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## UNIVERSITY EDUCATION IN MINING AT THE BEGINNING OF THE THIRD MILLENIUM\*

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A short review of the world mining situation at the beginning of the new millennium is given. A comparison between the mining industries of Croatia and the USA regarding production per capita is presented. The basic information about the European Mining Course (EMC) is also given, as well as about the university education in mining at the Faculty of Mining, Geology and Petroleum Engineering in Zagreb.

**Ključne riječi:** Rudarstvo, Rudarstvo u Hrvatskoj, Sveučilišna edukacija u rudarstvu

Prikazano je ukratko stanje rudarstva u svijetu na početku novog milenija. Rudarstvo u Hrvatskoj uspoređeno je s rudarstvom u SAD-u po opsegu proizvodnje po stanovniku. Prikazane su osnovne informacije o Europskom rudarskom studiju (European Mining Course - EMC), te o izobrazbi rudarskih inženjera na Rudarsko-geološko-naftnom fakultetu u Zagrebu.

### Introduction

In the last thirty years the university education in mining has been a much discussed subject in western, industrially developed countries due to the insufficient number of students interested in these studies. Mining, as a branch of economy, is continually increasing; however, its image does not follow up.

The mining industry, as one of the basic and oldest branches of economy, often reported about by newspapers as associated to many accidents, with mines located very far from urban areas, has apparently ceased to be a challenge for students at the end of the century. The situation is not the same in industrially underdeveloped regions of the world, where the youth is not as fastidious, and universities do not have problems enrolling a sufficient number of students.

### A Glance at the Mining Industry

**World Mining.** The importance of world mining for society at the end of the second millennium may best be illustrated by the motto of the last XVIII World Mining Conference held in October 2000 in Las Vegas (USA): "*If you can't grow it, you have to mine it*".

Mining is as old as civilisation. However, in the last century more minerals have been excavated than in all the preceding millennia. As far as reserves of mineral resources in the world are concerned, there are no reports about shortage of any metal or non-metal raw material in the foreseeable future. The reserves of fossil and nuclear fuels are greater than experts have estimated several decades ago, when petroleum and gas reserves have been known of for only forty years ahead. Independent of the increase of reserve quantities in the last several decades and the continual increase of production - this being a consequence of enhanced investments into research studies - this type of race evidently has an end. The quantity of fossil fuel reserves is limited. All the prognostications about petroleum, gas and coal reserves prove that coal is still at the top.

The production of minerals according to quantity and quality is generally on the continual increase. Numerical

data about the production of minerals can be found in a number of data bases (Vujec, 1999). The continual increase in production at the average of 2-3% a year is due to a global increase in population, improved standard of living and many other factors. No changes in this regard are being predicted for the coming century either. The constant oscillations in supply and demand on both the local and world markets make for the changes in prices, and thus also for the production quantity of a particular mineral.

The establishment of big multinational companies (globalisation), who dictate developments on the world market of minerals, has been an unstoppable process in the last decades. Statistical data show that mining companies are far behind companies from other industrial areas. Thus, in the yearly publication "Who Owns Who" of the Swedish RMG (Raw Materials Group) (Hinde, 2000), the total value of the 10 wealthiest mining companies has been estimated at 80 billion USD, whereas the value of BPAmoco & Exxon Mobil has been estimated at 520 billion USD, and America Online merged with Time Warner at 182 billion USD. The same publication also presented the fact that the total value of global mergers and acquisitions of companies during 1999 amounted to 3400 billion USD, whereas in the mining group it amounted to only 19 billion USD (0.6%) in the same period.

The estimate about the value of total world mining production of minerals is very interesting. The value of the yearly petroleum production for 1999 has been estimated at 800 billion USD (73 million bbl/a day, 30 USD/bbl), and other minerals at 300 billion (coal 110, gold, alumina and copper 20 each, iron ore 15 etc.). The production is performed with the most up-to-date and sophisticated technology. The times of the pick and shovel are far behind us, and the security level (in view of the number of accidents) is among the highest compared to other industrial areas (civil engineering, agriculture, transport etc.).

In developed countries of the world environmental protection and reclamation is part of the mining production cycle of each and every plant and company. The legislative ruling ensures that from research to projecting of a mineral deposit care is taken about the influence of exploitation on

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the environment, and about excavation and reclamation completion, so that the effect of this process is most acceptable for the environment.

Through recycling of metal products countries managed to substantially diminish the demand for certain metals. Today recycling is an important economical activity, indispensable in the sense of environmental protection and energy saving.

**The Mining Industry in Croatia.** After the bauxite mines for aluminium production ceased (1990) and soon after the last coal mine in Tupljak was closed down (1999), the mining industry in Croatia needed a recovery from an apparent psychological setback caused by numerous newspaper articles on "Last Coal Mine in Croatia Closed Down". In reality this statement was only partly true. In the "golden age" of mining in Croatia, i.e. before and after the II World War, lignite, brown and bituminous coal were excavated in many companies almost throughout Croatia. Alumina was dug out in Istria and Dalmatia in many

How developed Croatia's mining industry is, we will try to estimate through a comparison with the USA mining industry as the first mining power in the world. For the comparison to be possible we will present the consumption rate (USA) and production rate (Croatia) for particular groups of minerals (Table 1).

The mining industry in Croatia produces about 30 million tons of minerals or 6305 kg per capita, which is only 29% of the production in the USA. It does not surprise that Croatia does not produce metallic minerals or fossil and nuclear fuels in sufficient quantities, since such mineral deposits are poor on its territory; however, it is characteristic that Croatia's per capita production of raw materials for the building industry amounts to only 43% - gravel, sand, stone - of which we have enough, and the need is substantial in view of the condition of the traffic infrastructure. The said quantities of minerals are produced by 225 companies in Croatia, employing 8 400 workers in the mining industry. Apart from a number of exceptions, the compa-

Table 1 Consumption (Production) of Minerals (1999)  
Tablica 1 Potrošnja (proizvodnja) mineralnih sirovina (1999)

Mineral Commodity <i>Mineralna sirovina</i>	Kg/Per Capita <i>Kg/po stanovniku</i>		Total (1000 t) <i>Ukupno (1000 t)</i>	
	USA	Hrvatska	USA	Hrvatska
Sand and Gravel <i>Pijesak i šljunak</i> Stone - <i>Kamen</i>	9 738	4 218	2 630 000	19 823
Natural Gas <i>Prirodni plin</i>	3 511	275	948 890	1 293
Petroleum Products <i>Naftni proizvodi</i>	3 502	330	946 430	1 551
Coal - <i>Ugljen</i>	3 448		931 836	-
Iron Ore <i>Željezna ruda</i>	249		67 293	-
Salt - <i>Sol</i>	178	4	48 105	19
Phosphate Rock <i>Fosfati</i>	162		43 781	-
Clays - <i>Gline</i>	137	471	37 025	2 201
Other Metal/Nonmetal <i>Ostali metali i nemetali</i>	867	1 007	193 234	4 734
Total - <i>Sveukupno</i>	21 792	6 305	5 846 594	29 621

Source: Mineral Information Institut, USGS, Ministry of economy of the Rep. of Croatia  
Izvor: Mineral Information Institut, US Geological Survey, Ministarstvo gospodarstva RH

locations. Not much attention was paid to the excavation of non-metals in view of mining, although it was present. After the 60-ies the petroleum and gas production replaced coal as a power-supply source, and the production of non-metals, including minerals for building materials gained importance not only in Croatia. At the end of the millenium the mining industry in Croatia consisted of the production of petroleum, gas and non-metal minerals, and this is how it is probably going to remain for most of the coming century. The absolute production value today is certainly much higher than it was in the "good old mining days", when the reputation of mining was completely different.

panies are small. A part of the companies has been privatized, another part is still stateowned and yet another part has been sold to foreign companies, and thus has entered the process of globalisation.

#### New World Trends in the University Education in Mining

In countries with a high standard of living (USA, Canada, Australia, Western Europe, Japan) the interest for mining studies has decreased for different reasons.

The USA, Canada and Australia are big mining powers both in view of the production rate of minerals and its share

in their economy. However, in the last thirty years the interest of domestic students for a university education in mining has decreased in these countries. This is simply a fact for which we can find various explanations, such as: students are in search of more attractive professions: professions which are easier and less dangerous and which provide fast and safe prosperity etc.

*Mining is simply not an attractive occupation for young people any more.* Minerals are an unrecoverable natural resource, and this fact suggests that a replacement needs to be found for them. Apart from that, the educational system and mass media present the mining industry as creating ecological problems. Unfortunately, mining companies, associations and universities do not properly inform the public about the importance of mining today and for the future. Until we find efficient power supply sources other than coal, petroleum, gas and uranium, until we find a replacement for metals and non-metals of which transport and communication systems, our homes and finally weapons with which we kill each other are being build, the mining industry will remain the basic branch of every economy. From the viewpoint of mining fans, this is a heartbreaking appeal, but miners should be aware that most citizens today hardly have a notion about what a mine is, how it looks like, and that it is not a place where only accidents

In the European Union (EU) classic mining (coal, metallic minerals) has been seriously reduced. In some countries quarries are not treated as mining. In such a situation the poor interest of young people to study mining is understandable. European multinational companies possess mines on other continents, for which they need their own skilled personnel. Apart from that the EU is a significant consumer and still a producer of minerals. Universities and faculties also try to justify their existence. In the EU 38 universities have mining departments, which is considered too high a number for the present situation in mining. Some universities are trying to find a solution that will be satisfying to both them and the mining companies.

Following very thorough preparations four universities - the Delft University of Technology (TUD), Rheinisch-Westfälische Technische Hochschule - Aachen (RWTH), Helsinki University of Technology (HUT) and Imperial College - Royal School of Mines (RSM) - are, with the financial support of the EU and mining companies, establishing an inter-university course of studies. The name of the course is the European Mining Course (EMC), and the first started in the academic year 1996/97.

At a meeting of the Society of Mining Professors at the TU Delft in 2000 the university professor Hans de Ruiter, one of the founders of EMC, presented a table (Table 2)

Table 2 Origin of Students in EMC and EMEC  
 Tablica 2 Porijeklo studenata u EMC-u i EMEC-u

**European Mining Course**

Country	Place	University	96-97	97-98	98-99	99-00	00-01
Germany	Aachen	RWTH	2	4	4	1	4
	Clausthal	TU Clausthal		2	1		
	Freiberg	TU Freiberg			1	2	2
The Netherlands	Delft	TUD	2	5	2	3	3
Finland	Helsinki	HUT	2	3	2	2	1
United Kingdom	London	RSM	2	4	3	3	4
Austria	Leoben	TU Leoben			1		
Canada	Kingston	Queen's			2	1	1
Australia	Brisbane	U. of Queensland				1	1
Spain	Madrid	via RWTH				1	
USA	Virginia	Virginia Tech					2
Poland	Wroclaw					1	1
<b>Total</b>			<b>8</b>	<b>18</b>	<b>16</b>	<b>15</b>	<b>19</b>

**European Mineral Engineering Course**

Country	Place	University	98-99	99-00	00-01
Germany	Aachen	RWTH	3	3	3
The Netherlands	Delft	TUD	1	6	7
Finland	Helsinki	HUT	1		1
United Kingdom	London	RSM			
Poland	Wroclaw				1
Chile	Concepcion	U. de Concepcion		2	1
Argentina	San Juan	U. de San Juan		2	1
<b>Total</b>			<b>5</b>	<b>13</b>	<b>14</b>

happen, but where the most up-to-date equipment is applied and where, thanks to robotization, the least number of accidents happen per number of employees.

with the origin of students in EMC through the years and the disposition of courses at the different universities (Table 3).

Table 3 Disposition of Courses at Universities  
 Talica 3 Raspored kolegija po univerzitetima

EMC:

Helsinki:	- Mineral economics - Rock mechanics - Mineral processing / plant design - Mine maintenance and automation
London:	- Project evaluation / feasibility study - Mine management - Rock Mechanics - Financial aspects of projects and companies
Aachen:	- Open pit mining - Environmental matters - Ventilation (in co-operation with RSM)
Delft:	- Industrial minerals - Alluvial mining - Geostatistics - Case study

E MEC:

Delft:	- Mineral Economics - Sampling and statistics - Flowsheets, mass balances - Alluvial Mining - Hydrometallurgy - Recycling, course I
Aachen:	- Case study
Leeds:	- Modelling and simulation - Instrumentation and control - Finance and Economics
Helsinki:	- Multiphase flows - Particle & Powder technology - Comminution: theory & practice - Classification - Flotation - Recycling, course II - Industrial Minerals - Plant Design

Two years after the EMC began, comprising the mining engineering education, the European Mineral Engineering Course (EMEC) also commenced, covering the education of engineers in mineral processing and recycling (Table 3). Apart from the four already mentioned universities, the university of Leeds and Camborne School of Mines have also joined the organization of the course.

Figure 1 shows the plan of study with time and locations at the particular universities. For three school years the students gain basic engineer, mining and geology knowledge at their domestic faculties, according to a mutually agreed programme, of course; the students spend practically only one school year at universities abroad, studying specialist, professional subjects and gaining international experience. It is needless to say, stresses Prof. H. de Reuter, that student attendance of classes is mostly 100%. Since last year at the domestic faculty there has been a master of science (M.S.) thesis worked on.

As the umbrella organisation for coordinating the present and future curricula programmes, the Federation of European Mineral Programs (FEMP) was established in 1999 with two basic tasks (de Reuter, 2000):

- establishing stronger ties between partners and setting up an integrated European network of education programmes in mining;

- establishing contacts with the European mining and mineral industry. The members of Euromines and other mining companies have established the Industrial Advisory Committee, which in cooperation with FEMP solves concrete problems between industry and university.

Figures 2 and 3 show some already existing connections and contacts within European and world universities, as well as possible future study centres and their mutual links according to the idea of the founders of EMC and EMEC.

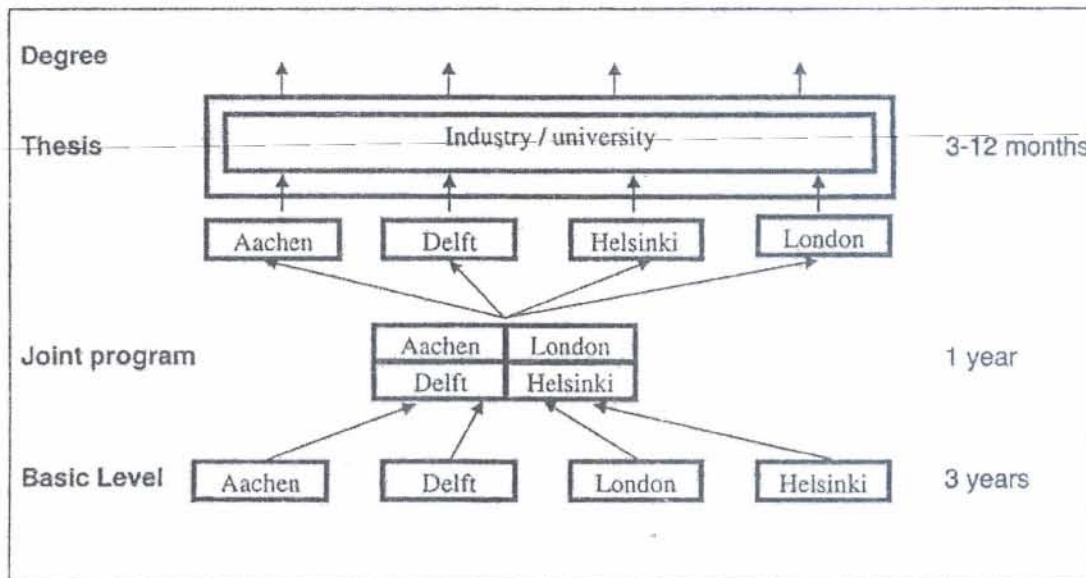


Fig. 1. Plan of Study - time and locations (According to de Reuter)  
 Sl. 1. Raspored studija po vremenu i lokacijama

The course has been given in English so far, whereas future centres would operate in other languages as well, also through distant multi-medial presentations and other innovations in informatics.

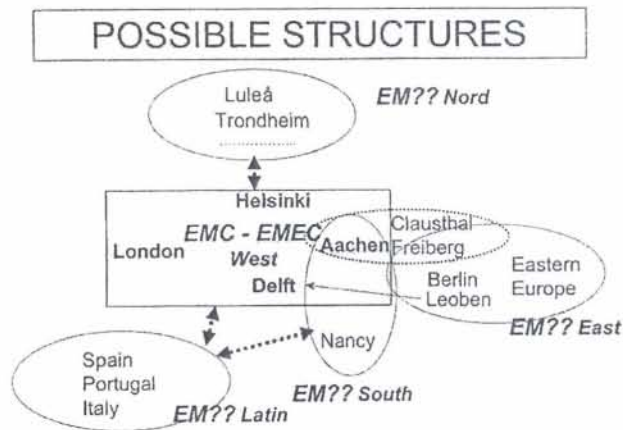


Fig. 2. Possible European Structure of Study (According to de Reuter)  
 Sl. 2. Moguća europska struktura studija

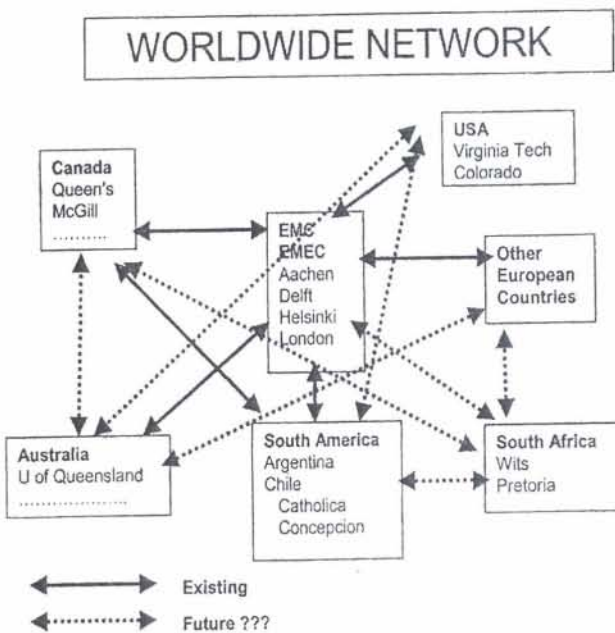


Fig. 3. Worldwide Network of Study Centres (According to de Reuter)  
 Sl. 3. Svjetska povezanost studijskih centara

East European countries in transition are seeking for their way of joining Europe, so that on 30.11-1.12.2000 the "Third European Mining and Metallurgy Academies Rectors' Conference" was held in Cracow. Programmes and experiences were presented from the following schools: Cracow, Gliwica (Poland), Miskolca (Hungary), Ostrawe (the Czech Republic), Košica (the Slovak Republic), Ukraine, Freiberg, Clausthal (Germany), Ploiesti, Baia Mare, Sibiu, Petrosani (Rumania) and Zagreb. The conference bore the title "European Conference", but most of the participants (except for Germany) were from universities of countries in transition. Countries in transition that had no representatives were: Albania, Bosnia and Herzegowi-

na, Bulgaria, Estonia, Yugoslavia, FYR of Macedonia and Slovenia. At this conference, as well as at two previous ones, mainly the existing curricula programmes were presented, as well as the prospects of some universities to educate skilled professionals in mining and metallurgy.

The problems that countries in transition and their mining industries have faced in the last ten years are completely different from those in already mentioned developed countries. The countries in transition have faced problems of old technologies, ownership transformation, reduced production, high unemployment rate etc. In view of such conditions there is still, as a rule, a sufficient number of students of mining (the more frequent problem being that not all young people who would like to study can actually do so). Beside all these problems the mentioned countries are trying to find their own way of nearing the EU and the industrially developed world, which inhibits their mutual cooperation.

### University Education in Mining at the Faculty of Mining, Geology and Petroleum Engineering in Zagreb.

The Faculty was founded in 1939 as the "Department of Mining and Metallurgy" of the then Technical Faculty. At the beginning there was only the program of study for mining, whereas the introduction of metallurgy was intended for one year later, but was not carried out. According to the initial program of study, universal mining engineers (B.Sc.) were educated. In the academic year 1951/52 two degree programs: the mining (with specialization: coal + metallic ores and petroleum) and the mining-geological engineering were introduced. Thus, according to this degree program universal mining engineers for the exploitation of all types of minerals, except for petroleum and gas, were educated. A third degree program at the Department of Mining of the then already established Faculty of Mining, Geology and Petroleum Engineering has been introduced 1974/75. With this program the mining and geotechnical engineering as specializations have been introduced. In the specialization of mining universal mining engineers for the exploitation of minerals are still educated, and at the specialization of geotechnical engineering there are more subjects concerned with engineering geology, soil and rock mechanics, so that such an engineer can work on tunnelling, exploration and exploitation of water, injecting and consolidating of soil and rocks, as well as other related special work. Since that time geotechnical engineering, scientific research and laboratory development have considerably improved at the faculty.

The fourth degree program was introduced in the academic year 1998/99. There are seven semesters of teaching for all students jointly, and in the 8<sup>th</sup> semester the following specializations are taught: production of minerals, underground space and tunnels, waste disposal and treatment. For the verification of this degree program a round table meeting under the title "University Education in Mining in the New Millenium" was held on 11.05.2000 at the Faculty of Mining, Geology and Petroleum Engineering, with about 40 guests from the Ministry of Economy, mining industry and many professors of the faculty. After a detailed presentation of the program a discussion ensued in which the following points were made:

- the Faculty of Mining, Geology and Petroleum Engineering should retain its name and basic activity, and that is exploration and exploitation of minerals;

- the first two years of study should be common for all the three educational degree programs at the Faculty (mining, geology and petroleum engineering);

- in the specialisation - "underground space and tunnels" (the former "geotechnical engineering"), the former name kept, and effort made that mining engineers (BSc.) have the same legal status as civil engineers in the construction of tunnels;

- in the specialisation "waste disposal and treatment" there as a lack of a number of basic mining subjects; for graduates this probably means that they will, according to present provisions, lose the right to sit for the state examination in the mining profession;

- the need to improve the economic and legal components of the education of mining engineers was pointed out;

- a number of participants in the discussion stressed the need for the studies to be modernised in accordance with the practice in Europe.

Until the time this paper has been written, there was unfortunately no reaction by the Faculty to the points made at the round table, however, they will be taken into consideration in future programmes.

Apart from the four mentioned degree programs, in the last couple of years there have been some minor changes in the teaching programme. However, these have not brought about new specialisations, so that we will not consider them in this paper.

Until 4. December 2000 853 students graduated in mining, which means that on the average 15 mining engineers graduate a year. Statistical data show that after graduation all mining engineers manage to find an employment in a reasonable period of time.

At the Faculty 60 students are enrolled in the first year in the mining degree program, and so far there has always been so many students enrolled; however, the problem of completing the studies successfully still remains, this being a problem of our whole university education. Through the reorganisation of the curricula at the faculties, which is inevitable in the near future, the efficacy of studying will be improved, and also the number of enrolled students of mining will have to be adjusted to the needs of the mining industry in Croatia.

Until 4. December 2000 73 students, i.e. 8.5% of the graduates have achieved a master's degree, and a doctor's

degree was achieved by 52 candidates or 6 % of graduate mining engineers. In view of the fact that graduate studies were introduced at the Department of Mining in the academic year 1965/66 and the first candidates obtained the master's degree in 1969, it is evident that with such a small number of master and doctor of science degrees neither the faculty nor the mining industry can be satisfied. At graduate studies scientists-researchers should be educated for the industry, not only for the needs of the faculty. Research within graduate studies should be a bond between the industry and the faculty, to the benefit of both.

## Conclusion

The characteristic of mining at the beginning of the new millenium is globalisation, i.e. establishing of large multinational companies, especially for minerals traditional in mining, and these are metallics, fossil and nuclear fuels raw materials. Non-metal minerals, and especially building materials cannot be transported at long distances and thus have to be employed locally. The production rate of most of minerals is continually growing, although it has been slow down in the last decades.

In developed regions of the world the interest of young generations to study mining has been decreasing for several decades already. For students in less developed regions of the world mining has been, and will probably continue to be for many years, a profession attractive enough for a lifetime.

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## Edukacija rudarskih visokoškolskih kadrova na početku trećeg milenija

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### Uvod

Edukacija visokoškolskih kadrova u rudarstvu, s obzirom na nedovoljan broj studenata, na dnevnom je redu u zapadnim industrijski razvijenim državama već tridesetak godina. Rudarstvo kao privredna grana u stalnom je usponu što ne prati njegov imidž.

Rudarstvo kao osnovna i jedna od najstarijih privrednih grana, koju u tisku prate opisi mnogih nesretnih slučajeva, dok su rudnici smješteni daleko od urbanih sredina, prestaje na kraju stoljeća biti izazov za studente. Situacija nije ista i u industrijski nerazvijenom dijelu svijeta. Tamo mladež nije toliko izbirljiva i sveučilišta nemaju problema s upisom dovoljnog broja studenata.

### Pogled na rudarstvo

Važnost **svjetskog rudarstva** za društvo na kraju drugog milenija možda najbolje ilustrira moto posljednjeg XVIII Svjetskog rudarskog kongresa održanog u listopadu 2000. u Las Vegasu (SAD) "ako neće izrasti, moraš iskopati u rudniku" ("if you can't grow it, you have to mine it").

Rudarstvo je staro koliko i civilizacija, no, u ovom stoljeću je otkopano mineralnih sirovina više nego svih prethodnih tisućljeća. Što se rezervi mineralnih sirovina tiče u svijetu nema izvješća o manjku zalih za sada sagledivi vremenski period, za niti jednu sirovinu iz grupe met-

alnih i nemetalnih sirovina. Rezerve energetskih mineralnih sirovina znatno su veće nego se to činilo stručnjacima pred nekoliko desetljeća, kada su bile poznate rezerve nafte i plina za svega četrdesetak godina. Neovisno o povećanju količina rezervi u posljednjih nekoliko desetljeća, pri stalnom povećanju proizvodnje, što je posljedica sve većih ulaganja u istraživanje, toj utrci očito ima granice. Količina rezervi fosilnih goriva je ograničena. Sve prognoze o rezervama nafte, plina i ugljena pokazuju da tu ipak najbolje stoji ugljen.

Proizvodnja mineralnih sirovina, po količini i vrijednosti, u općem je stalnom porastu. Numeričke podatke o proizvodnji mineralnih sirovina nalazimo u više baza podataka (V u j e c , 1999). Stalna tendencija povećanja proizvodnje u nekom prosječnom iznosu od 2 do 3% godišnje uvjetovana je globalnim povećanjem broja ljudi, poboljšanjem standarda i nizom drugih utjecajnih veličina. Nikakve promjene u tom pogledu ne predviđaju se za nastupajuće stoljeće. Stalne oscilacije ponude i potražnje, kako na lokalnom, tako i na svjetskom tržištu diktiraju oscilacije cijena a time i intenzitet proizvodnje pojedine mineralne sirovine.

Stvaranje velikih multinacionalnih kompanija - globalizacija - koje diktiraju zbivanja na svjetskom tržištu mineralnih sirovina nezaustavljiv je proces u posljednjim desetljećima. Statistički podaci pokazuju da po svojoj vrijednosti rudarske kompanije znatno zaostaju za kompanijama u drugim industrijskim grupacijama. Tako je u godišnjoj publikaciji

“Who Owns Who”, švedskog RMG-a (Raw Materials Group) (H i n d e , 2000) ukupna vrijednosti 10 najbogatijih rudarskih kompanija ocijenjena na 80 milijardi USD, dok je vrijednost BPAmoco & Exxon Mobil-a 520 milijardi USD, a America Online udružena s Time Warnerom vrijedi 182 milijarde USD. U istoj publikaciji iznesen je podatak da je ukupna vrijednost međusobnog preuzimanja kompanija tijekom 1999. godine iznosila 3400 milijardi USD, dok je to u rudarskoj grupaciji u isto vrijeme bilo samo 19 milijardi USD (0,6 %).

Zanimljiv je podatak o procjeni vrijednosti ukupne svjetske rudarske proizvodnje mineralnih sirovina. Vrijednost godišnje proizvodnje nafte za 1999. procijenjena je na 800 milijardi USD (73 miliona bbl/dan, 30 USD/bbl), a ostalih mineralnih sirovina na 300 milijardi (ugljen 110, zlato, boksit i bakar po 20 svaki, željezna ruda 15 i t.d.). Sva ova proizvodnja odvijala se primjenom najsvremenije i najsoficiranije tehnologije. Vremena krampa i lopate daleko su iza nas, a sigurnost (po broju nesretnih slučajeva) je u usporedbi s drugim industrijskim granama (graditeljstvo, agrar, transport itd.) među najpovoljnijima.

*Zaštita okoliša u razvijenim državama svijeta ugrađena je u rudarski proizvodni ciklus svakog pogona i firme. Zakonodavnom regulativom osigurano je da se od istraživanja preko projektiranja nekog ležišta vodi računa kakav će utjecaj ta eksploatacija imati na okoliš i kako će se okončati otkopavanje a da cjelokupni efekat tog zahvata bude što prihvatljiviji za okolinu.*

*Recikliranjem metalnih proizvoda uspjelo se na tržištu znatno smanjiti potražnju za nekim metalima. Recikliranje je danas važna ekonomska djelatnost, nezaobilazna u smislu zaštite okoliša i uštede energije.*

**Rudarstvo u Hrvatskoj** je nakon gašenja proizvodnje boksita za proizvodnju aluminija (1990) i ubrzo zatim zatvaranja posljednjeg ugljenokopa Tupljak (1999) trebalo oporavak od prividnog psihološkog efekta koji su izazivali mnogobrojni članci u dnevnoj štampi na temu *“zatvara se posljednji rudnik u Hrvatskoj”*. U stvarnosti ocjena je bila samo djelomice točna. U “zlatno” doba rudarstva Hrvatske, a to je vrijeme prije i nakon Drugog svjetskog rata, lignit, kameni i mrki ugljen se otkopavalo u velikom broju poduzeća na gotovo cijelom teritoriju Republike. Boksit je otkopavan na području Istre i Dalmacije na velikom broju lokacija. Otkopavanje nemetala, iako je i ono bilo prisutno, nije se u rudarskom smislu pridavala neka važnost. Nakon šezdesetih u energetskom smislu proizvodnja nafte i plina nadomještaju ugljen, a proizvodnja nemetala, uključujući mineralne sirovine za proizvodnju građevinskih materijala, dobiva novo značenje. Rudarstvo u Hrvatskoj na kraju milenija je proizvodnja nafte, plina i nemetalnih mineralnih sirovina, a tako će izgleda ostati i dobar dio nadolazećeg stoljeća. U apsolutnoj vrijednosti proizvodnja danas vrijedi sigurno više nego je to bilo u “dobra stara rudarska vremena”, kada je imidž rudarstva bio sasvim drugačiji.

Koliko Hrvatska ima rudarstva pokušati ćemo ocijeniti iz usporedbe s rudarstvom SAD-a kao prve rudarske velesile. Da bi usporedba bila moguća prikazat ćemo opseg potrošnje (SAD) i proizvodnje (Hrvatska) za pojedine grupe mineralnih sirovina (tablica 1).

U rudarstvu Hrvatske proizvođači se oko 30 milijuna tona mineralnih sirovina ili po stanovniku 6305 kg što je svega 29 % od proizvodnje SAD-a. Nije neobično što ne proizvodimo metalne ili u dovoljnoj mjeri energetske mineralne sirovine, jer su njihova ležišta siromašna na našem prostoru, ali je karakteristično da proizvodimo po stanovniku svega 43 % sirovina za građevinske materijale i izgradnju (šljunak, pijesak, kamen) kojih imamo dovoljno, a potrebe su izrazite s obzirom na stanje prometne infrastrukture. Nemetalne mineralne sirovine proizvođači u Hrvatskoj 225 tvrtki koje zapošljavaju 8400 radnika na rudarskoj proizvodnji. Osim nekoliko iznimki radi se o malim tvrtkama. Dio tvrtki još je uvijek u državnom vlasništvu, a dio je prodan stranim kompanijama i tako ušao u proces globalizacije.

### Novi svjetski trendovi u rudarskoj edukaciji

U državama visokog standarda (SAD, Kanada, Australija, Zapadna Europa, Japan) opao je interes za studij rudarstva. Razlozi nisu svagdje isti.

Sjedinjene Američke Države, Kanada i Australija rudarske su velesile, kako po opsegu proizvodnje mineralnih sirovina, tako i po njihovom učešću u gospodarstvu tih država. Međutim, interes domicilnih studenata u tim državama u posljednjih tridesetak godina za studij rudarstva opada. To je naprosto činjenica za koju možemo naći niz opravdanja, kao: studenti traže atraktivnija zanimanja, traže se lakša i manje opasna zvanja, traže se zvanja koja osiguravaju brzi i sigurniji prosperitet, etc.

*Rudarstvo jednostavno više nije atraktivno zanimanje za mlade. Mineralne sirovine su neobnovljivi prirodni resurs i ta činjenica sugerira da za njih treba naći zamjenu. Uz to se preko školskog sistema i medija na rudarstvo upućuje kao na djelatnost koja stvara probleme sa zaštitom okoliša. Nažalost, rudarske kompanije, udruženja i univerziteti premalo čine na stvarnom informiranju pučanstva o važnosti rudarstva danas i sutra. Sve dotle dok se ne pronađu efikasni izvori energije umjesto ugljena, nafte, plina i urana, dok se ne nađe zamjena za metale i nemetale od čega su sagrađeni svi transportni sustavi, komunikacijski sistemi, naši domovi i konačno oružje kojim se ubijamo, rudarstvo će biti temeljna grana svake privrede. Sa stanovništa ljubitelja rudarstva to je srednoprateljski apel, no rudari trebaju biti svjesni da većina građanstva danas*

nema neku posebnu predodžbu šta je to rudnik, kako izgleda, da to nije samo mjesto gdje se događaju nesreće, već je to danas mjesto gdje se primjenjuje najsvremenija oprema i gdje se zahvaljujući robotizaciji događa najmanje nesretnih slučajeva po broju zaposlenih.

U Europskoj uniji (EU) klasično rudarstvo (ugljen, metali) je reducirano. Kamenolomi (quarries) u nekim državama ne tretiraju se kao rudarstvo. U takvoj situaciji razumljiv je manji interes studenata za studij rudarstva. Europske multinacionalne kompanije imaju rudnike na drugim kontinentima za što im je potreban vlastiti stručni kadar. Uz to EU je značajan potrošač i još uvijek proizvođač mineralnih sirovina. Visokoškolske ustanove nastoje također naći razlog za svoje postojanje. Rudarske odjele ima 38 sveučilišta u EU - što se za postojeće stanje rudarstva smatra prevelikim brojem. Pojedini univerziteti pokušavaju naći rješenja koja će zadovoljiti njih i rudarske kompanije.

Nakon temeljitih priprema četiri sveučilišta - Delft University of Technology (TUD, Nizozemska), Rheinisch-Westfälische Hochschule - Aachen (RWTH, Njemačka), Helsinki University of Technology (HUT, Finska) i Imperial College - Royal School of Mines (RSM, Engleska), stvaraju, uz financijsku pomoć EU i rudarskih kompanija, interuniverzitetski studij. Studij nosi naziv *European Mining Course* (EMC) i prva je godina započela šk. god. 1996/97.

Prema izlaganju prof. Hans de Reutera, jednog od osnivača EMC-a, na sastanku Society of Mining Professors (2000.) na TU Delft, prikazano je porijeklo studenata po godinama (tabl. 2) te raspored kolegija po univerzitetima (tabl. 3).

Dvije godine nakon početka nastave na EMC-u, koji se odnosio na izobrazbu rudarskog inženjera, započela je nastava na European Mineral Engineering Course-u (EMEC), koji je pokriva naobrazbu inženjera iz oplemenjivanja mineralnih sirovina i recikliranja (tabl. 3). U organizaciju nastave uz već spomenuta četiri sveučilišta uključila su se i sveučilišta Leeds i Camborne School of Mines.

Na slici 1 pokazan je raspored boravka studenata na pojedinim univerzitetima. Tri školske godine studenti uče osnovna inženjerska znanja i temeljna znanja iz rudarstva i geologije na domicilnom fakultetu, prema zajednički usklađenom programu, a praktično samo jednu školsku godinu studenti borave na drugim univerzitetima studirajući specijalističke predmete struke stječući međunarodno iskustvo. Nije potrebno isticati, naglašava prof. H. de Reuter, prisustvo studenata na nastavi je uglavnom 100 %. U posljednjoj godini na domicilnom fakultetu izradu je se magistarska radnja (M.sc.).

Kao krovna organizacija za koordinaciju postojećih i budućih školskih programa osnovana je koncem 1999. *Federacija europskih rudarskih programa* (FEMP) s dva osnovna zadatka (de Reuter, 2000):

- ostvarivanja čvršće veze među partnerima i stvaranja europske integrirane mreže rudarskih školskih programa,
- ostvarivanja veze s europskom rudarskom industrijom. Članice udruženja Euromines-a i druga rudarska poduzeća formirale su Industrijski savjetodavni komitet koji u suradnji s FEMP-om rješava konkretne odnose industrije i univerziteta.

Na slikama 2 i 3 prikazane su neke postojeće veze i kontakti unutar Europskih i svjetskih univerziteta i eventualni budući centri i njihova povezanost prema zamisli organizatora EMC-a i EMEC-a. Dosadašnji studij organiziran je na engleskom jeziku, a budući centri radili bi i na drugim jezicima, daljinskim multimedijskim prezentacijama i uz sve novitete novog informatičkog društva.

Tranzicijske države istočne Europe traže svoj put približavanja te je 30.11. i 1.12.2000. organizirana *“Third European Mining and Metallurgy Academies Rectors Conference”* u Cracowu. Predstavljeni su programi i iskustva škola iz: Crakowa, Gliwica (Poljska), Miskolca (Mađarska), Ostrawe (Češka), Košica (Slovačka), Ukraine, Freiberga, Clausthala (Njemačka), Ploiesti, Baia Mare, Sibiu, Petrosani (Rumunjska) i Zagreba. Konferencija je bila pod naslovom *“European Conference”* no prisustvovali su uglavnom (osim Njemačke) predstavnici univerza tranzicijskih država. Od tranzicijskih država prikazima nisu bile zastupljene: Albanija, Bosna i Hercegovina, Bugarska, Estonija, Jugoslavija, Makedonija i Slovenija. Na toj konferenciji, kao i na dvije ranije, predstavljani su uglavnom postojeći nastavni programi te mogućnosti pojedinih univerziteta na izobrazbi kadrova iz područja rudarstva i metalurgije.

Problemi s kojima su se susrele države u tranziciji i njihovo rudarstvo u posljednjih deset godina sasvim su druge prirode nego je to u ranije spominjanim industrijski razvijenim državama. Države u tranziciji susrele su se s problemom zastarjelih tehnologija, pretvorbom državnog u privatno vlasništvo, redukcijom proizvodnje, visokim stupnjem nezaposlenosti, itd. U takvim uvjetima studenata u pravilu ima dovoljno, češće se javlja problem da ne mogu studirati svi koji bi htjeli. Uza sve te probleme ove države traže pojedinačni put približavanja EU i industrijski razvijenom svijetu, što ih sputava u međusobnoj suradnji.

### Studij rudarstva na Rudarsko-geološko-naftnom fakultetu u Zagrebu

Fakultet je osnovan 1939. kao “Odsjek za rudarstvo i metalurgiju” tadašnjeg Tehničkog fakulteta. U početku je otvoren samo rudarski smjer, a otvaranje metalurgije ostavljeno je za godinu dana kasnije, što se nije ostvarilo. *Po početnom nastavnom planu* obrazovan je univerzalni diplo-

mirani rudarski inženjer. Šk. god. 1951/52 uvode se *rudarsko-pogonski smjer* (s usmjerenjima ugljen i metali te nafta) i *rudarsko-geološki smjer*. Dakle, i po tom nastavnom planu školuje se univerzalni diplomirani rudarski inženjer za eksploataciju svih vrsta mineralnih sirovina, osim nafte i plina. *Treći nastavni plan* na Rudarskom odjelu tada već formiranog Rudarsko-geološko-naftnog fakulteta primjenjuje se od šk. god. 1974/75. Tim nastavnim planom uvode se smjerovi rudarstvo i geotehnika. Na smjeru rudarstvo obrazuje se i dalje za univerzalnog diplomiranog rudarskog inženjera za eksploataciju svih vrsta mineralnih sirovina, a na smjeru geotehnika predaje se više inženjerske geologije, mehanike tla i stijena, kako bi taj inženjer mogao raditi u tunelogradnji, istraživanju i eksploataciji vode, injektiranju i konsolidaciji tla i stijena te drugim specijalnim radovima u tlu i stijenama. Od tog vremena do danas na fakultetu je u nastavi, znanstvenom istraživanju i u razvoju laboratorija znatno ojačala geotehnička komponenta.

*Četvrti nastavni plan* započeo se primjenjivati šk. god. 1998/99. Sedam semestara je zajedničke nastave za sve studente, a u 8. semestru upisuju se moduli:

1. - dobivanje mineralnih sirovina,
2. - podzemne prostorije i tuneli i
3. - zbrinjavanje i odlaganje otpada.

Radi verifikacije ovog nastavnog plana 11.5.2000. održan je na RGNF-u, uz prisustvo dvadeset gostiju iz Ministarstva gospodarstva i privrede te većeg broja nastavnika fakulteta *okrugli stol* na temu "*Studij rudarstva u novom tisućljeću*". Nakon detaljnog prezentiranja nastavnog plana uslijedila je rasprava u kojoj su istaknute slijedeće preporuke:

- Rudarsko-geološko-naftni fakultet *treba zadržati nepromijenjeno ime i osnovnu djelatnost*, a to je istraživanje i eksploatacija mineralnih sirovina,
- prve dvije godine studija na sva tri obrazovna profila Fakulteta trebale bi biti zajedničke,
- u modulu - podzemne prostorije i tuneli - (ranijem "geotehničkom smjeru") zadržati raniji naziv, te uložiti napor da se ti inženjeri i zakonski izjednače s dipl.inž. građevinarstva pri izgradnji tunela;
- u modulu - zbrinjavanje i odlaganje otpada - nedostaje nekoliko osnovnih rudarskih kolegija čime bi, prema sadašnjim propisima, završeni studenti najvjerojatnije izgubili pravo polaganja državnog ispita iz rudarske struke;
- istaknuta je potreba jačanja ekonomske i pravne komponente u naobrazbi rudarskih inženjera
- više diskutirana istaklo je potrebu moderniziranja studija u suglasju s europskom praksom.

Nažalost, do vremena pisanja ovog rada na primjedbe istaknute na okruglom stolu nije bilo reakcije od strane Fakulteta, ali će one biti razmatrane u budućim programima.

Osim spomenuta četiri nastavna plana bilo je tijekom proteklih godina i drugih manjih promjena nastavnih planova, ali prilikom tih promjena nisu uvedeni novi smjerovi pa ih ovom prilikom i ne obrađujemo.

Do 4.12.2000. diplomiralo je rudarstvo 853 dipl.ing., što znači da prosječno godišnje diplomira 15 inženjera rudarstva. Statistički podaci pokazuju da svi završeni studenti u razumnom roku nakon diplome uspiju naći zaposlenje.

U prvu godinu studija upisuje se na ovom obrazovnom profilu 60 studenata godišnje, i sva su mjesta dosada uvijek bila popunjena, no problem je uspješnosti studiranja, što je u stvari problem cijelog našeg visokoškolskog sistema. Reorganizacijom visokoškolske nastave, koja je u skoroj budućnosti neminovna, povećati će se efikasnost studiranja ali će tada trebati broj upisanih studenata na rudarstvu prilagoditi potrebama rudarstva Hrvatske.

Postdiplomski studij je do 4.12.2000. završilo 73 studenata ili 8,5% diplomiranih, a disertaciju je obranilo 52 kandidata ili 6% diplomiranih inženjera rudarstva. Uzme li se u obzir da je postdiplomski nastava započela na Rudarskom odjelu RGN fakulteta šk.god. 1965/66 i da su prvi kandidati magistrirali 1969. evidentno je da sa tako malim brojem magisterija i doktorata nemože biti zadovoljan niti fakultet niti rudarska privreda. U postdiplomskoj nastavi treba obrazovati istraživače za industriju a ne samo za potrebe fakulteta. Istraživanja u okviru postdiplomske nastave trebaju povezivati industriju i fakultet na obostranu korist.

#### Zaključak

Karakteristika rudarstva na početku milenija je globalizacija tj. stvaranje velikih multinacionalnih kompanija pogotovo u dijelu rudarski tradicionalnih mineralnih sirovina a to su metalne i energetske sirovine. Nemetalne mineralne sirovine, a posebice građevinski materijali, ne nose dugi transport i vezane su za lokalne sredine. Rast proizvodnje većine mineralnih sirovina je stalan, iako usporen u posljednjim desetljećima.

U industrijski razvijenom dijelu svijeta interes mladih generacija za studiranje rudarstva opada već nekoliko desetljeća. Za studente u manje razvijenom dijelu svijeta rudarstvo je danas, a biti će još godinama, dovoljno atraktivno zvanje za životni poziv.