific articles.

The studies in the course were very intensive and required full-time active participation. During the course, I had the chance to become familiar with different research teams and teachers of the Industry and Natural Resources Division of Lapland UAS and to see presentations given by them.

I think one of the challenging things was to produce written English because the whole Intensive English Course was focused on spoken language. When I wrote the article, I learned a simple structure for content and more vocabulary concerning the mining industry. This article could be used in education, for example, during the laboratory exercises.

– Rauno Toppila

Pasi Laurila

Measuring technologies in mine surveying

This article is a short introduction to the modern measuring technologies in mine surveying. Mine surveying is a special field of land surveying. Mine surveyors are involved in every aspect of a mining operation. In particular, mine surveyors are responsible for maintaining an accurate plan of the mine as a whole. Modern surveying technologies are based on electro-optical and digital surveying instruments that are controlled by computers and connected to the Internet. Modern mine surveyors accurately, quickly and efficiently produce various 2D and 3D representations of the real world with the purpose of assisting various mining operations.

LAND SURVEYING

Most people think quite simply that land surveying is the technique, profession, and
Most people think quite simply that land surveying is the technique, profession and science of determining the terrestrial position of points and the distances and angles between them. These positions of points and measurements are further understood to be used to establish various maps, property boundaries and other purposes required by clients and authorities.

A more professional approach to land surveying is to see it as a multidisciplinary science, which has three strong sides, namely measurement science, land management and spatial information management. The strength of the land surveying profession lies in this multidisciplinary approach. Measurement science refers to surveying and mapping. They are clearly technical disciplines within natural and technical sciences. Land management refers to cadastral surveying and land use planning, which are judicial and managerial disciplines within social science. Spatial information management refers to GIS, or geographic information system. A GIS is a link between measurement science and land management. (Figure 1.)

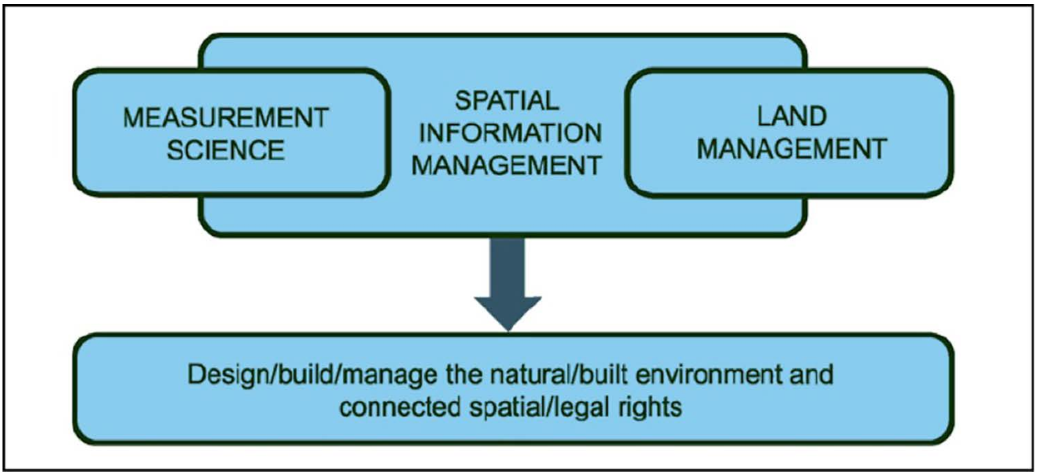


Figure 1. The educational profile of a land surveying engineer (Enemark 2007).

MINE SURVEYING

Mine surveying is a special field of land surveying. Mine surveyors are involved in every aspect of a mining operation. This includes land use planning, legal issues, initial exploration, initial construction of mine operations, ongoing mining works and rehabilitation of the site after mining is completed. Mine surveyors are responsible for maintaining an accurate plan of the mine as a whole. They update maps of the surface layout to account for new buildings and other structures, and they also survey the open-pit and underground mine workings in order to keep a record of the mining operation.

Mine surveyors help find precious and non-precious metals and minerals by measuring mines, tunnels and other underground or surface works. More importantly, the mine surveyors are involved in the measuring process to calculate the ore production, in volume or mass units, from the mining operation. In addition to this, the volume of the dumps of waste accumulating on the surface of the mining property will also be surveyed. This aspect of the work has turned the mine surveyor into a kind of manager of the resources of the mine.

Since valuable minerals occur in a variety of concentrations in the ore, the mine surveyor, in cooperation with the geologist, is responsible for dividing up the ore body into blocks where the average grades of the ore are known. This allows the mining engineer to decide which blocks are economical to extract and which are not. As a result of this information, a plan for the extraction of a blended mixture of low and high grade ores can be made. This planning ensures that the mining process is prolonged, the removal of ore is optimized and the metallurgical processing plant, which will not work well if there are large grade variations, is able to operate at consistently high levels of efficiency. (Figure 2.)

Figure 2. 3D visualization of an extraction plan (red) and extracted ore body (yellow) from Endomines' Pampalo Mine (Ikonen 2014).

Blasting is usually required prior to excavation. The process involves the use of drilling machines to drill a pattern of holes, which are then loaded with explosives and detonated. Surveyors are involved in the process by setting out pegs or other marks for an area to be prepared for drilling, pegs for drill operators to know where to drill, as well as surveying the material once it has been blasted. In open pit mines, machine guidance systems may be in use. Drilling machines have GPS receivers attached and they are able to drill a pattern without the use of pegs. The surveyors are the operators responsible for these machine guidance systems.

Safety is possibly the biggest issue in any mine, and it is the mine surveyor who plays an important role by accurately locating potential hazards, such as flooded tunnels. Finally, plans prepared by mine surveyors become very important historical documents not only for future mining of the site but also for various future developments and environmental planning of the site.

CONTROL SURVEYS

The surveying starts from control points. They are used to define a coordinate reference system, vertical reference system or combined 3D coordinate system. The coordinates and elevations of the control points are measured with special control survey methods. The purpose of control surveys is to provide a uniform framework of reference for the surveying activities within a given area. Triangulation and traversing are used to define the coordinates of control points. Total stations and GPS receivers are used to make the necessary measurements for coordinates. For a vertical reference system, line leveling is the most accurate method to define elevations of vertical control points, or benchmarks.

A baseline is the simplest way to establish the coordinate reference system. Two control points define the baseline and the reference system. The mine baseline is usually oriented in the direction of the ore deposit. It is often taken as the X axis of the rectangular coordinate system (Figure 3). The reference system is easily extended from the baseline by traversing or by triangulation with a total station.

In general, reference systems can be local, national, continental or global systems. Mine reference systems are quite often local systems. Anyway, coordinate transformations between local and national systems have to be defined, because the national authorities use documents and GIS data sets on the national system. (Mining Act 621/2011; Government Decree on Mining Activities 391/2012.)

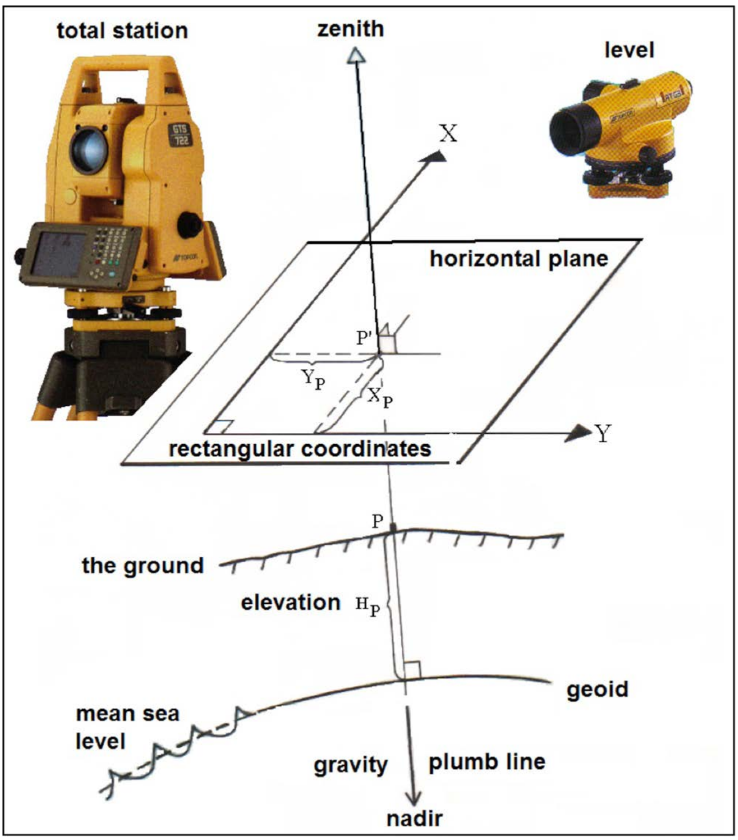


Figure 3. A coordinate reference system defines the rectangular coordinates on a horizontal plane. A vertical reference system defines the mean sea level, or another reference level, from which elevations are measured. Total stations and levels are common surveying instruments used to measure coordinates and elevations. (Laurila 2012.)

SURVEYING TECHNIQUES AND EQUIPMENT

Mine surveyors use various surveying techniques and instruments, including total stations, laser scanners, satellite positioning and aerial surveying methods, to make their measurements of surface and underground works. Modern surveying instruments are electro-optical and digital devices that are controlled by computers and connected to the Internet.

TOTAL STATIONS

Total stations, or tachymeters, are one of the most common surveying instruments used today (figures 3 and 4). They consist of an electronic theodolite and an electronic distance measurement (EDM) device. A theodolite is used to measure horizontal and vertical angles. Robotic total stations are available which allow for single-person operation by controlling the instrument using remote control. Robotic total stations are also capable of scanning the objects, but they are much slower scanners than the special terrestrial laser scanners are. In general, robotics allow for the automation of measurements. Robotics and automation are important in, for example, hazardous places where occupational safety is in question.

Total stations are used with a prism which reflects light signals back to the measurement device to determine a distance measurement. Most total stations can also be used in reflectorless mode. Then they can obtain a distance measurement to an object without the use of a prism. Total stations have the ability to record measurements on data recorders or field computers. The measurements can be processed using computer software in the field or in the office after returning from the survey.

Total stations are not only used for collecting surveys, but also for setting out designs. Using a prism on a plumbing pole, a surveyor can determine where pegs or other marks need to be placed. Most total stations have setting out features and they can use loaded design information to determine where the prism is located with reference to the control points or the design lines. (Figure 4.)

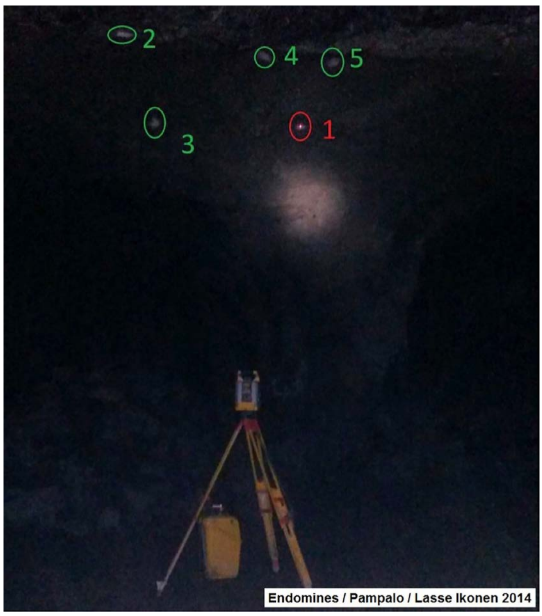


Figure 4. A total station is used to set out the drilling pattern in Endomines' Pampalo Mine (Ikonen 2014).

LASER SCANNERS

A laser scanner combines an electronic distance measuring device and a two-dimensional orientation measuring device with a scanning mechanism (Figure 5). A terrestrial laser scanner is like a fully automatic total station. The output of laser scanning is often referred to as a point cloud. The term comes from the visualization of the measurements. The points are colored according to the intensity or distance of the return signals, and the resulting image appears as a combination of closely spaced dots (Figure 6).

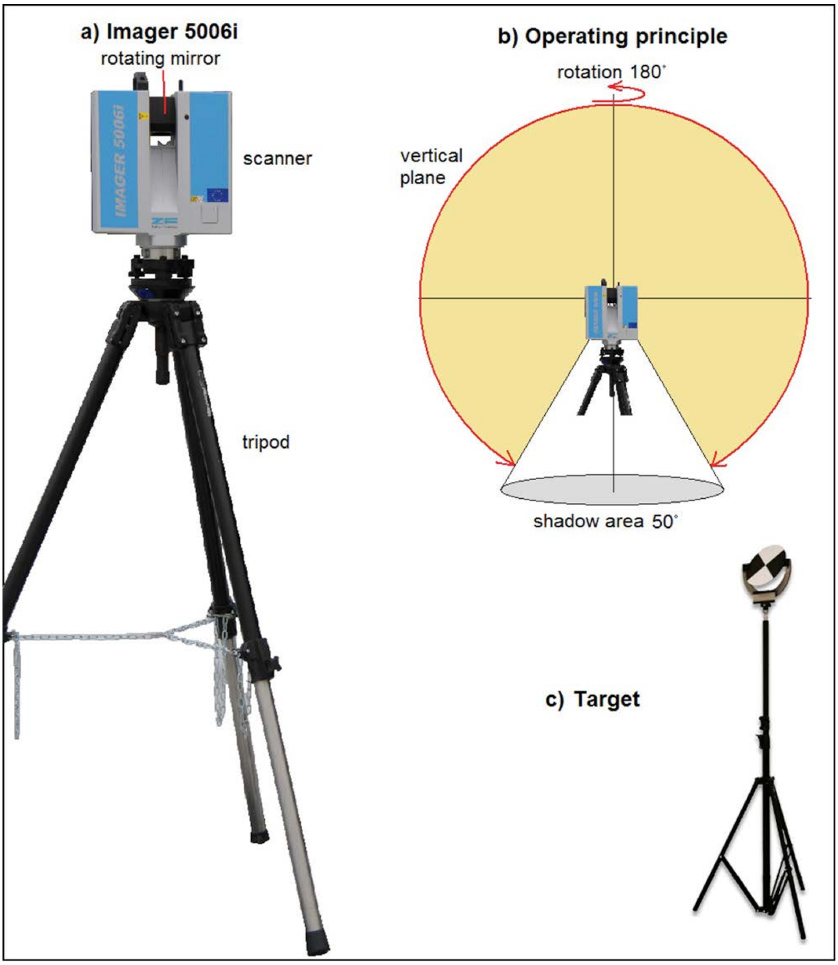


Figure 5. Terrestrial laser scanner Imager 5006i by Zoller Fröhlich (Laurila 2012).

The primary capability delivered by laser scanners is to be able to measure very detailed, very accurate 3D coordinate information across wide areas and to long ranges in relatively short periods of time. It is common for laser scanners to produce hundreds of thousands of measurements in a second. No access to the scene being scanned is required, which is important in inaccessible or hazardous places.

Laser scanners have heavy reliance on software processing to enable the delivery of useful results. The point clouds produced as raw data from laser scanners, while visually impressive, are not immediately applicable as survey deliverables. Generally, they require the use of specialized software algorithms and workflows to be fully effective.

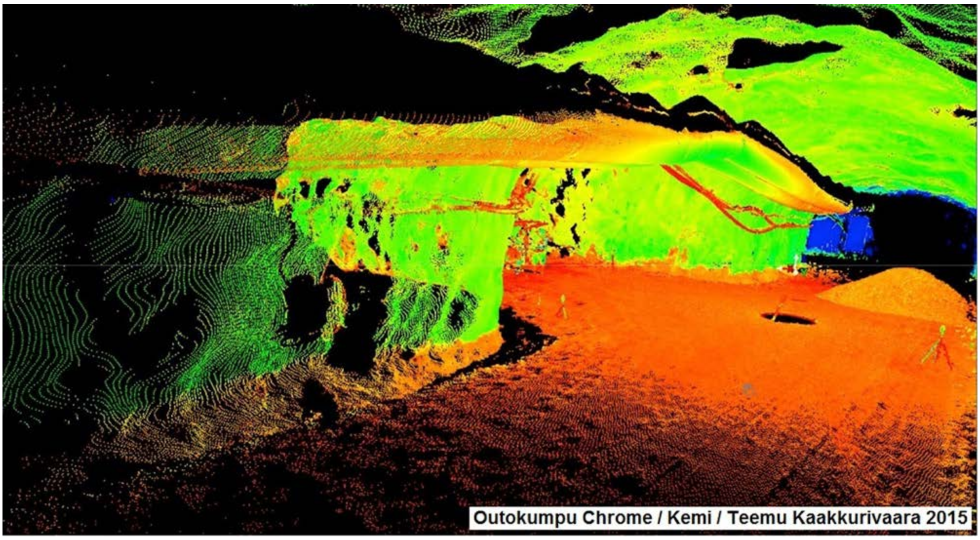


Figure 6. A colored point cloud from Outokumpu Chrome's Kemi Mine (Kaakkurivaara 2015).

SATELLITE POSITIONING

For most people, satellite positioning means GPS, or Global Positioning System. Professional users of satellite-based positioning are already used to the abbreviation GNSS, or Global Navigation Satellite System. Current fully-operational Global Navigation Satellite Systems include the American GPS and the Russian GLONASS. In addition, the European Galileo and the Chinese Compass systems are under development. Satellite positioning offers user friendly ways to define one's position even on millimeter accuracy.

Satellite positioning is based on accurate time determination. The satellite receiver measures the time difference between the transmitted and received radio signal. The time difference denotes the signal travel time, which reveals the distance between the satellite and the user antenna. Utilizing distance measurements between the user antenna and four different satellites, the receiver can calculate receiver coordinates in a global 3D reference system, which is known as WGS84.

Mine surveyors have to work on centimeter accuracy, or better. This is possible with relative positioning techniques, which employ two or more receivers simultaneously tracking the same satellites. Of the two receivers, one is selected as a reference, or base, which remains stationary at a control point. The coordinates of the other receiver, known as the rover, are unknown. They are determined relative to the base using measurements recorded simultaneously at the two receivers. The rover receiver may or may not be stationary, depending on the type of the survey operation.

Real Time Kinematic (RTK) surveying is a relative satellite positioning technique that is especially important for mapping and setting out surveys. It offers centimeter accuracies in real time. RTK surveying uses measurements of the phase of the signal's carrier wave, rather than the information content of the signal, and relies on a single reference station or interpolated virtual station to provide real-time corrections, providing up to centimeter-level accuracy. (Picture 1.)

Satellite positioning is possible when there is a line of sight from the receiver antenna to the satellites. This means that satellite positioning is not possible in underground mines.

Picture 1. Base and remote receivers for real time kinematic (RTK) survey. The base receiver is at a control point. In the middle can be seen the antenna of the radio modem. From Lappland Goldminers' Pahtavaara Mine. (Puro & Vedenpää 2013.)

AERIAL SURVEYING METHODS

Aerial surveying refers to various methods of collecting imagery by using airplanes, helicopters, UAVs or other aerial methods. Typical types of data collected are images on various visible and invisible bands of the electromagnetic spectrum, such as visible, infrared or microwave bands. Geophysical data, such as aeromagnetic or gravity data, is also collected. Aerial surveying should be distinguished from satellite imagery technologies because of its better resolution, quality and different atmospheric conditions.

Photogrammetry is a 3D coordinate measuring technique that employs the use of multiple aerial photos which are triangulated. Working in the same fashion as human eyes do to perceive depth, using multiple photos will derive similar information. A mathematical intersection between two photos can be used to determine 3D measurements.

In mining, aerial photogrammetry can be used, for example, for general mapping and environmental monitoring. Aerial photogrammetry may also be implemented into GIS systems for visualization, modeling and analysis purposes.

Airborne laser scanner refers to a remote sensing instrument which uses infrared laser to produce point cloud data of a large area while flying over it. Laser scanners are often used in mining to assist with engineering and surveying applications.

The most recent development in aerial surveying is the use of unmanned aerial vehicles (UAVs). They are remotely piloted light aircraft that can carry cameras, laser scanners and other sensors. Advances in miniaturization, communications, strength of lightweight materials and power supplies have permitted significant advances in UAV design. The abbreviation UAV refers usually to the aircraft only. UAS, unmanned aerial system, is a more comprehensive abbreviation. It also includes the ground control system and pre- and post-processing software. (Figure 7.)

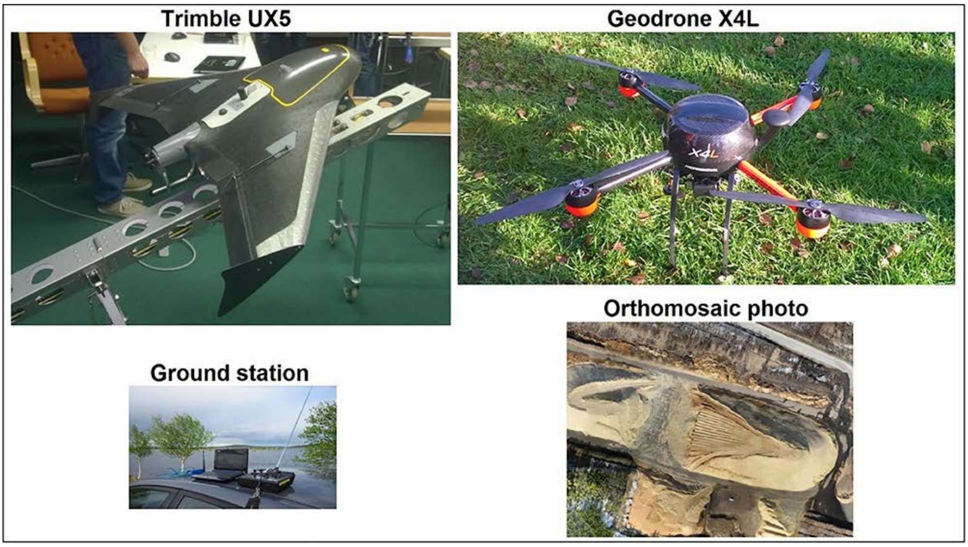


Figure 7. An unmanned aerial system (UAS) is a combination of hardware and software that produces 2D and 3D data and image products, such as digital terrain models and orthomosaic photos.

CONCLUSIONS

Mine surveyors are land surveyors who work in demanding conditions in open-pit and underground mines. They are capable of using highly sophisticated surveying techniques to accurately, quickly and efficiently produce various 2D and 3D representations of the real world with the purpose of assisting various mining operations. In every mine, you can find a mine surveyor, or even two or more. In particular, mine surveyors are responsible for maintaining an accurate plan of the mine as a whole. Quite often they do more than that. Land surveying is a multidisciplinary science, and educated mine surveyors are capable of working in every aspect of a mining operation. Mine surveyors could be thought of as of managers of the resources of the mine.

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REFLECTION

After high school in 1974, my teacher told me that you know English well, but your pronunciation is quite Multian. She referred to my home place Multia in Central Finland. In the 1980s I worked in Saudi Arabia, and in the 1990s I taught Namibian students at Tampere University of Technology. Later I have taught exchange students in Rovaniemi. After all these years, my pronunciation is still quite Multian. It is not something I am ashamed of, it is part of my personality, but it was my main reason for starting the Wonder Pot club's English course in spring 2015. I liked to exercise and improve my spoken English.

At the Wonder Pot club's school, the students had alter egos. I decided that my alter ego was Ernst Hemingway, the late famous novelist and Nobel Prize winner in literature. He is not my favorite novelist, but I felt deep sympathy toward him among the other possible alter egos. I like to read and write. Mainly I read science and history books. I am very proud that have written one lecture book on land surveying and several articles for professional magazines. I am a member of the Finnish Association of Non-fiction Writers. So, I liked to be the novelist of the Wonder Pot club.

We had three busy school weeks in Loma-Vietonen, where the campus of the Wonder Pot club is located. The first week was in February, the second in March and the third in April. We listened, talked, read, played and sang, of course in English, as the fundamental rule of the club says. We had great times there in Loma-Vietonen. An important part of the day was that every night, after a long and hard day's work, we had dinner and sauna with good stories and normal beverages.

Between the school weeks, we also had some homework to do. The most demanding work was an essay and presentation for the third school week. Everyone could select his or her topic. My selection was "Measuring Technologies in Mine Surveying". I am very much interested in this specific part of land surveying, which is really important for the planning and safe operating of all kinds of mines. I did my best as the novelist of the Wonder Pot club. I am proud that the article will be published now. I wish that I have the time and energy to continue with other articles related to mine surveying. I also wish to have an opportunity to use my knowledge of mine surveying to educate future mine surveyors.

– Pasi Laurila

Janne Poikajärvi & Juha Vesa

Underground mining

This task was originally given at an English course early this year. We were handling underground mining because it is familiar to us. The task was to prepare a compact presentation about underground mining to our colleagues. It was challenging to explain things briefly because underground mining has so many different sections.

EXCAVATION AND DRILLING

UNDERGROUND MINING

Each mine is unique. Some mines have been in continuous operation for more than centuries (e.g. the Rio Tinto mine in Spain) while others are just starting up. The start-up phase can last many years, even many decades (e.g. the Sokli project in Finland). A mine can operate as an open pit mine or an underground mine. An underground mine (UG) is a challenging working environment. Protecting the health and safety of the workers is important in mining operations.

Picture 1. Stope recovery blast, AEF Kittilä mine (photo: Juha Vesa).

EXCAVATION IN UNDERGROUND MINING

"The underground mine is located in the bedrock inside the earth in which miners work to recover minerals hidden in the rock mass. They drill, charge and blast to access and recover the ore. The ore is taken to the surface to be refined into a high-grade concentrate." (Jennings 1998.) The basic underground mining work is the same all over the world, but in Finland there are some challenges. One key challenge is the hard rock. This means more holes drilled and a higher energy consumption. But on the other hand, this means good stability in the tunnels and other underground areas.

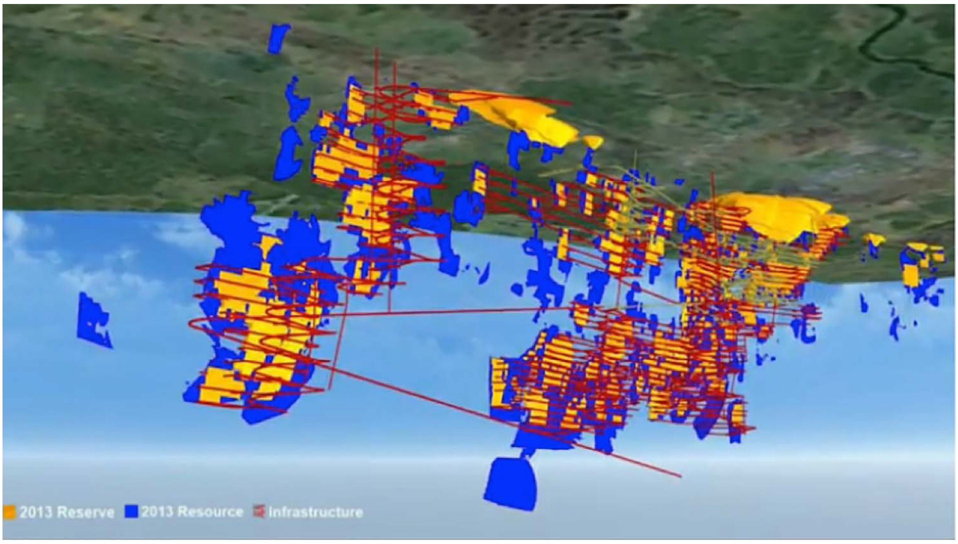

Figure 1. Ore body and underground mine structures (Agnico Eagle Finland 2015).

An underground mine needs a special underground infrastructure. There is a need for shafts, tunnels and chambers. Almost all mining activities are located underground. Quite often, crushing is done underground and the crushed rock is hoisted or hauled to the surface. All underground openings need services such as exhaust ventilation and fresh air. Of the need of fresh air, 80% is caused by diesel engines even though nowadays we use lots of electrical devices.

MEASURING, DRILLING AND BLASTING

The first phase in underground excavation is measuring. Nowadays, the tunnel network is laser scaled and the information is quickly available for use in mine planning. This is also a health and safety issue, because the stability of the bedrock must be observed. After planning, it is time to drill holes. The drilling is mainly done by face drilling rigs (see picture 2).

Picture 2. Face drilling rig (Atlas Copco 2015).

The drilled holes are charged with emulsion or bulk explosives which can be blasted with boosters and detonators. Modern blasting is done by electronic detonators. This can only be carried out with special equipment and it is an important safety issue.

After blasting, ventilation is needed because of the dangerous gases from the blast. Quite often, the rock material is also watered to prevent a dust problem.

LOADING AND SCALING

LOADING AND HAULAGE EQUIPMENT

Blasted rock material is loaded with a wheel loader and hauled by an underground truck. Modern wheel loaders are semi-automatic or automatic machines. Diesel and electric engines are used. Rock haulage is done by underground trucks or by normal trucks equipped for underground conditions.

In stopes and other dangerous working environments where the worker's safety cannot be guaranteed, the machine can be operated by remote control. There is also equipment that can work automatically on the basis of certain data.

Picture 3. Underground wheel loader (photo: Janne Poikajärvi).

Picture 4. Underground wheel loader remote control unit (photo: Janne Poikajärvi).

SCALING AND REINFORCEMENT

Loose rock material is scaled from the tunnel roof and walls by a scaling rig. Scaling is an important part of safety in underground mines. Loose rock can cause accidents for workers and equipment. That is why it is important that all loose rock material is scaled from the tunnel roof and walls.

Picture 5. Scaling rig (Normet 2015).

The reinforcement of tunnels is very important for mining safety. The phases of reinforcement are bolting, screening and shotcreting. The length of the bolts varies from 1 meter to 40 meters. The bolts are made from steel wires, bars or tubes. Nowadays, the reinforcement work is done by a machine.

DEWATERING

There is a lot of water present in an underground mine. The water is removed from levels by gravity and from the tunnel by pump to the surface. Dewatering is critical work, because if we fail to do it properly, it can complicate or even prevent the whole operation.

Underground mine water contains lots of fine rock materials, which are removed by clarification. The residual material is disposed in a waste rock area according to the environmental permit.

CONCLUSIONS

Working in an underground mine is quite tough and demanding but not dangerous. Safety always comes first. Anyway, most people think that working in an underground mine is dangerous. In our opinion, the reason for this is that people do not have the basic information about how the work is done in underground mines. It is important to give honest information about what kind of a working environment an underground mine is.

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REFLECTION

By participating in the English course, I expected to get some practical tools to do teaching in English. My personal goal was very clear: it was to activate and improve my English skills.

Studying in this course was very activating and modern. Compared to the lessons in which I have previously taken part, this was more interesting and effective. The working days were long and in the evening we were exhausted. The teacher, Dominic Landon, is an innovative professional and the implementation of course was great. The teacher was very lively and spontaneous. I think that was the reason why the group was well activated, everybody had to take part in the conversations. The time in classes went fast because we were working fingers to the bone all the time.

When I was writing the article, I was rereading familiar things about mining. The challenge of writing the article was to find the right mining terms in English. This course gave a good foundation for using English in different kinds of situations. Also professionally, it was good to activate the mining vocabulary and also use it in practice.

- Juha Vesa

Lauri Kantola

Hydraulics and pneumatics in mining applications

This article provides basic knowledge on hydraulics and pneumatics in mining applications. These two energy transfer methods are widely applied in the field of mining. Both hydraulics and pneumatics are applications of fluid power. Pneumatic systems utilize gas (normally air) in energy transfer, while hydraulic systems utilize fluid (normally hydraulic oil). The main difference between these mediums is that gases are easily compressible while fluids are practically rigid. Therefore, these energy transfer methods have application areas of their own. In the mining industry, pneumatics (P) is usually applied in enrichment plants, laboratories and workshops. Hydraulics (H) is typically applied in mobile machinery and heavy duty applications (drilling, crushing, etc.). These systems (H/P) are usually automated at least at some level.

A fluid power system generally consists of four main phases:

- Phase 1: Creating hydraulic or pneumatic energy and delivering it to the system
- Phase 2: Manipulating the energy content by adjusting the pressure (p) or flow (Q)
- Phase 3: Directing the energy flow in the desired direction
- Phase 4: Using the energy for work (drilling, crushing, blowing, etc.)

Automation takes place especially in phases 2 and 3. Manipulating or directing energy is normally carried out by using valves. In modern industrial systems, valves are electrically controlled. Electrical control of pressure, flow or flow direction means that the energy of the system can be controlled. In Phase 4, actuators play the main role. The most typical actuators are cylinders (linear motion) and motors (rotation). The actuators may be equipped with sensors or limit switches providing additional information for the automation system. In Phase 1, automation may help the energy supply to work efficiently and economically.

This article introduces some common applications utilizing hydraulics or pneumatics. I hope that the article will guide the reader to the world of fluid power. This article is primarily meant for mining engineering students who are willing to learn basic information about hydraulics and pneumatics. Teachers may use the article as a part of a course.

PNEUMATICS IN MINING

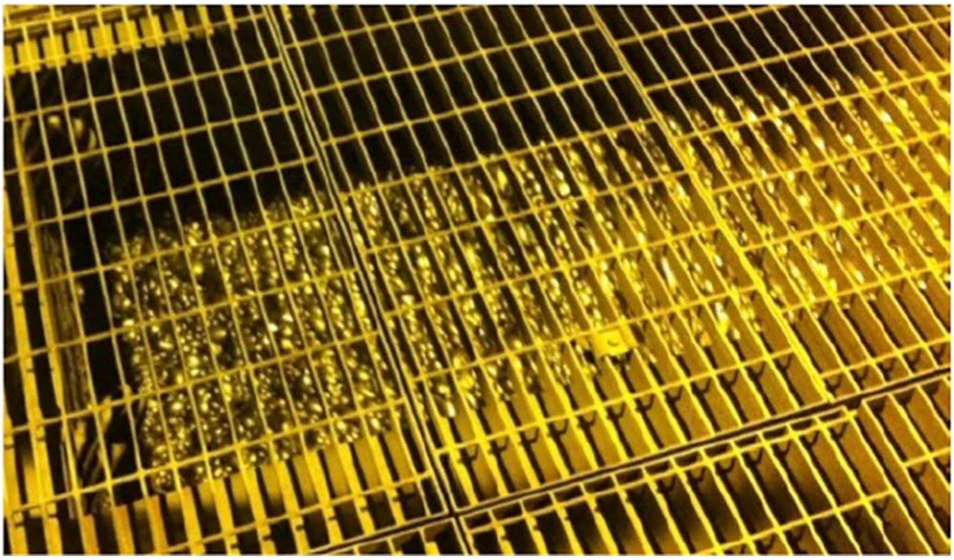
Pneumatic energy, or compressed air, is created by compressing atmospheric air using a compressor. There are several compressor types available, but the most common one is a screw compressor. In mining applications, special types of blowers are applied as well. The main difference between compressors and blowers is the pressure. Compressors build up a higher pressure than blowers. The main task of a compressor is to produce an adequate pressure and air flow.

In the mining industry, pneumatic applications can be found in enrichment plants, laboratories and workshops. The most typical applications or processes utilizing compressed air are:

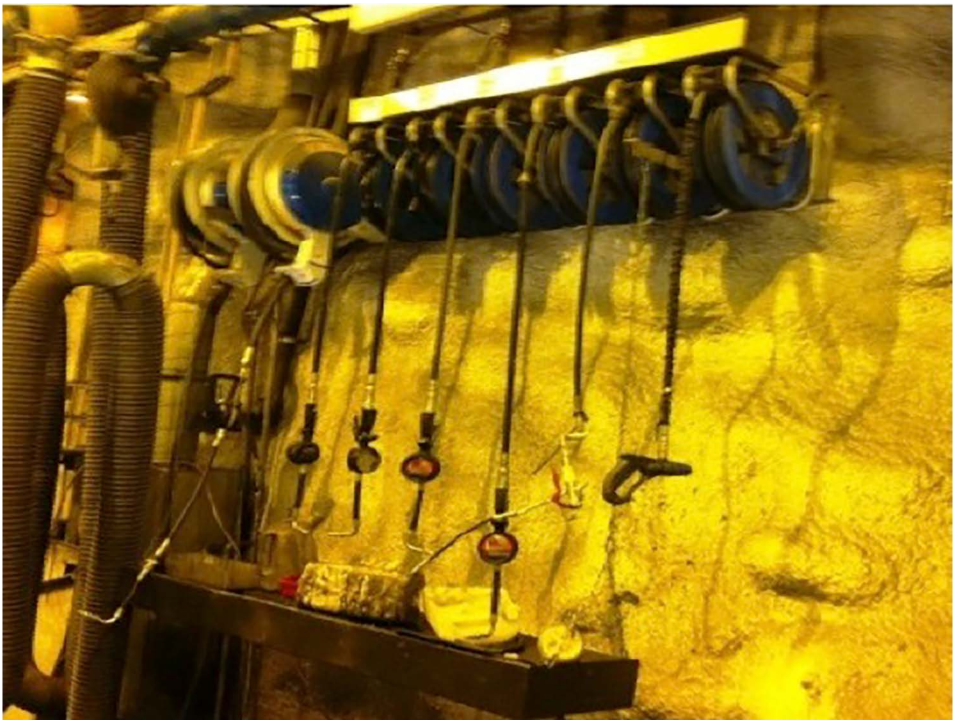
- Enrichment plant – flotation – pneumatically driven process valves, froth (Picture 1), etc.
- Laboratories – lab. equipment – compressed air is used for handling, cooling, cleaning, etc.
- Workshops – tools – compressed air is used for screwing, bolting, grinding, etc. (Picture 2)
- Machinery – drilling – for example, air hammers consume huge amounts of compressed air

The most important technical values for compressed air systems are:

- Pressure – Pa, Bar, MPa, KPa – usually ~ 8 Bar
- Flow – l/min, l/s, m3/min, m3/s – usually ~ 20 l/s…1 m3/s
- Power – compressor power = electrical power consumption – usually ~20 kW….0.5 MW
- Air consumption – equipment consumes air – the value of air consumption indicates how much



Picture 1. Froth created by compressed air.



Picture 2. Pneumatic power tools.

HYDRAULICS IN MINING

Hydraulic energy is created by using a hydraulic energy unit. The main components of the hydraulic energy unit are a hydraulic oil reservoir, electric motor (or combustion engine), hydraulic pump, filters and instrumentation. Hydraulic energy units may be mobile or stationary. The shape, size and other key properties of the unit are application-specific. Hydraulic oil transfers energy from the energy unit to actuators. Hydraulic oils are special oil-based liquids capable of transferring energy, cooling and lubricating components of a hydraulic system. Actuators are typically hydraulic cylinders or motors. Cylinders produce linear motion, high forces and are typically dual acting. Motors produce rotating motion and high torques. The mining industry is considered as a heavy industry. Therefore, hydraulic energy is used almost everywhere:

- Mobile machinery – drilling – hydraulic energy for moving, drilling, boom handling, etc.
- Processes – process equipment – crushers, grinders, cranes (Picture 3), etc.
- Material handling – equipment – jacks, manipulators, conveyors, etc.
- Equipment – lubrication – hydrostatic and hydrodynamic bearings

The most important technical values for hydraulic systems are:

- Pressure – Bar, MPa – usually close to 200 Bar (= 20 MPa)
- Flow – l/min – usually from 20 l/min to 150 l/min
- Power – hydraulic power – usually 20 kW….150 kW

Picture 3. Underground hydraulic manipulator.

UNDERSTANDING CIRCUITS – ISO 1219

The ISO 1219 (ISO 1219-1:2012) standard establishes the basic elements for hydraulic and pneumatic symbols. Fluid power systems can be expressed (or drawn) by using the symbols. A hydraulic or pneumatic circuit (or schematic) is the most common way to express a system structure. The circuits can be drawn by using special circuit drawing software or a 2D CAD tool. Some of the computer-aided tools allow functional simulation as well. For engineering calculations, there are formulas and computer-aided tools available.

Understanding the standard symbols is essential for understanding fluid power systems. There are hundreds of system components on the market, so the area of fluid power system design is wide. Figure 1 shows an example of a hydraulic circuit. What can be seen from the figure are actuators (5 dual acting cylinders), direction control valves (4 proportional valves and 1 solenoid valve), flow control valves (2 two-way flow control valves) and safety features (10 solenoid-operated 2/2 lock valves). Additional information in the drawing is given by using texts (e.g. cylinder sizes), letters (e.g. ports A, B, etc.) and electrical symbols (e.g. analog position sensors and pressure sensors).

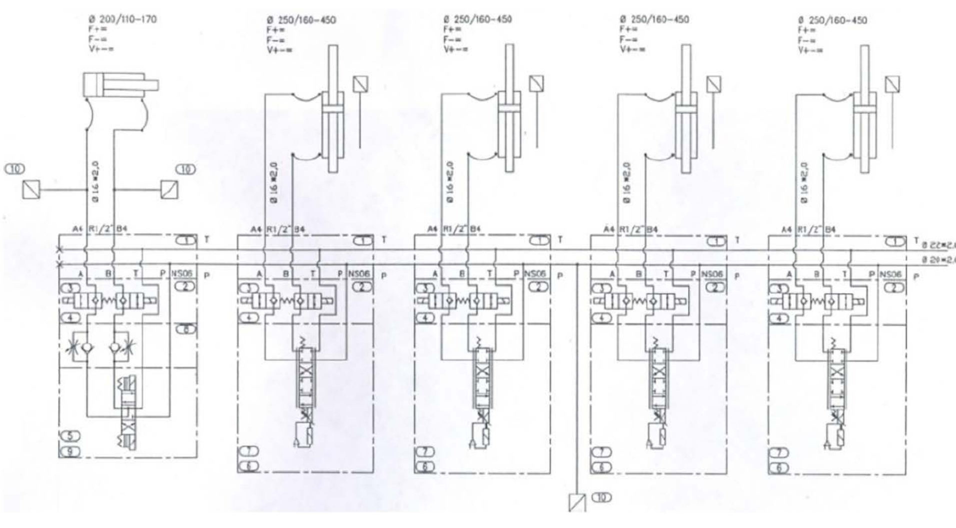


Figure 1. An example of a hydraulic circuit.

HYDRAULICS AND PNEUMATICS AT LAPLAND UAS

Lapland University of Applied Sciences (Lapland UAS) provides engineering education on hydraulics, pneumatics and other related topics. Students of mechanical engineering have approximately 15 ECTS credits of machine automation studies in the curriculum. The machine automation laboratory is located on the Kemi campus and was rebuilt in 2012. The laboratory equipment was supplied by Festo Gmbh. In the laboratory, hydraulics and pneumatics are learned in an active manner. The students are able to draw, simulate and build hydraulic and pneumatic circuits. A variety of measurements can be carried out and recorded. A data acquisition interface allows both measurements and control. The valve technologies include manual and passive components, solenoid valves, open loop proportional technologies and closed loop servo systems.

The machine automation laboratory markets its services for the local industry as well. The local industry consists mainly of steel, paper and mining companies. It is important that Lapland UAS is able to serve the companies and constantly perceives the needs and wishes of the professional field. During the academic year, there are three to four special courses arranged for the industry. Both standard and customer-specific courses are available. The industry partners force us to keep the premises up to date and develop our services and expertise. This kind of service business is very important for the faculty of Industry and Natural Resources of Lapland UAS. Picture 4 shows the machine automation laboratory.

Picture 4. Machine automation laboratory.

CONCLUSIONS

This article is a short introduction to hydraulics and pneumatics in mining applications. The target group is the students who want to learn things about machine automation and fluid power systems. The content of the article is loosely based on the wider study that was made by the writer for the GeoProsPD program during the years 2013–2014. The GeoProsPD is a 60 ECTS professional development program at the University of Oulu that consists of mining-related lectures, seminars and workshops as well as individual project work.

SOURCES:

ISO 1219-1:2012. Fluid power systems and components - Graphical symbols and circuit diagrams - Part 1: Graphical symbols for conventional use and data-processing applications.

REFLECTION

The English course for mining was held at the Loma-Vietonen holiday village during spring 2015. There were three sessions of three days each. The teaching (or learning) method used in the course was suggestopedia.

At the beginning of the course, the method was quite difficult to understand, but when I look back I must say that it worked very well! The peaceful and comfortable surroundings, music, physical exercises, etc. helped the students to concentrate on the topics and on the language.

My personal expectations regarding the course were to make my English more fluent, practice oral discussion skills and learn new vocabulary. During the course, I was lucky to meet great people from the university, developed my professional skills, gained confidence to use the language and improved my vocabulary.

It is now much easier to communicate and teach in English, especially in difficult situations. Special thanks go to my famous and glamorous co-students and the teacher Dominic Landon! Hope to meet you again, “Jack”, and wish you all the best!

– Lauri Kantola

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This publication is based on the English course that strengthened the language skills of the teachers in the School of Industry and Natural Resources at Lapland University of Applied Sciences. The course was funded by the Northern Mining Network project, in which Lapland and Kajaani Universities of Applied Sciences are together developing international cooperation and networking in the mining industry.

The participants of the suggestopedic intensive English course were teachers, senior lecturers, principal lecturers and project workers from R&D at Lapland UAS. The target was to be prepared to give lectures in English and to be able to participate in international projects.

This publication gathers together presentations written during the course. The articles include presentations of the current state of the mining industry, teaching, laboratories at Lapland UAS, projects, etc. The course was a success, and the results, namely being able to speak and learning mining-specific vocabulary, developed decisively.

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