# VUORITEOLLISUUS BERGSHANTERINGEN

N:o 2 1993
51. vuosikerta
ISSN 0042-9317

JULKAISIJA: VUORIMIESYHDISTYS - BERGSMANNAFÖRENINGEN r.y.





## OHJELMA

*M. Mussorgsky: Yö autiolla vuorella*
Polyteknikkojen Orkesteri,
kapellimestari Hannu Norjanen

AVAUSSANAT
Puheenjohtaja,
professori Raimo Matikainen

VALTIOVALLAN TERVEHDYS
Kauppa- ja teollisuusministeri
Pekka Tuomisto

SUOMEN VUORITEOLLISUUDEN NÄKYMÄT
Pääjohtaja Markku Mannerkoski,
Valtion teknillinen tutkimuskeskus

*T. Kuula: Kansanlaulu*
Polyteknikkojen Orkesteri,
kapellimestari Hannu Norjanen

ANSIOMITALIEN JAKO
Puheenjohtaja,
professori Raimo Matikainen

*R. Wagner: Prelude*
*(oopperasta Nürnbergin mestarilaulajat)*
Polyteknikkojen Orkesteri,
kapellimestari Hannu Norjanen

TAUKO

NON-FERROUS METALS –
THE CHALLENGES AHEAD
Sir Arvi Parbo,
Western Mining Corporation

STEEL IN THE NEXT CENTURY –
CHALLENGE AND CHANGE
Secretary General Lenhard Holschuh,
International Iron and Steel Institute






SVEDALA

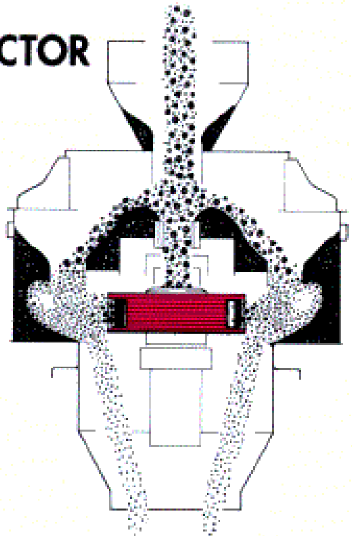
# BARMAC ROCK-ON-ROCK CRUSHER

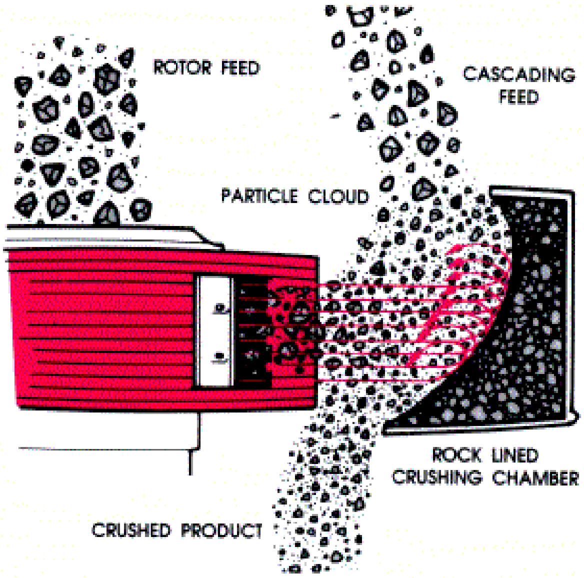
# THE PATENTED BARMAC ROCK-ON-ROCK CRUSHING ACTION

The Tidco Barmac rock-on-rock crusher uses a field proven rock lined rotor that acts as a high velocity stone pump hurling a continuous rock stream into a tightly packed rock lined crushing chamber.

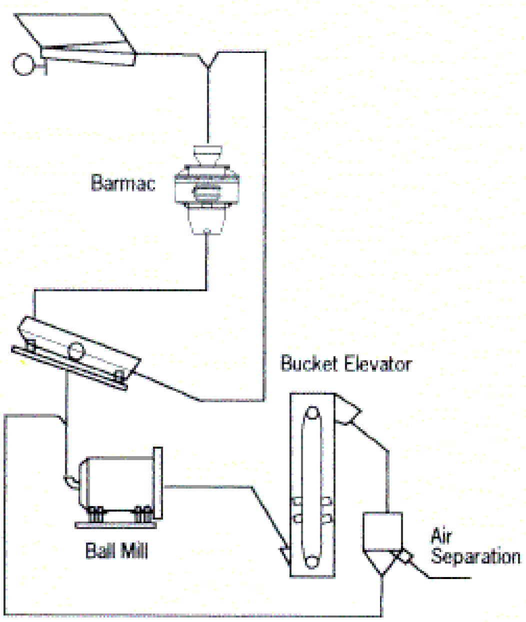
Material fed into the top of the machine is accelerated in the BARMAC patented rock lined rotor, achieving exit velocities of up to 90 meters per second. The rotor continuously discharges into a highly turbulent particle cloud contained within the crushing chamber where reduction occurs primarily by rock-on-rock impact, attrition and abrasion.

**DUOPACTOR**






## BARMAC CUTS COMMINUTION COSTS




**CEMENT CLINKER PREGRNDING EXAMPLE**

**Mill Data:**
Make: Ball Mill 2,4 x 12m
Capacity: 25 TPH
Installed Power: 783 kW

**Pregrinder Data:**
Make: Barmac 6900 Duopactor
Capacity: 68 TPH
Installed Power: 112 kW

| Total Plant | Before | After | Change |
|---|---|---|---|
| Mill Feed F(100) | 25mm | 3,0mm | |
| Mill Feed F(80) | 18mm | 1,6mm | |
| Capacity | 25 TPH | 32 TPH | 28 % + |
| Specific Power | 31,3 kW/hr/T | 27,9 kW/hr/T | 11 % - |

**ALLIS**
**MINERAL SYSTEMS**

**ROLAC**

Oy Rolac Ab
Salmitie 4, 02430 Masala.
Puhelin 90 2976122, Telefax 90 2975587

# VUORITEOLLISUUS BERGSHANTERINGEN

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## SISÄLTÖ ■ INNEHÅLL

VUORITEOLLISUUS
BERGSHANTERINGEN

**VUORIMIESYHDISTYKSEN HALLITUS**
**20.3.1993**

Prof. Raimo Matikainen 90-451 2804
puheenjohtaja Fax 90-451 2812
Teknillinen korkeakoulu
Materiaali- ja kalliotekniikan laitos
Vuorimiehentie 2
02150 ESPOO

TkT Aulis Saarinen 981-327 711
varapuheenjohtaja Fax 981-327 462
Rautaruukki Oy
PL 217
90101 OULU

DI Matti Heiniö 931-241 4111
Tamrock Oy
PL 279
33101 TAMPERE

DI Kari Norberg 982-230 2273
Rautaruukki Oy
Raahen terästehdas
PL 93
92101 RAAHE

TkL Matti Tyni 971-671 671
Malmikaivos Oy Luikonlahti
73670 LUIKONLAHTI

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Betonimiehenkuja 4
02150 ESPOO

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Outokumpu Kokkola Zinc Oy
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67101 KOKKOLA

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DI Eelis Eskelinen 953-510 111
Oy Partek Ab
53500 LAPPEENRANTA

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95400 TORNIO

TkT Matti Ketola 973-556 345
Outokumpu Finnmines Oy
Tehtaankatu 2
86500 OUTOKUMPU

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Outokumpu Oy Fax 90-421 3888
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Outokumpu Finnmines Oy, malminetsintä
Tehtaankatu 2
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Betonimiehenkuja 4
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puh.joht.
Kemira Oy Siilinjärven tehtaat, kaivos
PL 20
71811 SIILINJÄRVI

DI Jarmo Frii 973-556 209
siht.
Outokumpu Mining Services Oy
PL 15
83501 OUTOKUMPU

**Metallurgijaosto**
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puh.joht.
Outokumpu Engineering
PL 86
02201 ESPOO

TkL Lars Helle 90-421 3933
siht.
Outokumpu Engineering Contractors
PL 862
02201 ESPOO

**Rikastus- ja prosessitekniikan jaosto**
TkL Ulla-Riitta Lahtinen 90-451 2794
puh.joht.
Teknillinen korkeakoulu
Materiaali- ja kalliotekniikan laitos
Vuorimiehentie 2 A
02150 ESPOO

DI Jorma Reinikainen
siht.
Tyysterniementie 3 B 10
53900 LAPPEENRANTA

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DI Paavo Eerola, puh.joht. 973-5561
Outokumpu Mining Services
83500 OUTOKUMPU

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Materiaali- ja kalliotekniikan laitos
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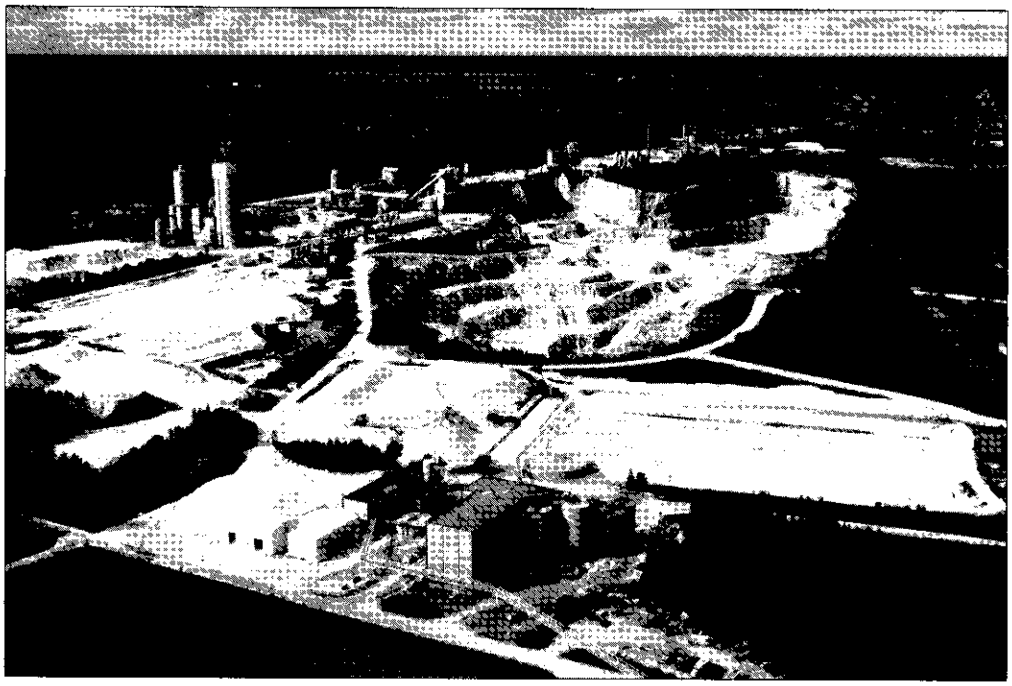
Outokumpu Mining Services
83500 OUTOKUMPU

Rikastusteknillinen toimikunta:
DI Jarmo Aaltonen, puh.joht. 971-400 111
Kemira Oy
Siilinjärven tehtaat ja kaivos
PL 20
71801 SIILINJÄRVI

Tutkimusvaltuuskunnan ja sen toimikuntien sihteeri:
FT Jyrki Parkkinen 90-46931
Geologinen tutkimuskeskus Fax 90-462 205
Betonimiehenkuja 4
02150 ESPOO

# BUILT ON ROCK



*Partek Lappeenranta Works*

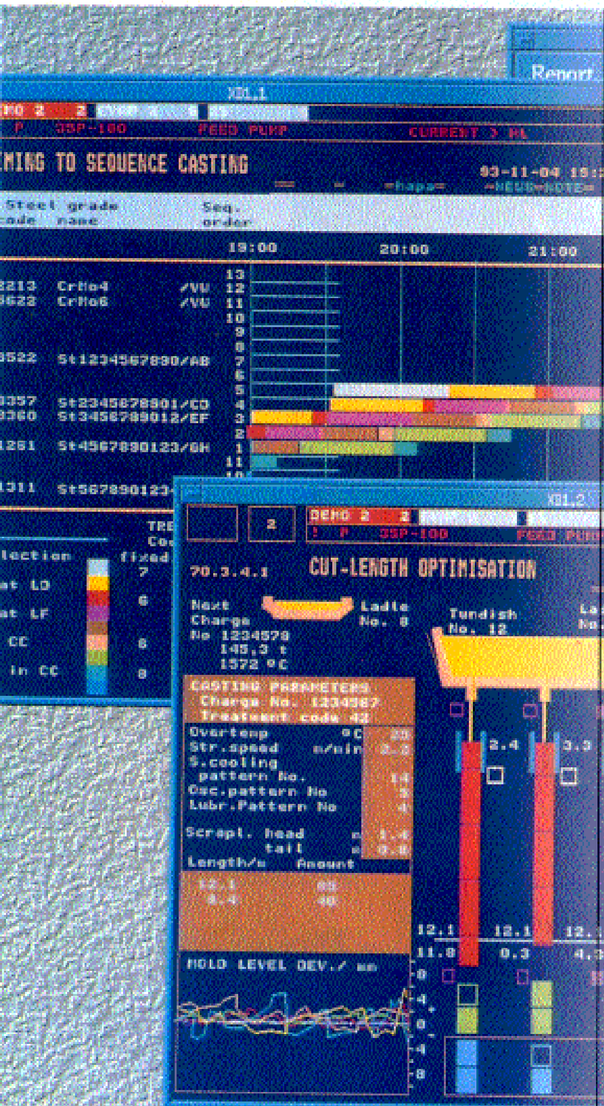
## THE PARTEK ROCK BASED INDUSTRIES IN FINLAND

| Partek Minerals | Partek Sementti | Lohja | Partek Betonila * | Paroc |
|---|---|---|---|---|
| *lime, industrial minerals* | *cement* | *on-site construction work, masonry work, civil engineering* | *concrete constructions* | *insulation materials* |

*[shaded box] Partek 50% Metra 50%*

* *Partek 50 % Euroc 50 % (Partek-Metra 25 %)*

# X-ikkunointi tekee integroiduista sovelluksista entistä monipuolisemman tietolähteen.



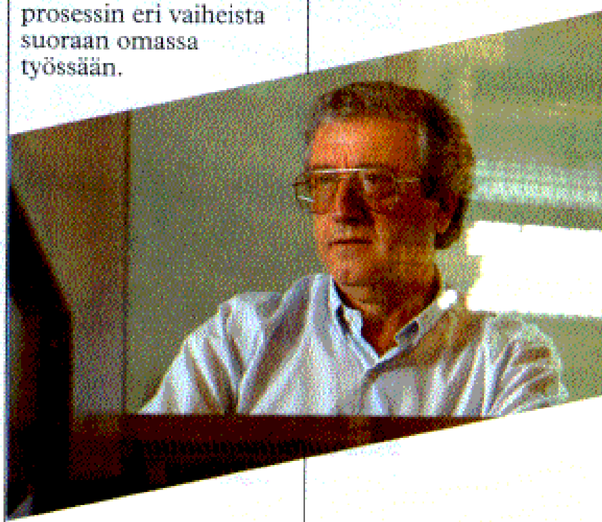

Tuotannolta vaaditaan nyt joustavuutta. Jotta siihen päästäisiin, on tietoa pystyttävä siirtämään aivan uudella teholla prosessinohjaus- ja informaatiojärjestelmien välillä.

Valmet Automationin X-ikkunointi auttaa tekemään juuri sen.

X-ikkunoinnin avoimen käyttäjäliitynnän kautta voidaan eri järjestelmissä toimivien sovellusten tieto koota yhteen käyttäjäympäristöön.

X-ikkunointi mahdollistaa käyttöhenkilöstölle pääsyn tähän tietoon suoraan omalta työasemalta. He eivät siis tarvitse enää näyttöä jokaista järjestelmää varten erikseen. Näin käyttäjä on aina ajan tasalla tuotannon kulun ja siinä tarvittavien muutosten suhteen.

Koska prosessinäytöt avautuvat muidenkin tietojärjestelmien kautta, myös käytönjohto, tuotannonsuunnittelu, tutkimus ja tehtaanjohto voivat soveltaa tarvitsemaansa tietoa prosessin eri vaiheista suoraan omassa työssään.



Luotettavuus ja yhteensopivuus olivat pääkriteerit, kun Valmet Automationin X-valvomoratkaisua suunniteltiin. X-ikkunointi toimii Damatic XD -teknologian kanssa ja siinä käytetään samoja ergonomisia käyttöperiaatteita. Sovellusten yhteensopivuus mahdollistaa aikaisempien Damatic XD -ratkaisujen käyttämisen X-valvomoympäristössä.

Valmet Automationin Damatic XD:n hajautetun ikkunointijärjestelmän avulla tehtaasi maksimoi automaatioinvestointiensa hyödyt.

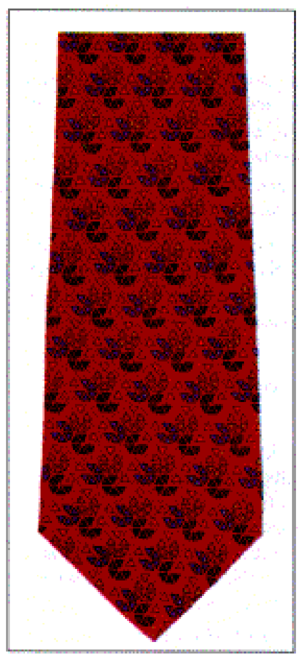
**VALMET** Automation

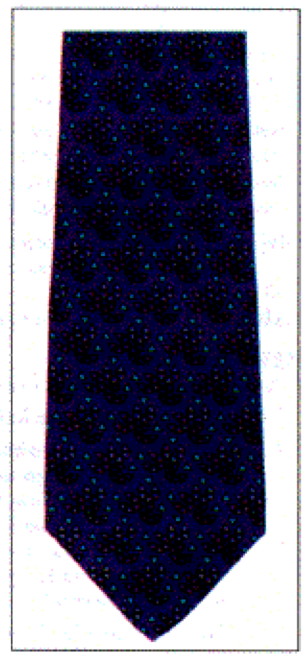
**Valmet Automation Oy,** PL 237, Lentokentäntie 11, 33101 Tampere
Puhelin (931) 266 8111, Telefax (931) 266 8523

TÄVYYTTÄ • JATKUVAA KEHITYSTÄ • JATKUVAA KÄYTETTÄVYYTTÄ • JATKUVAA KEHI

# Vuorimiesyhdistyksen uudet solmiot ovat ilmestyneet! Tilaa omasi!!!

Solmiot on suunnitellut ja valmistanut Marja Kurki Desing ja niitä on kahta väriä. Solmioiden materiaalina on silkki.





**Tilauskuponki**

**Tilaan solmioita à 150 mk seuraavasti:**

| Väri | kpl |
|---|---|
| Punainen | |
| Sininen | |

Tilaajan nimi ______________________

Lähiosoite ______________________

Postinumero ______________________

Postitoimipaikka ______________________

Allekirjoitus ______________________

Postimerkki

**Marjatta Parkkinen**
**Outokumpu Oy**
**PL 280**
**02101 ESPOO**

# METALLURGISEN TEOLLISUUDEN SIVUTUOTTEIDEN HYÖTYKÄYTTÖ (M0602L)

## 26.–27.1.1994 Sokos Hotel Vantaa, Hertaksentie 2, Tikkurilan asema-aukio, Vantaa

Teollisuudella on tulevaisuudessa yhä suurempi vastuu toiminnastaan ja sen vaikutuksista ympäristöömme. Kansainväliset määräykset ja säädökset, jotka ohjaavat yritysten toimintaa, edellyttävät myös valmistusprosessien eri vaiheissa syntyvien sivutuotteiden hyödyntämistä tai varastoimista niin, että niistä ei ole haittaa tai vaaraa ympäristölle.

Koulutustilaisuudessa käsitellään ko. alueen tämän päivän ja tulevaisuuden vaatimuksia sekä erilaisia tekniikoita ja ratkaisumalleja asioiden hoitamiseksi.

**Kohderyhmä:** Koulutustilaisuus on suunniteltu metallurgisen teollisuuden sekä sen sivutuotteita jalostavien ja käyttävien yritysten tuotanto- ja kehitystehtävissä toimiville asiantuntijoille.

**Suunnittelutoimikunta:**
Fil.toht. Aimo Hiltunen, SKJ yhtiöt Oy (puh.joht.)
Apul.prof. Heikki Jalkanen, TKK
Vanhempi tutkija Timo Lintumaa, Outokumpu Polarit Oy
Teknologia johtaja Heikki Tuovinen, Outokumpu Research Oy
Tekn.joht. Matti Vattulainen, Oy Ekokem Ab
Koulutussuunnittelija Jorma Vihinen, AEL – INSKO (siht.)

**Ilmoittautumiset:** Ilmoittautumiset 20.1.1994 mennessä.
Puhelimitse (90) 530 7444 tai (90) 53 071/Asiakaspalvelu
Kirjeitse AEL – INSKO/Asiakaspalvelu, Kaarnatie 4,
00410 HELSINKI. Ilmoittautuminen vahvistetaan kutsulle ennen tilaisuuden alkua. Jos varattu kurssipaikka jätetään käyttämättä, peritään 50 % osallistumismaksusta.

**Osallistumismaksu:** 3 400 mk henkilöltä. Maksuun sisältyy koulutustilaisuudessa jaettava aineisto sekä ohjelmaan merkityt ateriat ja kahvit.

**Alennus lentomatkoista:** Ilmoittautumisen yhteydessä voi pyytää lentoa varten IT-koodin, jolla saa tietyistä Finnairin lennoista 25 % alennuksen.

**Majoitus:** Osallistujat voivat varata majoituksen suoraan hotelli Vantaasta, puh. (90) 857 851. Majoitushinta on 490 mk/vrk yhden hengen huoneessa ja 245 mk/vrk/2 hlö.

**Lisätietoja:** Koulutussuunnittelija Jorma Vihinen, puh. (90) 530 7298.

### KESKIVIIKKO 26.1.

*Puheenjohtaja: Fil.toht. Aimo Hiltunen, SKJ yhtiöt Oy*

9.00– **Ilmoittautuminen ja kahvi**

9.30– **Uudistuvan jätelainsäädännön vaikutukset sivutuotteiden ja toisioraaka-aineiden hyödyntämiseen**
*Ympäristönsuojeluasiamies Benny Hasenson, Teollisuuden ja Työnantajain Keskusliitto*
Jätelaki- ja jäteasetusehdotusten sisältö. Hyödyntämisvelvoitteet. EY:n kierrätysmääräykset ja metalliteollisuus. Suomen viranomaisten lupa- ja valvontakäytännön erityispiirteet.

10.30– **Sivutuotteiden ja jätteiden muodostuminen metallurgisissa prosesseissa**
*Apul.prof. Heikki Jalkanen, TKK, Materiaali- ja kalliotekniikan laitos*
*Professori Lauri Holappa, TKK*
Metallurgisten sivutuotteiden (ja jätteiden) luonnehdinta. Raaka-aineiden rooli sivutuotteiden muodostumisessa. Sivutuotteiden muodostuminen erityyppisissä prosesseissa. Prosessiolosuhteiden rooli sivutuotteiden ja niiden ominaisuuksien muotoutumisessa. Sivutuotteiden ja jätteiden kierrätys. Mahdollisuudet sivutuotteiden modifiointiin primääriprosessien yhteydessä.

12.30– L o u n a s

13.30– **Integroidun terästehtaan sivutuotteet**
*FK Jukka Putro, Rautaruukki Oy Raahen terästehdas*
Sivutuotteet: Kuonat,kuonaromut, pölyt, lietteet, hilseet. Sivutuotteiden: Määrät, analyysit, ominaisuudet. Materiaalien hyödyntämismahdollisuudet. Nykytilanne Raahen terästehtaalla.

14.30– **Erikoisteräksen valmistuksessa syntyvät sivutuotteet**
*Dipl.ins. Håkan Hakulin, Outokumpu Oy*
Sivutuotteet, niiden kemialliset koostumukset ja muut ominaisuudet. Sivutuotteiden varastointia koskevat määräykset. Nykyinen hyötykäyttö. Suunnitelmat ja mahdollisuudet hyötykäytön tehostamiseksi.

15.30– K a h v i

16.00– **Sivutuotesideaineet**
*Tekn.toht. Tarja Häkkinen, VTT/Rakennustekniikka*
Hydrauliset ominaisuudet, kovettumisen perusteet. Tyypilliset vaikutukset. Soveltuvat käyttökohteet: betonit, erikoisbetonit/korkealujuusbetonit, stabilointi/maabetoni.

17.00–18.00 **Metallurgisten sivutuotteiden raaka-ainepotentiaalin hyödyntäminen**
*Dipl.ins. Pertti Koskinen, VTT/Rakennusmateriaalilaboratorio*
Eri sivutuotteiden teoreettiset mahdollisuudet kysymykseen tulevilla levilla sovellusalueilla, joita ovat ainakin: sementti ja betoni, muut rakennusmateriaalit, esim. kevytosa, maanparannusaineet, keramiikka- ja lasituotteet, eristysmateriaalit, tulenkestävät materiaalit.

18.30– S a u n a  j a  i l t a p a l a

### TORSTAI 27.1.

*Puheenjohtaja: Apul.prof. Heikki Jalkanen, TKK*

8.00– **Sivutuotteiden käyttö maarakentamisessa**
*Tekn.toht. Kauko Kujala, Oulun yliopisto/Geotekniikan laboratorio*
Tie- ja maarakentamisen materiaalitekniset vaatimukset. Sivutuotteiden fysikaaliset ominaisuudet. Sivutuotteiden sideaineominaisuuksien hyödyntäminen maastabiloinnissa. Sivutuotteet ja koerakentaminen.

9.00– **Kupari ja nikkelituotannon sivutuotteet**
*Dipl.ins. Jaakko Poijärvi, Outokumpu Harjavalta Metals Oy*
Sivutuotteiden muodostuminen, kierrätys ja prosessointi. Kupari- ja nikkelisulaton kuonat, pölyt ja kaasut. Rikkihappotehtaan pesuhapot ja sakat. Kuparielektrolyysin oheistuotteet ja sakat. Nikkelitehtaan sakat.

10.00– **Sinkin valmistus ja sivutuotteet**
*Kehitysjohtaja Aimo Järvinen, Outokumpu Kokkola Zinc Oy*
Sinkkitehdas: prosessi, sivutuotteiden valmistus. Raaka-aineet: Rikasteet, muut. Epäpuhtaudet: vaikutukset prosessiin.

11.00– L o u n a s

12.00– **Kierrätysmetallien talteenotto ja prosessointi**
*Dipl.ins. Erkki Koski-Lammi, Kuusakoski Oy, Heinolan tehtaat*
Kierrätysmetallien talteenotto ja keräys Suomessa. Metallien prosessointi ja jalostus metallurgiseen tuotantoon sopivaksi Kuusakoski Oy:ssä. Jalometallien kierrätys. Sinkkivalkoislinja. Kaapelikäsittely. Heinolan tehtaan monimetalliprosessit. Prosessointiin liittyvät ongelmat. Tuotannosta syntyvät jätteet ja niiden mahdollinen uudelleen käyttö.

13.00– K a h v i

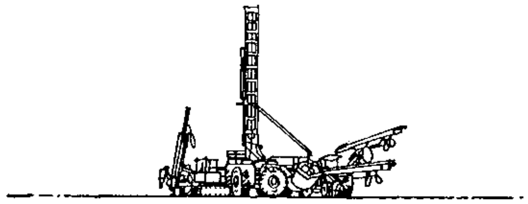
13.30– **Sivutuotteet liiketoimintana**
*Fil.toht. Aimo Hiltunen, SKJ yhtiöt Oy*
Sivutuotteiden materiaaliominaisuudet/tuotantoprosessit. Tuotekehitys materiaaliominaisuuksien pohjalta. Tuotteiden laatuvaatimukset ja kilpailukyky. Sivutuotteiden markkinointi.

14.30– **Ympäristövaikutukset prosessien arviointikriteereinä**
*Dipl.ins. Matti Palperi, Finx Oy*
Mitä ympäristövaikutuksia huomioidaan. Arviointimenetelmistä. Ympäristövaikutusten merkitys prosessien vertailussa ja kehityksen suuntaamisessa.

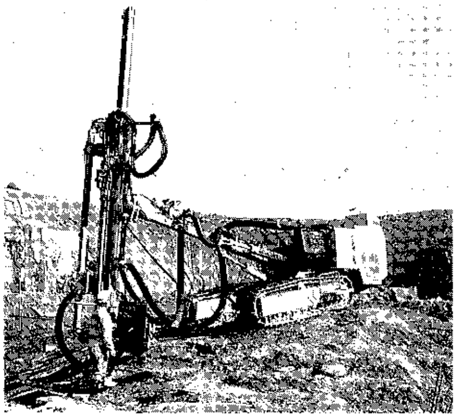
15.30 **Tilaisuus päättyy**

(Muutokset mahdollisia)

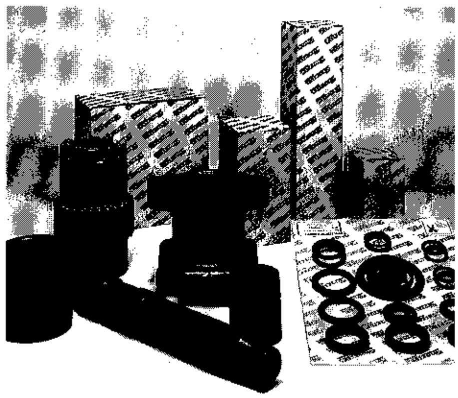
**INSKO**
**Vuorimiesyhdistys ry**



# KIVEN JA KALLION LOUHINTAAN

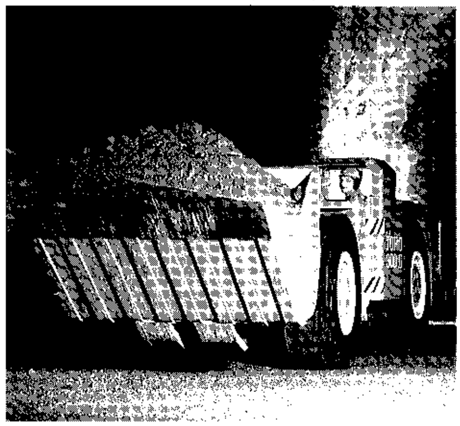


**TAMROCK SURFACE**
- avolouhintaporauslaitteet
- hyötykiven porauslaitteet



**TAMROCK PARTS**
- alkuperäiset varaosat
- huoltotuki
- koulutus
- huolto- ja käyttöohjeet

**TAMROCK UNDERGROUND**
- tunnelin- ja peränajolaitteet
- tuotantolouhintaporauslaitteet
- pultitus- ja rusnauslaitteet
- nousuporauslaitteet



**TAMROCK LOADERS**
- maanalaiset louheen lastaus- ja siirtolaitteet

**TAMROCK**

TAMROCK
PL 100, SF 33311 TAMPERE
Puh. 931-241 4111, Fax 931-241 4849
Tlx 22193 sf

# The Finnish Association of Mining and Metallurgical Engineers 50th Anniversary Gala Meeting

**Opening speech**
**Chairman, professori Raimo Matikainen**

## FOUNDING OF THE ASSOCIATION

As the recently published history of our association tells us, on the 12th of January 1943 twenty-nine mining engineers met in Helsinki to establish their own association. The engineers represented eight different companies, while two were there as private individuals. The purpose of the association was defined simply as "to promote the development of the mining industry in Finland, to safeguard the common interests of its members and to act as a link between them". The rules of association further emphasized that the purpose of the association was not to obtain profit or other direct financial gain for its members. The society has honoured these unselfish goals it originally set for itself throughout its fifty year existence.

The history of the Association is very closely linked with the development of the mining and metallurgical industry in Finland. As a result of the rapid growth in the number of members, in 1951 the association divided into three sections, geological, mining and metallurigical. In 1971 the mineral processing engineers split away from the mining section to form their own section. Today, the association has a total of 2040 members, of whom more than half belong to the metallurgical section. This division clearly reflects the current state of the industry and the present demand for engineers, which is mainly for those with skills in metallurgy and upgrading metals.

The Association of Mining and Metallurgical Engineers was established largely on the same lines as similar associations in the other Nordic countries. Close contacts have been maintained with these associations all this time, just as the industrial sectors in these countries have worked closely together. During the difficult period after the 2nd World War in particular, these links with other Nordic countries were extremely important for us. Cooperation was not limited to participation in annual major events, but was evident in very practical ways, especially in research and education. We have had in particular a wide range of joint activities with Jernkontoret, the Swedish steel producers association, in research and generally promoting the interests of the industry. It should also be remembered that in the 1930s very many Finnish graduate engineers were actually educated at Royal Institute of Technology in Stockholm. Cooperation has continued to this date with the universisites of technology in both Stockholm and Luleå.

## SIGNIFICANCE OF FINLAND'S MINING INDUSTRY

The mining industry forms the foundation for many diverse forms of upgrading and manufacturing with metals and minerals. In the production of metals the emphasis is clearly on exporting, whereas in the industrial minerals sector it is on products to replace imported goods, serving other parts of industry such as paper making and construction. The added value generated by the mining industry is extremely high if we include the whole chain, from our own mining activity through to the finished metal or metal product. It is a similar story in the industrial minerals industry. The effect on employment is truly considerable if account is taken not just of production activity itself but also of what has come about as a consequence; this include the manufacture and export of advanced, internationally recognized machinery and equipment, as well as local support services. The mining industry has been a major in regional development policy.

Having our own natural resources was a vital stimulus in this development. The copper ore at Outokumpu formed the core of the industry, but the discovery of many new ore deposits, and the mining operations that followed, led quickly to the diversification of the metallurgical industry, to upgrading and manufacturing of metal products.

This growth required extreme boldness and farsightedness on the part of engineers and decision-makers at the time, for it was truly rapid in the 1950s and 1960s. This was a period of engineer-led building for the whole industrial sector. Unfortunately since this period of intense growth very few exploitable ore deposits have been found in Finland.

The rise in the number of upgrading plants soon led to an increased use of foreign concentrates. Indeed, steel production switched entirely to using imported concentrates. Since Finland has not had sufficient ore resources, companies have placed more emphasis on mining joint ventures abroad to guarantee their supply of raw materials. A company with its own supply of raw materials as part of its metallurgical production chain obtains the benefit of synergy, which is of great financial significance in counteracting external disruptions to the market. This benefit derives from the fact that for several non-ferrous metals, the cost of mining activities, and therefore of the concentrates, may form 60 or even 80 per cent of the market price of the metal.

One positive feature is that the prospects for mining do seem to be brightening up slightly, after a long time, even in Finland. The upgrading chain here needs to be as complete as possible if it is to provide the long-term, financially solid basis needed for education and research. The revival of Finnish mining activities is really essential today if the teaching of geology and mining is to continue in Finland. Many people have indeed been questioning whether it should, in these times when financial profit is the only thing that matters. Providing education in Finland does not in any way limit the international nature of the mining industry. This has been obvious for the Finnish industry right from the start, meaning not simply the Nordic countries but also on a worldwide level. As an example, starting in 1994 instruction in mining engineering at Helsinki university will be given in English.

## A FORWARD-THINKING INDUSTRY

The mining industry is a heavy basic industry which has not been very popular with the public during the so-called 'years of plenty'. People have generally been highly uncomplimentary about mines and the mining industry, calling it a twilight or smoke stack industry, for example. This is rather unkind considering that in Finland the mining industry has on the whole been very profitable.

Of course industry always has difficulties as well when international markets and prices fluctuate excessively, but the industry has provided a huge amount of jobs, and these have frequently been in development regions. The pace of investment in the metallurgical industry has been really fast in Finland. In addition to offering increased capacity, this has also maintained production technology at a very high international level, which is absolutely necessary if companies are to succeed and be competitive today.

Even though the ore resources in many of the present metal mines are depleting fast, the mines have been kept profitable through the use of mechanization and automation. As far as industrial minerals are concerned, mineral deposits are clearly much larger, and marketing is taking on a more important role. The limestone industry is going through a vigorous period of adapting to the well-known slump in construction volume and the challenge of international competition.

It can be said that the Finnish mining and metal industry has a healthy basis. However, everything must be done to find our own raw material resources, both ore and industrial minerals, making use of the good professional skills available while we still have them.

## EFFECTIVE USE OF HIGH TECHNOLOGY

Finland's mining industry has preserved its profitalibility by taking quick advantage of automation and high technology. The proportion spent on research and development here is completely up to international standards, and we have often managed to apply new technology faster than our competitors on the initiative of our own staff. High technology has no value in itself unless it is applied quickly in production.

Research is very closely linked to the association's activities. The research committee has concentrated its efforts mainly on mining, but issues especially involving environmental protection, energy-saving technology and recycling are visibly uniting all sectors of the mining industry again. The distinction between mining and metallurgical research becomes blurred when considering new alternative processes, environmental issues and automation. Finnish industry has provided an excellent testing basis for equipment manufacturers, as well as the tough, constructive criticism need for exporting. Several development projects linked to extensive technology programmes are currently being carried out for the mining industry; these are being partly funded by the Finnish Ministry of Trade and Industry and by TEKES, the Finnish Technology Centre. The aim of these projects is to preserve our competitive position in the industry into the future. Some of the projects are joint projects with other Nordic countries.

## COOPERATION VITAL

Cooperation between the different professional groups within the industry has been a strength of the mining and metallurgical industry all along. The broad-based education received by everyone in the industry has made this easier, as have the close ties with industrial companies. These ties have been one of our greatest strengths when building up Finnish industry, and are still so, even in foreign projects. In all its activities the Association of Mining and Metallurgical Engineers has tried to support this cooperation in all its contacts with members and in its research work.

The international trend of early specialization in the foundational stage of studies is now spreading to Finland, but the problems it brings will be highlighted when the new engineers qualify and start looking for jobs. It is much easier for someone who has a broad-based knowledge of theory to specialize later in an industrial situation, according to the specific needs at the time.

Educational institutions and companies do work closely together today, but I would still appeal to companies, particularly during these very difficult times, to take more notice of the needs of students for industrial experience.

This is the only way we can ensure that the industry gets the new, more active personnel resources that it needs, who will in time be responsible for the future of our industrial sector.

Dear guests

About 800 members have registered for this annual conference of the Association, and that is a lot for a professional organization for engineers in Finland. This demonstrates how active people are in this sector and their sense of belonging together. It also shows that the industry is still very much alive and well. On this note may I welcome you all to the Association's 50th anniversary meeting, to our anniversary seminar and to the traditional annual conference. May I especially welcome the representatives from the associations in the other Nordic countries. For the first time we also have with us a representative from the Estonian association of mining and metallurgical engineers — the chairman Väinö Viilup. Welcome to this gathering of mining engineers. I trust you'll feel at home here.

I would especially like to welcome our speakers, who are leading international experts in the field. Thank you for coming to our anniversary seminar, and I hope you will also have an interesting, enjoyable weekend here in Finland.

## YHTEENVETO

## 50-VUOTISJUHLAKOKOUKSEN AVAUSSANAT

Yhdistys on kasvanut kuluneen 50 vuoden kuluessa yli 2000 jäsentä käsittäväksi henkilöyhdistykseksi, jossa on edustettuna kaikki vuoriteollisuutta edustavat teknilliset erikoisalat. Vuoriteollisuuden nopea kasvu ajoittuu lähinnä 1950—60 luvuille, jolloin avattiin useita uusia kaivoksia ja niiden raaka-ainevarojen varaan jatkojalostuslaitoksia. Jatkojalostus on edelleen kasvanut ja se käyttää nykyään jo pääosiltaan ulkomaisia rikasteita ja raaka-aineita. Vuoriteollisuus on perusteollisuutta, jossa ollaan rohkeasti uusien itsekehitettyjen prosessien avulla ennakkoluulottomasti ratkaistu jatkojalostuksen ongelmat käyttäen apuna tekniikan ja tieteen viimeisimpiä sovellutuksia. Vuoriteollisuuden alalla on erityisen tärkeätä tiivis poikkitieteellinen yhteistyö alan eri ammattiryhmien välillä, joka on osaltaan johtanut kansainvälisen kilpailukyvyn kannalta arvokkaaseen kokonaisvaltaiseen ajattelutapaan ja teknisiin ratkaisuihin. Yhdistys on omalta osaltaan pyrkinyt kaikin käytettävissä olevien keinojen avulla edistämään alan kehitystä. Ansio yhdistyksen elinvoimasta ja aktiivisesta toiminnasta lankeaa sen jäsenistölle ja aivan erikoisesti toimihenkilöille. Vuorimieshenki on kuvastunut ja kuvastuu edelleen yhdistyksen kaikesta toiminnasta.

# State's Address for the Anniversary Meeting of the Finnish Association of Mining and Metallurgical Engineers

**Minister of Trade and Industry Pekka Tuomisto**

Marina Congress Center in Helsinki on 19 March 1993

The founding of the Finnish Association of Mining and Metallurgical Engineers fifty years ago was a brave and far-reaching step at a time when the nation was struggling with huge external difficulties. In the preceding decade, the 1940s, the mining industry and business had seen a notable activation. This was then followed by a long period of expansion, which culminated in the early 1980s, when the extraction of ores and minerals came to exceed 20 million tons a year, against only 1—2 million in the 1940s. Credit for the increase goes to the painstaking work of the skilled Finnish engineers specialized in the field. In the past few decades, mining, metal-making and dressing of minerals have greatly contributed to the increase in our national welfare. In those days, building of mines in outlying areas of the country was most successful regional and employment policy.

The preconditions for industrial development have changed essentially since those days. Our future will increasingly rely on knowledge, technical skills and knowhow. Besides the traditional wood and metal, we are now adding a third leg — consisting of advanced technology and worldwide markets — to the substructure of our industries.

But we cannot forget other traditional industries either. It will be essential for us to invest in their technological basis and to improve any other prerequisites for their development. Lots of energy at competitive prices will, for example, be needed in metal-making. The existing plans say for the expansion of nuclear energy in our country are significant for the mining industries' continued operation and plans of extension.

In increasing the knowhow in this field, a key position is naturally held by the Geological Survey on one hand and the university departments concerned on the other hand. The industry's exploration projects have also been given public subsidies through the Ministry of Trade and Industry and the Finnish Technology Development Centre (TEKES).

The Ministry's role has traditionally been to provide finance for the early prospecting. Government funds are also allocated in terms of various programmes conducted jointly with the industry itself. These have related to the automation of mining, dressing technologies, energy conservation within the various metallurgical processes and so on. With the mining industry as a reliable partner, participation in such projects relating to the various phases of exploration has been a natural function for the State.

The mining business is governed by a Mining Law, the purpose of which is to encourage mining and prospecting in the country. Every Finnish citizen and corporate body is fully free to acquire rights under this Law.

To foreigners the government can grant, and has also done so, rights under the Mining Law through a special licence to be obtained from the Council of State. This has been possible in cases where the foreign applicant has been willing to cooperate with a Finnish company. Experience has been positive in these cases.

Our forthcoming membership of the European Economic Area led us last year to revise the old Finnish Mining Law to meet the new requirements. The chief amendment concerned foreigners' rights of mining and prospecting. After the entry into force of the new Law, any resident of a country belonging to the European Economic Area will have the same rights as our own citizens now have. The same will apply to every foreign corporate body established under the laws and regulations of any of the EEA member states provided that it has its central administration and its principal place of business in one of the member states.

In addition, the Ministry of Trade and Industry may continue to grant, at its own discretion, permits to individuals and corporate bodies belonging to any other states especially if they are partners in a joint venture with a Finnish company or if reciprocity will be involved.

Though the new Law has already been adopted by the Finnish Parliament, it does not apply as yet. The entry into force will take place simultaneously with our joining in the European Economic Area.

I already take this opportunity to welcome foreign enterprises to carry out prospecting and mining in our country. Recent years have revealed several entirely new type of metals and minerals in the Finnish soil. The prospects of an experienced mining firm to obtain favourable results in the field can be considered reasonably good.

One example of the new sites of exploration is the Keivitsa nickel and copper deposit in Sodankylä. It was found last year by the Geological Survey of Finland. The exploration of this ore body is only beginning, so that any precise results permitting the identification of its extent and average grades cannot be quoted. In the light of the preliminary findings both the volume and coverage of the deposit would seem to be turning out really large.

Besides Keivitsa, certain companies have other new and promising sites of exploration as well. Today, the prospects of mining and dressing in Finland can once again be looked upon optimistically.

Internationally, Finnish mining is well-known and esteemed. The present association and its members have significantly contributed to the development of the mining industry. I am glad to note in this context the publication of the "Mining Industry 2000", a technology programme piloting us into the future, which has been jointly drawn up by this association and the industry.

It is my privilege to bring the greetings of the government to this jubilee meeting, accompanied by wishes of continued success for the association and its membership. Despite the difficulties our economy is facing today, mining, metal-making and dressing of minerals has been managing reasonably well and is sure, by means of systematic efforts, to survive the hard times.

# Kauppa- ja teollisuusministeri Pekka Tuomiston tervehdyspuhe Vuorimiesyhdistyksen 50-vuotisjuhlakokouksessa 19.3.1993

Marina Congress Center Helsingissä 19. maaliskuuta 1993

Vuorimiesyhdistyksen perustaminen 50 v sitten oli rohkea ja kauaskantoinen toimenpide aikana, jolloin maa kamppaili mittavien ulkoisten vaikeuksien kanssa. Vuoriteollisuus lähti 1940-luvulla mittavaan nousuun. Kun malmien ja mineraalien vuosilouhinta 1940-luvulla oli tasolla 2—3 milj. tn oli se kohonnut 1980-luvun alkupuolella yli 20 milj. tonniin. Tämä on saavutettu suomalaisten vuorimiesten taitavalla ja sitkeällä uurastuksella. Kaivostoiminnalla sekä metallien valmistuksella ja mineraalien jalostuksella on ollut menneinä vuosikymmeninä oma merkittävä vaikutuksensa hyvinvoinnin lisäämisessä. Kaivosten syntyminen syrjäseuduille oli menneinä vuosikymmeninä luontevaa ja edullista kehitysalue- ja työllisyyspolitiikkaa.

Teollisuuden kehitysedellytykset ovat noista ajoista varsin oleellisesti muuttuneet. Tulevaisuutemme on entistä enemmän tiedon, taidon ja osaamisen varassa. Pyrimme luomaan teollisuuteen puun ja metallin lisäksi kolmannen tukijalan, joka perustuisi pitkälle kehitettyyn teknologiaan ja maailmanlaajuisiin markkinoihin.

Samalla on kuitenkin pidettävä huolta perinteisistä teollisuudenaloista. Myös niiden tarvitsemaan teknologiaan on panostettava ja parannettava muita kehitysedellytyksiä. Esimerkiksi vuoriteollisuudessa metallien valmistus tarvitsee runsaasti energiaa kilpailukykyiseen hintaan. Tämän johdosta vireillä olevat ydinenergiaratkaisut ovat vuoriteollisuuden toiminnalle ja suunnitteilla oleville laajennuksille merkityksellisiä.

Tämän alan tietotaidon lisäämisessä ovat luonnollisesti geologian tutkimuskeskus sekä korkeakoulujen tämän alan laitokset keskeisessä asemassa. Lisäksi julkisella rahoituksella sekä kauppa- ja teollisuusministeriön että TEKESin kautta on tuettu vuoriteollisuuden tutkimushankkeita. Perinteisesti kauppa- ja teollisuusministeriö on tukenut prosessin alkupäätä malminetsintää. Valtio osallistuu rahoituksellaan mm. kaivoksen automatisointiohjelman, rikastusprosessin teknologiaohjelman sekä metallurgisten prosessien energiasäästöohjelman rahoitukseen yhteisesti teollisuuden kanssa. Kun osapuolena on luotettava vuoriteollisuus on ollut helppoa osallistua valtion rahoituksella näihin tutkimushankkeisiin.

Kaivostoimintaa säätelee kaivoslaki, jonka tarkoituksena on kaivostoiminnan edistäminen. Kaivoslain oikeuksien hankkiminen on avoin ja vapaa Suomen kansalaisille ja yhteisöille.

Ulkomaalaiselle voidaan ja on myönnetty kaivoslain oikeuksia valtioneuvoston erikseen antamalla luvalla tapauksissa, joissa on ollut kyseessä yhteistoiminta suomalaisen yrityksen kanssa. Näistä on saatu myönteisiä kokemuksia.

Viime vuonna on lainsäädäntöämme mm. kaivoslakia muutettu vastaamaan ETA:aan liittymisen edellytyksiä. Ulkomaisten oikeutta rajoittavaa säännöstä on muutettu niin, että ETA-alueella asuvalla henkilöllä ja sellaisella ulkomaisella yhteisöllä, joka on perustettu jonkin ETA-valtion lainsäädännön mukaan ja jolla on sääntömääräinen kotipaikka, keskushallinto tai päätoimipaikka jossakin ETA-valtiossa, on samanlaiset oikeudet kuin suomalaisella henkilöllä tai yhteisöllä.

Tämän lisäksi ministeriö voi myöntää harkintansa mukaan luvan myös muiden maiden yhteisöille ja henkilöille varsinkin yhteisyrityksille tai vastavuoroisuuden perusteella.

Edellä selostettu kaivoslain muutos on eduskunnan hyväksymä, mutta tämä lainmuutos saatetaan voimaan vasta samanaikaisesti ETA:n voimaantulon yhteydessä.

Toivotan ulkomaiset alan yritykset tervetulleeksi sekä malminetsintään että kaivostoimintaan. Meillä on viime vuosina löydetty useita kokonaan uudentyyppisiäkin metalli- ja mineraaliesiintymiä. Voidaan katsoa olevan kohtuullisia mahdollisuuksia asiansa osaaville yrityksille saavuttaa myönteisiä tuloksia.

Uusista tutkimuskohteista mainittakoon esimerkkinä Sodankylässä sijaitseva Keivitsan nikkeli-kupariesiintymä, jonka geologian tutkimuskeskus on viime vuonna löytänyt. Tämän malmiaiheen tutkimukset ovat alkuvaiheessaan, joten vielä ei ole käytettävissä tutkimukseen perustuvia riittäviä tuloksia tutkimuskohteen suuruuden ja keskipitoisuuksien määrittelemiseksi. Alustavien tulosten perusteella esiintymä näyttäisi muodostuvan kooltaan hyvin suureksi ja laaja-alaiseksi ja tähänastiset tiedot pitoisuuksista näyttävät kohtuullisilta. Suomen kaivosteollisuuden uusi lippulaiva saattaa olla pian vesillelaskettavissa.

Tämän lisäksi myös eräillä yhtiöillä on uusia lupaavia tutkimuskohteita. Kaivostoimintaan ja jatkojalostukseen on perusteltua suhtautua jälleen optimistisesti.

Suomen vuoriteollisuus on kansainvälisesti tunnettu ja tunnustettu. Vuorimiesyhdistys ja sen jäsenistö on merkittävästi vaikuttanut vuoriteollisuuden kehittymiseen. Mainittakoon, että Vuorimiesyhdistykseltä on yhteistyössä teollisuuden kanssa vastikään valmistunut Kaivosteollisuus 2000 teknologiaohjelma, joka luotsaa tulevaisuuteen.

Esitän Vuorimiesyhdistykselle, sen jäsenistölle ja 50-vuotisjuhlakokouksen osallistujille valtiovallan tervehdyksen ja menestyksen toivotukset. Vaikeasta taloudellisesta ajasta huolimatta kaivosteollisuus, metallien valmistus ja mineraalien jalostustoiminta ovat kohtuullisen hyvin menestyneet ja määrätietoisella työllä tulevat selviytymään tämän ajan yli.

# Prospects for the Finnish Mining and Metallurgical Industry

**Professor Markku Mannerkoski, Director General of the Technical Research Centre of Finland**

The Finnish Association of Mining and Metallurgical Engineers
50th Anniversary Meeting at Marina Congress Center in Helsinki on 19 March 1993

Over the past four decades, industrial production in the OECD countries has increased fivefold. The service industries grew even faster than that. As a result, factory production, which used to account for more than one third of the GDP of the European OECD countries, dropped to less than a quarter.

Finland industrialized relatively late but rapidly. In the course of the said four decades, industrial production increased here seven-fold. At the same time, the industry's share of GDP increased steadily for a long time, reaching its peak in 1974 when it accounted for one quarter of the total. It remained at this level until 1980, being at that point of time consistent with other European OECD countries.

## NEED FOR RE-INDUSTRIALIZATION

When the relative share of factory production in the Finnish GDP began to decline in the early 1980s, this was considered as a sign of progress, as an indication that we were moving ahead, along with others, towards a post-industrial society. Unfortunately, the pace of these developments in Finland soon overtook other countries. As a result, we have fallen clearly below the OECD level in Europe, even if other countries are complaining about the same problem. Traditionally, the percentage of factory employees in the entire workforce has been low in Finland owing to structural factors, and now this indicator is one of the lowest in Europe.

Gladly, we seem to have reached some sort of consensus on the fact that Finnish industry is simply too small to serve s a locomotive for the service and public sectors of the present size and to sustain the current income redistribution policies. By the end of this decade, Finland must regain its position that, relatively speaking, prevailed in 1980. Only a year ago, a working party chaired by the former chairman of this Society, Mr Pertti Voutilainen, drafted a definite programme for such re-industrialization.

Europe is being integrated and the four freedoms associated with this process are being extended, although certainly at a slower pace than expected at the time when the global exonomy was looking up. Under these changing circumstances, we will have to re-establish our competitive advantage as individuals, companies and society. To succeed, we need comprehensive programmes and actions, as well as small-scale efforts such as picking berries.

One of the basic premises is that any activity that profitably meets the needs of the customers is, by definition, worth backing. The Finnish economy will be revitalized on this basis, involving organic growth from bottom to top. A top-down approach can merely provide the general organizational framwork for recovery. To achieve both, we must be able to recognize our competitive advantages.

## PORTER'S DIAMOND

According to standard economic theory, the increase in national wealth is primarily based on the availability and price of natural resources, labour and capital. Recently, the "Diamond Model" developed by Professor Michael E. Porter, of Harvard Business School, which emphasizes real competitive advantage, has attracted a great deal of attention throughout the world. Backed by a four-year research programme, involving a total of thirty resarchers, into the competitiveness of ten economically significant nations, Porter stresses that national wealth is not inherited but created. The national advantage in competition is determined by a country's capacity for innovation and product upgrading. Companies survive in the competition because of challenges and pressures. They benefit from highly competitive home markets, aggressive subcontractors and demanding domestic customers. Now that Finland has applied for admission to the European Community, some self-styled patriot feel the need for a new war of independence. Porter suggests, however, that with increasing global competition, the significance of individual nations will increase rather than diminish. According to him, this is due to the fact that competition will increasingly be based on the acquisition and adoption of special skills, where national differences will provide a source of strength, not be a disadvantage.

This is how Porter draws his diamond. Its four points consist of the following attributes: 1) Factor Conditions, 2) Demand Conditions, 3) Related and Supporting Industries, and 4) Firm Strategy, Structure, Rivalry and the Playing Field. These basic factors are involved in dynamic mutual interaction, which determines the competitive advantage of companies and, ultimately, of the nation. Unfavourable conditions at one of the four points can be compensated for by extra benefits at others.

What can the diamond tell us about the prospects for Finland and Finland's mining and metallurgical industry today?

## FINLAND TO GRASP INNOVATION

The model helps illustrate the various stages of development of a nation's competive advantage. These stages are, successively, factor-of-production-oriented, investment-oriented, innovation-oriented and wealth-oriented. The first three stages are characterized by a continuous improvement of competitive advantages and the accumulation of wealth. The fourth stage means idleness and, ultimately, decline. Typical of his final stage is, inter alia, dwindling competition, decrease in investment to create factors of production, orientation to areas that do not benefit industry, decline of hands-on training and loss of attraction of a career in the industry, inflexibility on the labour market and loss of productivity relative to payroll costs.

At least the last-mentioned factor greatly contributed to the development where Finland's exports to the West decreased and the market shares of the open sector diminished in the 1980s. Probably, we showed some of the other signs of the wealth stage as well, although our affluence was largely an illusion based on borrowing, unusually favourable terms of trade, overheating of the economy and an unrealistically strong currency. Anyhow, the innovation stage must remain a permanent goal for Finland's economic policy. At the innovation stage, the diamond of national competitive advantage operates in a large number of sectors, effective use can be made of the basic factors of competitiveness, and their interaction is intense. Then companies will not only acquire and improve technology transferred from other countries but work hard to create such technology. Of course, cost competition will continue to be important but it is, to a great extent, based on increased productivity achieved as a result of improved know-how.

## FINNISH MINING INDUSTRY IN THE LIGHT OF THE DIAMOND

What about the Finnish mining industry? The establishment of this branch of industry in Finland was made possible by the country's timber resources, hydro-power, labour and, initially, imported ore. Over the years, richer ore deposits were also found in Finland. For a long time, all know-how was imported. What we had, then, was accumulation of wealth based on "inheritance" in the sense suggested by Porter. The copper deposits found at Outokumpu were exceptionally important in this respect, a true stroke of luck, even though geological know-how played a part in the discovery. That the ore could be exploited by Finland's own efforts must be credited to the courage and determination of Eero Mäkinen. It was of decisive importance to the future development of the Finnish mining industry. In a private letter addressed to a member of the Standing Committee of Finances of Parliament, he wrote that if the mining concession is granted to a company controlled by foreigners, he would collect all the dynamite available at Outokumpu, place it in the basement and blast the entire Committee to kingdom come. It was not necessary. Mäkinen's position prevailed. This explosion that never took place proved to be the starting shot for the Finnish mining industry in the process of moving away from inheritance-based subsistence to the narrow and rocky, yet rewarding road of continuously re-creating national competitiveness.

In the 1960s, the Rautaruukki company boldly introduced state-of-the-art production technology developed outside Finland and began to invest heavily in research and development that aimed at highly practical goals, while at the same time being based on a firm scientific approach. As a result, the company operates today one of the worlds's most productive steel mills. Other success stories, even if on a smaller scale, are also known.

However, Outokumpu has remained Finland's only truly rich ore deposit and our mines are being depleted. Is the cycle of the Finnish mining industry drawing to a close? Is it one of those mature branches of industry that took a battering in other industrialized countries in Europe already in the late 1970s, while similar changes in Finland were put off partly due to the brisk Soviet trade, or does it possess enough creativity to maintain its competitive advantage in future?

In terms of the four points of the Porter Diamond, i.e. the four factors affecting competitiveness, the position of the Finnish mining industry appears, in rough outline, as follows:

1) Factor Conditions: Imported raw materials play an important role but they are supplied, to a great extent, by affiliated companies or subsidiaries or under long-term supply contracts. Finland's price competitiveness, infrastructure and level of skills is high. However, there have been disturbing uncertainties concerning the energy supply.

2) Demand Conditions: Porter emphasizes the importance of a high standard of quality on the home market and the resultant domestic competition as a factor contributing to international competitive advantage. In the case of a small country like Finland and a major industry like mining, this point of view is important mainly with regard to the related and supporting industries. After all, the Finnish mining industry has already expanded internationally to a considerable degree both in terms of exports and direct investments, which has required the ability to face open competition.

3) Related and Supporting Industries: The production, sales and consultation activities concerning the machinery and equipment, instruments, paints, plastics and building materials related to this industry are highly advanced.

4) Strategy, Structure, Rivalry and Playing Field: The Finnish style of organization and management is probably closer to a German-type hierarchic approach than, say, an Italian family-firm approach, which is more flexible and suitable for brand products. This is probably no drawback for the Finnish mining industry because it is not concerned with consumer goods or selling with imagery. As down-to-earth people, we Finns still appreciate achievements attained in the basic industries and the stamp of smokestack industry has not alienated all the talent. A healthy spirit of competition, even if low in profile, is still very much alive. Moreover, the Finnish mining industry has proved its efficiency in comparison with its competitors.

Accordingly, fairly effective and interactive use is being made of all the four basic factors of competition in this branch of industry. The worst potential threat seems to concern the availability of moderately priced electricity.

## TURNING DISADVANTAGES INTO ADVANTAGES

Porter point out that the drawback caused by a shortage or depletion of any single inherited factor of production may, in fact, give an effective boost to competitiveness. While it is hard to believe that the Swedes developed into superb down-hill skiers because the hills in their country are low and so they had to learn to make maximum use of the difference in height, as Porter suggests in one of his examples, it is safe to say, when looking at the Finnish mining industry, that obstacles may promote innovation.

Samples provided by ordinary people and the technology of the 1950s and 1960s made it possible to locate a major sulphide ore deposit approximately every five years. When exposed deposits could no longer be found, major investments were made in metal ore prospecting in Finland in the 1970s and early 1980s in an attempt to overcome the new difficulties encountered in prospecting. As a result, the level of skills in this field is now high in Finland. Although the prospecting activities have subsequently reverted to a lower level of intensity, prospects for success still exists. For example, prospectors have returned to areas that have already been explored and left to await further research, only this time using more advanced methods and better ideas, and actually found workable deposits.

As a rule, ore deposits in Finland are limited, poor, located below the ground and hard to mine and enrich. To exploit such deposits, a great deal of research and development efforts have been required. As a result, Finland is highly advanced in the field of mechanized mining and automated concentration technology. The pace of development has been swift. Thanks to a couple of decades of product development, Finnish machinery and equipment are known as first-class products throughout the world. Backed by solid basic know-how, we have been able to offer services to completely new areas such as coal mines, not to mention rock engineering and earth construction.

Mastery of ore prospecting techniques as well as excavation and conceneration technology, gained as a result of adverse conditions, has been of great assistance in securing supplies of raw materials from mines acquired abroad. Even mines doomed to closure as unprofitable have been kept successfully opened with the aid of our high level technology.

Similar examples of how the emergence of an exceptionally favourable factor of production affects the whole and how a drawback can be transformed into competitive advantage can be found in the metallurgical industry as well. For instance, the construction of the power plant in Imatra, which was unusually large by contemporary standards, made it possible to produce electrical steel. On this basis, we are still able to compete in the highly competitive special-alloy steel market. A reverse example is the flash melting of copper. The background for this great innovation was the Finnish government's demand that Outokumpu Oy reduce the consumption of electricity required for copper melting because of the shortage of electricity right after the war. Subsequently, flash melting not only provided a basis for increased production but also led to substantial sales of technology.

Naturally, drawbacks can stimulate development only to the extent that they can be overcome. For example, a sufficient supply of moderately priced electricity is one of the essential prerequisites for the continued viability of Finland's basic industries.

## METAL CLUSTER

As well as the diamond, Porter discusses corporate clusters. This notion is rapidly gaining ground among Finnish economists as well. Clusters are groups of companies whose products have a higher probability of success than products manufactured outside such a cluster. A cluster denotes certain key products, special factors of production, realted products and services as well as customers. The various components of a cluster support one another and create a multiplier effect. It is only natural that it is easier for each nation to develop its economic activities on the basis of the existing corporate groups than without the foundation offered by them. This is an essential feature of highly developed economies. We only need to think of German cars and chemicals, Swiss banks and drugs, Italian footwear and textiles, Japanese semiconductors and consumer electronics, and U.S. films and aircraft.

The Reaserch Institute of the Finnish Economy (ETLA) brought together a broadly based group of researchers who presented a preliminary list of potential competitive clusters in Finland a couple of months ago. According to the list, there are seven such groups: forestry, metal, transportation, energy, telecommunications, environmental technology, and welfare technology. This selection was based on the OECD exports statistics. A Finnish manufacturer was considered to possess an competitive advantage if the product's market share was larger than that of an average Finnish export item, if exports exceeded imports and were directed mainly outside the most immediate neighbouring countries. A "metal" cluster would include mining, mining machines and equipment, basic metals and further processed products as well as related products and services.

As we see, we, the members of this Society, are not the only people to believe that mining and metallurgy will be one of the Finnish branches of industry that has sound future potential in terms of competitive advantage. Success will continue to require domestic resources. At this point, such resources consist, above all, of aggressive, innovative people who do not flinch at a challenge — the very sort of people who have always been found in the membership of this Society!

With the Professor Porter's diamond in mind, I wish to offer my congratulations on this special occasion and express my best wishes to the Finnish metal cluster and the people who are developing it.

## YHTEENVETO

## SUOMEN VUORITEOLLISUUDEN NÄKYMÄT

Perinteisen talousopin mukaan kansakunnan vaurastuminen perustuu lähinnä luonnonvarojen, työvoiman ja pääoman saatavuuteen ja hintaan. Viime aikoina on herättänyt mielenkiintoa siitä poikkeava Michael E. Porterin "timanttimalliksi" kiteyttämä näkemys. Kymmenen maan kilpailukykyä tutkittuaan Porter painottaa, että kansallista hyvinvointia eri peritä vaan se luodaan. Onnistuminen riippuu ratkaisevasti elinkeinoelämän innovointi- ja jalostuskyvystä. Yritykset selviytyvät kilpailijoittensa parissa haasteiden ja paineiden ansiosta. Ne hyötyvät voimakkaasti kilpailluista markkinoista, aggressiivisista alihankkijoista ja vaativista asiakkaista.

Tältä pohjalta Porter piirtää timanttinsa. Sen neljänä kärkenä ovat maan tuotannontekijäolot, kysyntäolot, tuki- ja lähialojen yritykset sekä yrityksen strategia, rakenne ja kilpailukenttä. Nämä perustekijät tukevat toisiaan dynaamisessa vuorovaikutuksessa, mikä ratkaisee yritysten ja sitä kautta maan kilpailukyvyn.

Mitkä ovat Suomen vuoriteollisuuden näkymät tämän mallin valossa? Kysymyksessä oli aluksi "perinnön" varassa kehittyvä vaurastuminen. Outokummun kuparimalmi oli poikkeuksellisen arvokas perintö. Sen hyödyntäminen suomalaisin voimin oli ratkaisevan tärkeää; lähdettiin kilpailukyvyn jatkuvan luomisen kiviselle mutta pitkälle vievälle polulle.

Nyt kaivoksemme ovat ehtymässä. Onko alan sykli päättymässä? Kilpailukyvyn neljän perustekijän suhteen tilanne näyttää seuraavanlaiselta:

1) Tuotannontekijäolot: Tuontiraaka-aineiden merkitys on suuri, mutta niitä hankitaan paljolti osakkuus- ja tytäryhtiöiltä tai muutoin varmoin toimitussopimuksin. Maan hintakilpailukyky on hyvä, samoin infrastruktuuri ja työvoiman taso. Perusenergianäkymät ovat olleet viime aikoina häiritsevän epävarmat.

2) Kysyntäolot: Kysymyksen ollessa pienestä maasta ja vuoriteollisuuden kaltaisesta suurteollisuudesta, kotimaisella kilpailulla on merkitystä vain tuki- ja liitännäisaloilla. Vuoriteollisuutemme kansainvälistyminen on pitkällä, mikä on edellyttänyt selviytymistä avoimessa kilpailussa.

3) Tuki- ja lähialat: Alaan liittyvien koneiden, laitteiden, instrumenttien, maalien, muovien ja rakennusmateriaalien tuotanto sekä teknologian myynti ja konsultointi ovat kehittyneet hyvin.

4) Strategia, rakenne ja kilpailukenttä: Suomalainen organisointi- ja johtamistyyli sopii hyvin perusteollisuuteen. Arvostamme edelleen saavutuksia sen piirissä. Omanarvontuntoinen kilpailuhenki on korkealla. Tehokkuus absoluuttisessa vertailussa kilpailijoihin nähden on osoitettu.

Kaikki neljä perustekijää ovat siis alalla varsin hyvin käytössä ja vuorovaikutuksessa. Pahin potentiaalinen uhka on viime aikoina liittynyt kohtuuhintaisen sähköenergian saantiin.

Olemme pitkällä malminetsintätaidoissa sekä mekanisoidussa louhinnassa ja automatisoidussa rikastustekniikassa. Osaaminen on ollut suureksi avuksi, kun on turvattu raaka-aineiden saanti ulkomailta. Muiden käsissä tuottamattomaksi tuomittuja kaivoksiakin on otettu menestyksellä käyttöön. Prosessimetallurgian tuotantomme on tehokasta ja merkittävin osin omaperäistä. Tämä on johtanut laajaan teknologian ja laitteiden myyntiin. Ne on opittu tuntemaan kaikkialla maailmassa huipputuotteina.

Porter puhuu timanttinsa yhteydessä yritysklustereista. Ne ovat ryhmiä, joiden sisällä tehdyt tuotteet ovat todennäköisemmin kansainvälisesti kilpailukykyisiä kuin ulkopuolella valmistetut. Ryhmän osat tukevat toisiaan ja synnyttävät kerrannaisvaikutuksia. Ne ovat kehittyneiden kansantalouksien keskeinen piirre.

ETLA:n tutkijaryhmän mukaan Suomen klustereita ovat metsä-, metalli-, kuljetus-, energia-, telekommunikaatio- ja ympäristöteknologia sekä hyvinvoinnin teknologia. "Metalliin" kuuluvat kaivososaaminen, kaivoskoneet ja -laitteet, perusmetalli ja jatkojalosteet erilaisine liitännäisineen. Ala onkin epäilyksittä myös tulevaisuudessa kilpailukykyisten suomalaisten alojen joukossa. Siihen tarvitaan vastaisuudessakin kotimaisia luonnonvaroja. Nyt sellaisina tulee kuitenkin pitää ensisijaisesti haasteita kaihtamattomia, taisteluvalmiita, innovatiivisia ihmisiä.

# The Importance of Finland's Raw Materials Policy

**Professor Veikko Lappalainen, Director of the Geological Survey of Finland**

50th Anniversary Meeting
Talks on Mining Industry

## Ladies and Gentlemen

Although capable of detaching himself from the Earth, Man, that rather singular creation, is still very much dependent on it. The elements of which our body is composed are the same as those that make up Mother Earth. We nourish ourselves on the bounty of the Earth and her products. Industry and technology have made modern man increasingly dependent on the raw materials enriched in geological processes. Use of these raw materials has, however, been augmented to such an extent that the sources of those easiest to extract have already been exhausted — or soon will be. Industrial countries are fast depleting their own resources and are turning their attention to those of the developing countries. At the same time, new instruments are being developed, both technical and statutory, for recycling raw materials. Finland is actively participating in these developments. With good reason, we are concerned about the exhaustion of the domestic, geological raw materials that are so important for our industry.

Together with my colleagues I chose "The importance of Finland's raw materials policy" as the title of my talk. Here I shall deal with the subject from the point of view of the Geological Survey of Finland (GSF), looking particularly at the occurrence, resources, availability and importance of geological raw materials in Finland. The GSF is a research centre financed by the Finnish government. As such it is obliged to support the mining industry and other branches of industry and commerce, and to undertake basic research in geology.

The field of operations of the GSF is thus large, comprising geological, geophysical and geochemical studies and related assignments. According to the Decree on the GSF, which specifies the field of activity in greater detail, it is the duty of the GSF to undertake the above studies, search for and assess land resources and carry out related tasks, thus producing information on the sectors referred to in the Act for the needs of society and industry with a view to promoting the balanced and sustainable use of natural resources, the planning of land use and environmental monitoring.

The Decree refers to the national importance of mining in the following words: The duty of the Geological Survey of Finland shall also be to safeguard the interests of the state and its entitlement to occurrences it has discovered and which contain minerals as referred to in the Mining Act.

With its contacts and information flows the GSF keeps abreast of developments in the raw material sector in this country. The raw materials service is one of the key sectors of activity, the others being the production of basic geological information and the use of geology in environmental management. The importance of geological raw materials is also emphasized in the research policy programmes of the GSF, three of which have been completed so far, i.e. the science policy programme, the cartography policy programme and the raw materials policy programme. The fourth one, the environment policy programme, will soon be ready.

The raw materials policy programme of the GSF sets out the objectives of the search for and assessment of raw materials. It also underlines the importance of geological raw materials for domestic industry and industrial new production and the significance of groundwater in public water supply. The programme also sets targets for the development of data banks for resources of geological raw materials. The data banks can be used to forecast the sufficiency of raw materials resources in the ground, raw material reserves for times of crisis and, the sustainable and controlled use of the ground.

As stated in the standing order of the GSF, prospecting for and studies of raw materials are undertaken by research departments and regional offices. The latter are included in the operative sector. With reference to the exploration department in particular, it is stated that the department undertakes basic research in ore geology and areal distribution of industrial minerals and safeguards the interests of the state in and its rights to occurences found by the GSF and referred to in the Mining Act.

The regional offices undertake geo-mapping, exploration, the search for and studies of other raw materials, and investigations assigned to them in the operational plan of the GSF. At the beginning of this year, the GSF implemented a management-by-results system and introduced profit centre budgeting. All units are now profit centres, which means that they all plan their own projects and have them approved. Approved projects will be provided with funds and given time limits. This new system permits the GSF to transfer research resources to economically important key areas.

The strategy of exploration is part of the general strategy of the GSF. It specifies the general scope of operations of exploration, and indicates how objectives can best be reached. In the less official mineral policy programme, the priority given to the various ore types is established on the basis of a service balance worked out a few years ago. It thus defines the metals and industrial minerals with priority in exploration. The remit of the Exploration Department is to search for and find occurrences of mineral raw materials and to assess the occurrences discovered. The primary goal is to find ore deposits that can be exploited economically by Finland's mining industry. Exploration as whole consists of a set of geoscientifically controlled technical procedures aimed at the discovery of ore deposits. To find an ore deposit, a number of tactical and operative measures are also needed. Management by result is one of the measures introduced to help achieve the goals.

The GSF selects explorational areas and targets for ore geological investigations on the basis of regional metallogenic and geophysical knowledge and the information in ore data banks. The existence of an geophysical or geochemical anomaly or an oregeologically potential area, a commission from an outside customer, a sample received from an amateur prospector or even someone's intuition may all be reasons for setting the exploration process in motion.

Mining for metallic ores is expected to decline rapidly in Finland. The outlook for the minerals industry is brighter due to the abundance of industrial minerals. Although Finland has only a few metallic mines we should not allow the current economic situation to paint the future of the sector in too subdued a shade. Last year the GSF submitted reports to the Ministry of Trade and Industry on eight mining claims it had studied; four were metallic ore deposits and four occurrences of industrial minerals. The metallic ore deposits were the titanium-iron-vanadium deposit at Karhunjupukka, Kolari, the Hangaslampi gold deposit in Kuusamo currently owned by Outokumpu Finnmines Oy, the gold occurrences at Osikonmäki, Rantasalmi, owned from the beginning of this year by Outokumpu Finnmines Oy, and the Kaapelikulma gold occurrence in Valkeakoski. The most important occurrences of industrial minerals are the kaolin deposit in Virtasalmi and the chromium marble occurrences in Kittilä. The biggest kaolin occurrences were acquired by Kemira Oy.

The GSF is undertaking exploration at several sites in the hope that the long-waited, economically viable ore deposit might finally be found. The following are the main exploration areas for this year:

The nickel-copper showings in Sodankylä, particularly the multimetal occurrence at Keivitsa, investigations of which are still at a very early stage;

the gold showings in the Kittilä and Kuusamo schists areas;

the gold showings in the Ilomantsi schist belt, particularly the Pampalo occurrence, where studies are still at the preliminary stage;

the nickel-copper-gold showings in the Kuhmo schist belt;

the zinc-lead-silver showings at Haukipudas;

the zinc showings in the Vihanti belt;

the nickel-copper showings at Ylivieska, Sievi and Rantasalmi;

and

the gold and zinc-copper showings in the Pirkanmaa area.

Two targets of industrial mineral studies worth mentioning are the kaolin occurrences at Virtasalmi and the titanium-phosphorus occurrences at Kauhajoki. Most of the sites investigated for building stones are in southern Finland, the main ones possibly in the Savo region.

But we have showings and ore potential sites in store, too. I have only mentioned those actually being studied now. The GSF can investigate and assess an occurrence it has discovered only to a certain level of mineral resource appraisal. Mining companies then carry out the follow-up studies, including the multiparameter ore reserve assessment on the basis of which it is decided whether or not to start production. If the decision is in the affirmative the appropriate plans are made. Exploration is a long-term activity, and the way from the discovery to the opening of a mine is long. Unfortunately, the public does not always realize this.

Competition between building stone companies, most of them small, has intensified during the current recession, and prospects for the domestic building stone sector are poor. The forecast is gloomy indeed. As a result, building stone companies have stepped up their export efforts. Some success has been achieved in this area because Finland's competitiveness is good in many target countries. More rapid growth would be desirable but is held up by the modest resources the small companies have at their disposal. A brighter future for the business is seen in the opening EC markets. However, first, the domestic market must be strengthened and the position of stone consolidated. The debate about the type of stone to be used on the elevations of the Finlandia Hall and the indecision of the authorities have done little to ease the situation.

Considering the reasearch capacity available and Finland's raw materials policy, the GSF has made its contribution in searching for and investigating building stone occurrences. The work has increasingly been done under contract. Our geologists have been actively involved in pin-pointing new economic material occurrences and also in acquiring new customers. The conventional role of researcher is no longer enough; today technical and economic skills are also needed. As experts, geologists contribute to the vitality of the domestic stone industry. In the 1970s, a decade of progress and prestige for engineering geology, building stone was taught as a subject at our universities of technology. Now once again students of architecture and civil engineering can learn about the building stone industry. The importance of promoting the long-term use of Finland's own hard stones, which are highly resistant to environmental pollution, has been realized (Fig. 1, 2 and 3).

**Fig. 1.** Finnish rock presents a challange to the designer and constructor, but is also a source of raw material. Espoo railway tunnel. The high-quality railway ballast was extracted from local rock.

**Kuva 1.** Suomalainen kallio, haaste suunnittelijalle ja rakentajalle, myös raaka-ainelähde. Espoon rautatietunneli. Korkealaatuinen raidesepeli jalostettu paikallisesta kalliosta.

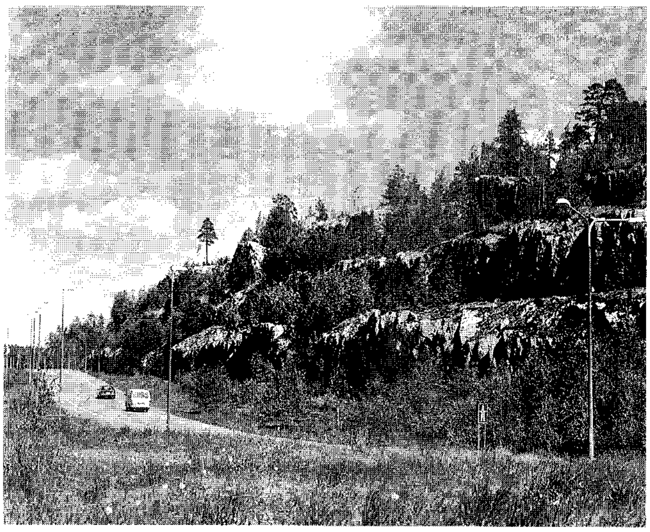


**Fig. 2.** The aggregate from this stepped rock at Vantaa was used as fill for the adjacent motorway and to some extent also as material for the base courses of motorway.

**Kuva 2.** Tämän Vantaalla sijaitsevan porrastetun kallion kiviaines on käytetty viereisen moottoritien täyteaineeksi ja osin tien rakennekerroksiin.

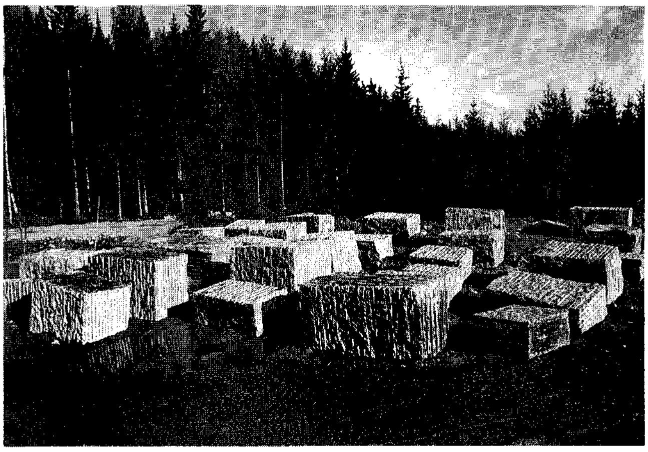


**Fig. 3.** Finnish building stone is strong and has good resistance to atmospheric pollution. It is also very beautiful.
**Kuva 3.** Suomalainen rakennuskivi on kaunista ja lujaa ja kestää hyvin ilmansaasteet.

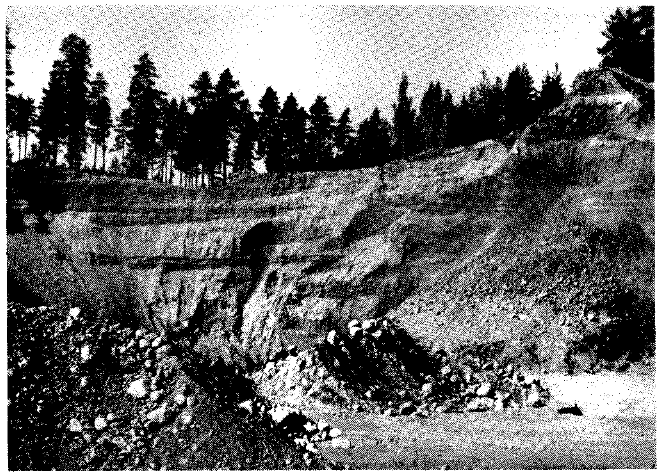


**Fig. 4.** The rich gravel and sand resources of this country are one of our national assets. (Photograph from Imatra).
**Kuva 4.** Maamme runsaat sora- ja hiekkavarat ovat osa kansallista pääomaa. (Valokuva Imatralta).

In the following I will take a brief look at geological resources other than those extractable from the solid bedrock, and their availability.

The bulk, or about 70 %, of the mineral matter used in Finland is extracted from glaciofluvial formations. Nonetheless, the proportion of aggregate taken directly from solid rock and refined increases annually by a couple of per cent. The value of a bedrock occurrence with high-quality rock material depends very much on the cost of transporting this material. Durability and homogenity are factors with which solid rock material can successfully compete with the less homogeneous glaciofluvial material. Unfortunately a rock occurrence with potential for industrial exploitation cannot be claimed. Extraction is regulated by the highly complex legislation on land resources. Grounds on which exploitation may be prevented are the scenic beauty of the landscape, the type of ground vegetation or the historical value of the area. According to statistics of the Finnish National Road Administration, it uses 30 million $m^3$ of mineral matter in bulk a year, of which 20 million $m^3$ is from outside the roadway. Currently, half of this mineral matter is crushed bedrock aggregate, accounting for 50 % of all mineral matter produced in Finland; the rest is used by local authorities, industry and the building sector. Mines hoist about 20 million tonnes of rock annually. Thus the amount of bedrock aggregate used by the Finnish National Road Administration slightly exceeds the total hoist of mines. Crushed rock aggregate has increasing economic importance, and at demanding building sites it is comparable to metallic ores; the material in the wearing course of a road is road ore.

Gravel and sand derive from bedrock, from which they were detached by the glacier. The finishing touch, i.e. sorting and accumulation, was given by fluvial processes, flowing water. Finland's gravel and sand resources were assessed in the 1970s, revealing that the country has 47 billion $m^3$ of these materials above the groundwater table. However, several factors restrict their exploitability, which is why we cannot talk about gravel and sand ore deposits. Thus, the availability of gravel and sand for building and the building industry is poor in many places and they have to be replaced by bedrock aggregates. During the current recession less than 40 million $m^3$ of gravel and sand is used a year. The value of this material at the site of use exceeds FIM 1 billion. As an industrial product its value is several billion marks (Fig. 4).

Till, the primary material detached from the solid rock by continental ice, is the dominant soil type in Finland. Tillbearing landforms, though, cover a mere 5 % of the land area, and only 10 % of them can be exploited. According to one assessment, the volume of extractable till is 7 billion $m^3$. The use of till, for example, through industrial crusing, is rather modest, less than 1 million $m^3$ a year.

The amount of clay that could be used as an industrial raw material is estimated to be 100 billion $m^3$. Assuming that the dry crust is 2 m thick, the potential volume of brick clay is a good 20 billion $m^3$. About 300—400 tonnes of this clay is used annually, corresponding to a raw material value of about FIM 1 million. Clay is also used for making expanded clay; this has a raw material value of about FIM 0.1—0.2 million a year.

Industry and other activities exploiting soil and rock materials are of considerable economic significance and, under normal conditions, both profitable and labour-intensive. In the 1980s, more than 60 000 people were employed in extracting and transporting land resources, and almost 4000 lorries were needed for haulage. The value of earth works and hydraulic engineering was FIM 15 billion. A quarter of the building stock in Finland, with an estimate value of FIM 260 billion, consists of earth and hydraulic structures, i.e. structures made of geological material and refined into technological products. These represent important nationl capital in the form of geological resources.

Geologically, Finland's mires are peat deposits. They are composed of a biomass that is currently of indisputable economic value. Finland has substantial peat resources — 600 000 hectares of peat ore — that can be used for energy production. The country's total peat resources amount to 70 billion $m^3$. Our peat mires contain over 6 billion tonnes of dry matter, of which over 3 billion tonnes is carbon, corresponding to 1.5 % of the total carbon stored in all the mires on Earth. We have, however, neither coal nor lignite. Mires appropriate for energy production contain, on average, 11 700 TWh energy per hectare, and resources of fuel peat amount to almost 20 billion $m^3$.

Using input-output analysis, the North Finland Institute has studied the impact of the peat industry on the production of other sectors and also on the revenues and employment situation of different sectors. With its indirect effects the impact of peat production of 9 TWh (c. 10 million $m^3$) on employment was 2700 man working years in 1983; the direct effect on employment was 1700 mwy. As fuel, peat ore is energy capital, which creates long-term jobs. In 1990, 18 TWh of energy was produced from fuel peat. If plans for the future are realized, annual peat consumption could increase to 25 million $m^3$. Green taxation will treat peat in the same way as wood, i.e. as a renewable energy resource.

Groundwater, a renewable natural resource, might be considered as a special ore extractable from soil and bedrock. Its solid state is ice, a pure hexagonal mineral. Part of our national wealth, groundwater is a raw material resource that fills voids in porous or fractured geological mass. Finding groundwater occurrences is one of the tasks of the geologist, and hydrogeology is one of the key research and operational sectors of the GSF. A supply of pure, fresh drinking water is a rare commodity on this planet, but regrettably, where still abundant, water is used wastefully. For the time being Finland is in a good position in terms of its groundwater resources but here, too, pollution constitutes a threat. The estimated annual rate of groundwater regeneration in Finland is about 1.5 billion $m^3$. Excluding the current use of water, the computational value of groundwater in Finland is over FIM 5 billion a year.

The Finnish ground still contains abundant geological raw material resources. Although regulated by Acts and Decrees, loosely deposited raw materials are the easiest to exploit. When in hard rock, the raw materials are concealed and can only be reached with the aid of knowledge, research and technology.

Discovering domestic metallic raw materials is problematic, if only because of the overburden which covers the bedrock in this country. One should be able to see through the drift and down into the bedrock. The problems are multi-disciplinary, i.e. geological, geophysical, geochemical and geotechnical. Unless new ore deposits are discovered, exploitation of many metal ores will end by 2000, thus increasing the need to use valuable foreign currency to import concentrates. Mining companies have several reserve occurrences at their disposal but these are considered subeconomic. The increase in industrial costs and the current economic climate world wide have raised the cut-off grade of ores even though advances in technology have had the opposite effect.

Nonetheless, considering the efforts made by the GSF to find new ore deposits, the potential of claims already transferred and investigated and the number of ore showings currently under survey, the future is not all that bleak. There are good grounds for optimism. To quote the journal of the mining industry Vuoriteollisuus, the search for and inventory of metals, industrial minerals and building stones is the substratum on which the export industry grows. I am pleased to be able to endorse the statement of the technology programme of Mining 2000 that the superior technical level of the mining industry and the high standard of tuition in mining and associated industries in Finland. However, success will not continue indefinitely unless sufficient investment is made in exploration. That is where the GSF comes in, as a prime mover in the raw materials service of Finland.

The search for raw materials is largely a matter of industrial policy. Every effort must be made to secure the availability of domestic geological raw materials and so to make this country self-sufficient in them. Times of crises should be taken into account, although the present trend towards integration has relaxed these conditions to some extent, and Finnish industry can exploit the raw materials of the mining industry abroad, too. On the other hand, integration will permit international competition and foreign companies to operate in Finland. As far as Finland's raw materials policy is concerned, it is clear that the barriers to world trade have been lowered at the same time as international competition has intensified. The exploration geologist, whether searching for metallic ores or other geological raw materials, needs to be well versed in a whole range of professional skills. This presents a challenge for our universities, which carry the responsibility for the content and scope of training. The traditional sharp divisions between disciplines will gradually fade, as, in my opinion, they already have to some extent. We have the high standard of basic research needed in exploration and in the localization of raw material occurrences. This, combined with the sophisticated methods at our disposal, should create a demand for the services of our experts outside Finland. Finland's raw materials policy must strive for continuous progress in the sectors associated with mining and give the search for raw materials the support that is its due. Mining and geological research have together clearly demonstrated the value of hard work to the national economy.

I shall close my talk by referring to the report of the state auditors to Parliament in 1991. They stressed that in the current situation, in which mining has declined at an alarming rate in Finland, all expertise in the sector should be activated to develop exploration techniques, ore research and ore refining. Cooperation between universities, research institutes and mining companies should be intensified. It is important for the economy of this country that ore and mineral deposits should be investigated comprehensively. Only then can deposits suitable for mining be effectively exploited.

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## YHTEENVETO

## SUOMEN RAAKA-AINEPOLIITTINEN MERKITYS

Geologian tutkimuskeskuksen (GTK) merkittävin avaintulosalue on valtakunnallinen raaka-ainehuolto. Geologisesti syntyneiden raaka-aineiden merkitys koostuu GTK:n raaka-ainepoliittisessa ohjelmassa. Siinä asetetaan päämäärät raaka-aineiden etsinnälle ja inventoinnille. Myös siinä osoitetaan geologisen raaka-ainepohjan merkitys kotimaiselle teollisuudelle ja teolliselle uustuotannolle. Lisäksi esitetään kehittämistavoitteet geologisten raaka-ainevarojen tieto- ja tasorekisterille. Rekisterien avulla voidaan tehdä ennusteita maankamaran raaka-ainevarojen riittävyydestä, vuosittaisista kulutusmääristä ja kriisiajan raaka-ainereserveistä.

Raaka-ainepolitiikka kytkeytyy raaka-aineita käyttävään ja jalostavaan teolliseen toimintaan. Julkisrahoitteisen GTK:n malminetsintätoiminnan toiminta-ajatuksena on etsiä ja löytää mineraalisia raaka-aine-esiintymiä sekä arvioida löytämänsä esiintymät. Ensisijaisena päämääränä on löytää sellaisia malmiesiintymiä, joita Suomessa oleva, mineraalisia raaka-aineita käyttävä teollisuus pystyy taloudellisesti hyödyntämään. Malminetsinnällä on mahdollisuus vaikuttaa kansantaloutemme kehitykseen positiivisesti. Tästä syystä geologisten raaka-aineiden etsintää tulee kaikin tavoin tukea kehittämällä alan tutkimusta ja teknologioita ja tehostamalla tutkimuslaitosten, korkeakoululaitoksen ja teollisuuden välistä vuorovaikutusta yhteistyöllä.

# Non Ferrous Metals — The Challenges Ahead

**Sir Arvi Parbo, Director General of the Western Mining Corporation, Australia**

Address to 50th Anniversary Annual Meeting of the Finnish Association of Mining and Metallurgical Engineers by Marina Congress Center in Helsinki on 19th March 1993

May I first of all congratulate the Finnish Association of Mining and Metallurgical Engineers on its 50th Anniversary, and bring you greetings and best wishes from your mineral industry colleagues in Australia.

While Finland and Australia are nearly at opposite ends of the Earth, there has been a surprising amount of interaction between the minerals industries in the two countries. Finnish miners and their descendants are well known for their skill and ability in many mining fields in Australia, with Mt. Isa in Queensland probably the largest centre. Finnish mining and metallurgical technology and equipment are well known and widely used in Australia. More recently, Finnish companies such as Outokumpu have become welcome direct participants in Australian mining. There has not been similar involvement by Australians in the industry in Finland, but many personal and corporate links and friendships have been established over the years. These are certain to grow in the future.

## FORECASTING THE FUTURE

Thank you for inviting me to speak about the future of the non-ferrous metals industry on this important occasion. I am approaching this task with much humility, because the record shows that the human ability to see into the future is very limited at best.

**Sir William Preece**, the Chief Engineer of the British Post Office, said in 1876:

"TheAmericans have need of the telephone, but we do not. We have plenty of messenger boys."

**Charles K. Duell**, Director of the U.S. Patent Office, in 1899 urged President McKinley to abolish the office, because

"Everything that can be invented has been invented."

This must be the only known instance in history where a public servant has proposed the abolition of his office.

**Wilbur Wright** told brother Orville after a disappointing flying experiment in 1901:

"Man won't fly for a thousand years."

**Robert Millikan**, Nobel Prize winner in physics in 1923, said:

"There is no likelihood man can ever tap the power of the atom."

**Harry M. Warner**, head of Warner Bros. Silent Pictures, is on record in 1927 asking:

"Who the hell wants to hear actors talk?"

**Thomas J. Watson**, the head of IBM, forecast confidently in 1958:

"I think there is a world market for about five computers."

In our own industry, you may remember the Paley Report, commissioned by President Truman in 1950. The Paley Commission, consisting of the foremost experts at the time, forecast the availability and demand for minerals for 25 years ahead.

Hindsight shows that they were well out in virtually every prediction. The demand forecasts were far below the actual demand. The estimates for the United States were reasonably realistic, but those for Europe, Japan and the developing countries were greatly understated. Notwithstanding the much greater than forecast production during the forty-odd years since then, the known resources of minerals are greater today than when the Paley Report was published.

The next major forecast on a world scale was the publication "Limits to Growth" in 1972. Comissioned by the Club of Rome this report, with certain qualifications, predicted that the world was within a short time running out of resources, including minerals. Given the assumptions made — that resources were limited, while consumption would grow exponentially — the conclusion was obvious. It was given an aura of authority because the result had been obtained from a computer model!

Such is the power of modern means for publicity, whether true or not, that many in the world, including governments and forecasters, accepted the conclusion. There are probably some who still believe it.

In the petroleum industry, a fear of imminent depletion of oil gripped many in the American oil industry and government at the end of World War I and well into the 1920s. The Director of the U.S. Bureau of Mines warned in 1919 that the known American oil reserves would be exhausted in exactly nine years and three months. There were calls in the Senate for the U.S. Navy to reconvert from oil back to coal[1].

In more recent times, fears of oil shortages were re-introduced on a world scale when the Club of Rome report was closely followed by the OPEC oil price increases in the 1970s, leading to predictions of energy shortages generally — remember the "energy crisis"? We have not heard about the energy crisis for quite some time.

Predicting what will happen in the minerals industry is clearly a highly hazardous business. Those engaged in it would not be wise to accept payment by result.

Against this background, it is with some trepidation that I attempt to speculate on what might happen in the non-ferrous metals industry in the future.

## THE NON-FERROUS METALS

This industry includes the heavy metals copper, lead, zinc, and tin, the light metals aluminium, magnesium, and titanium, the steel improvers chromium, cobalt, manganese, molybdenum, nickel, vanadium, and tungsten, and other alloying and special metals antimony, cadmium, mercury, and bismuth[2]. Conditions applying to particular metals in this diversified array vary considerably from time to time, although the main metals have common features.

Historically, copper and tin are amongst the earliest metals to serve humanity.

Copper is the most ancient metal, its use going back to the late Stone Age, about 10,000 years ago. An alloy of copper and tin, known as bronze, was used some 6,000 years ago. Alloys of copper with lead and antimony were also widely used during the

1) Daniel Yergin, **The Prize**, Simon & Schuster, 1991.

2) Lotte Müller-Ohlsen, **Non-Ferrous Metals**, Woodhead-Faulkner in association with Metallgesellschaft AG, 1981.

Bronze Age. By comparison the most widely used metal of modern civilisation, iron, came on the scene some 5,000 years ago.

On the other end of the time scale the commercial production of the most abundant metal in the earth's crust, aluminium, is only just over 100 years old. But while young in its applications, aluminium has quickly become the second most widely used metal after iron. The commercial use of nickel goes back only to the beginning of this century, while titanium metal was first produced in a useful form less than 60 years ago.

## ARE NON-FERROUS METALS GOING OUT OF FASHION?

While there are considerable short term variations, the consumption of the main non-ferrous metals continues to increase (Fig. 1—5), both in terms of total consumption (including scrap and other recycled materials) and consumption of newly mined metals.

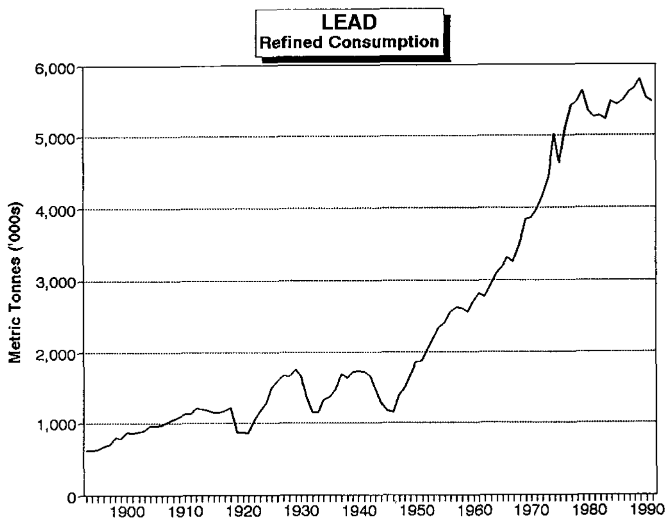


**Fig. 3.** The consumption of lead.
**Kuva 3.** Lyijyn kulutus.

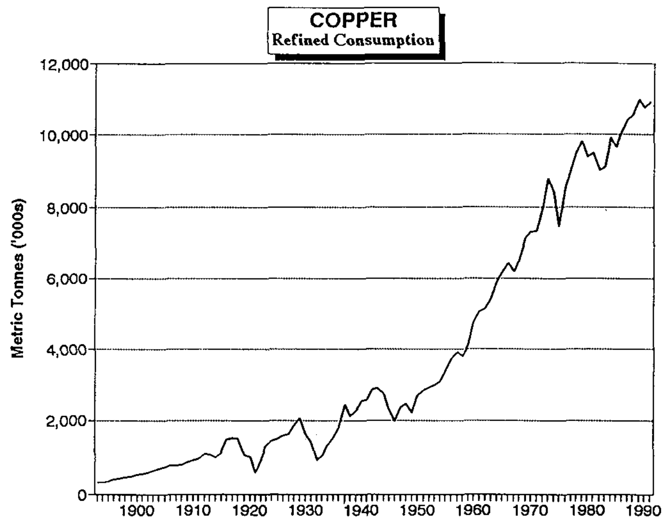


**Fig. 1.** The consumption of copper.
**Kuva 1.** Kuparin kulutus.

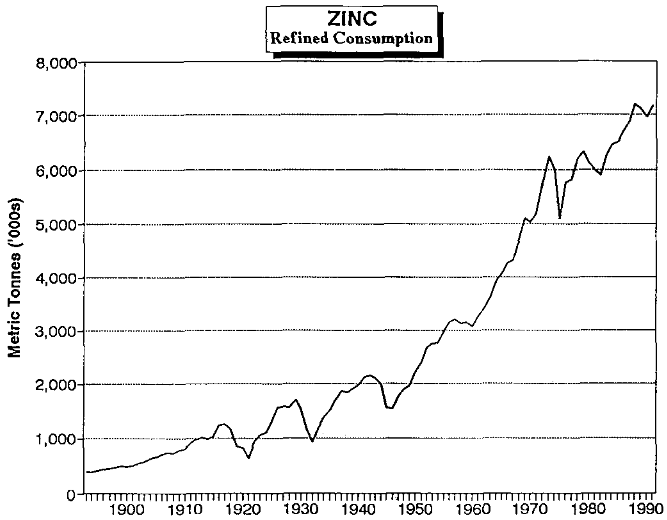


**Fig. 4.** The consumption of zinc.
**Kuva 4.** Sinkin kulutus.

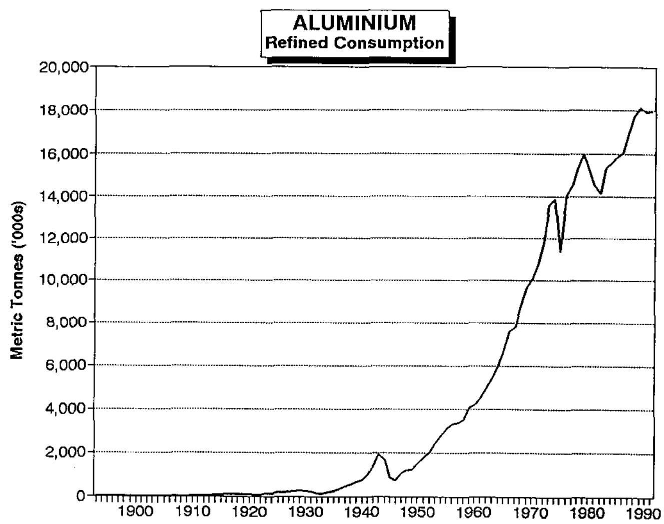


**Fig. 2.** The consumption of aluminium.
**Kuva 2.** Alumiinin kulutus.

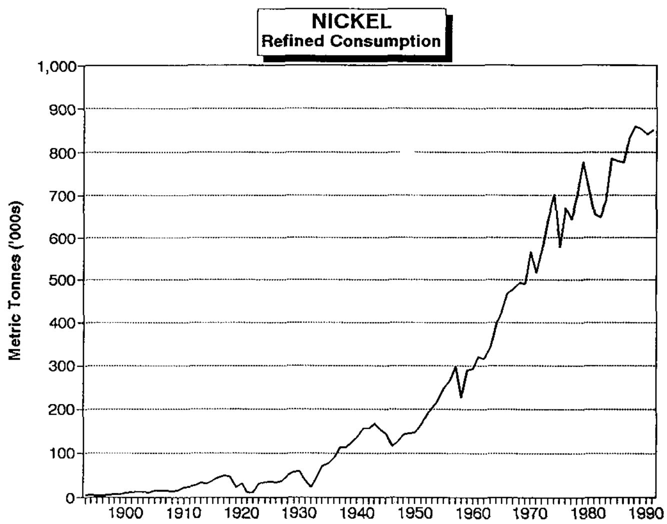


**Fig. 5.** The consumption of nickel.
**Kuva 5.** Nikkelin kulutus.

(Lähteet: World Metal Statistics Yearbook 1992 ja World Non-Ferrous Metal Production and Prices 1700—1976)

### Metals Intensity Declining

While consumption is growing, the western world's metals intensity, which measures metal consumption relative to Gross Domestic Product, fell sharply between 1973 and 1983. In non-ferrous metals the downturn ranged from 16 % to 43 %. One of the major reasons for this decline was the oil price increases during that period. Since then the fall in metals intensity has slowed appreciably (Table 1). In the case of nickel, it has been reversed because the consumption of stainless steel, the largest use for nickel, has grown at a higher rate than GDP.

**Table 1.** Falls in metals intensity, non-ferrous metals.
**Taulukko 1.** Metallien kulutuksen lasku suhteessa bruttokansantuotteeseen. (Tiedonanto: B.R. Stewardson, Chief Economist, The Broken Hill Proprietary Co. Ltd., Febr. 1993)

| Metal | 1973-1983 | 1983-1991 |
|---|---|---|
| Copper | 23% | 1% |
| Zinc | 27% | 10% |
| Lead | 26% | 12% |
| Nickel | 25% | Increase 8% |
| Primary Aluminium | 16% | 3% |
| Tin | 43% | 5% |
| (By Comparison: Steel | 36% | 5%) |

There are differing views on whether metals intensity will continue declining in the future. This will certainly occur in mature industrialised economies where services represent a growing share of the Gross Domestic Product. New technology, substitution of other materials for metals, and the development of new weight-reducing alloys add to the lower intensity. On the other hand, the need of developing countries for infrastructure and consumer goods means higher metals intensity in the development period.

The most likely outcome is that the worldwide intensity will continue to decline, but at a slow rate. As noted previously, consumption will continue increasing.

## ARE WE RUNNING OUT OF NON-FERROUS METALS?

### Cyclic Markets

Old or young, all non-ferrous metals experience severe fluctuations in market conditions from time to time. There are times when supplies are short and prices rise strongly.

But instead of a prolonged shortage of these metals, the main problem has been and continues to be the periodic oversupply which depresses prices and makes it difficult for producers to secure adequate financial returns on their investment. The experience of the nickel industry in the last twenty five years is a good illustration.

In 1967, when Western Mining first became involved in nickel production, there was a world shortage of nickel. Since then there has been a downturn of markets in 1971 and 1972, an upturn in 1973 and 1974, a downturn from 1975 to 1978, an upturn in 1979 and 1980, a severe downturn from 1981 to 1986, an upturn from 1987to 1990, and the present downturn since 1991.

In times of downturn prices often fall below production cost. To obtain a satisfactory average return, this has to be made up by high profits during upturns. Recent experience has been that the downturn periods have been getting longer while the upturns tend to be shorter, making it more difficult to achieve adequate average returns.

With the exception of nickel, the real prices of the main non-ferrous metals have been declining. This has occurred while the average grade of the ore mined has decreased. Improved mining and processing technology and better management have made lower grade ore economic even at the reduced prices.

## WHERE WILL THE SUPPLIES COME FROM?

### Recycling

Recycling of metals is growing and is an increasingly important source of future supplies, although for some special applications primary metal remains necessary. Most metals can be recycled indefinitely from most uses; they are in effect renewable, provided the price justifies the cost of recovery. This is an advantage metals have over many competitive materials.

The non-ferrous metals are used mostly in the form of various alloys, which makes their recycling more difficult and more costly. The trend for equipment and products to be made from a mixture of materials adds to this problem. But there are also advantages. For example, recycled aluminium represents an energy saving of 95 %, compared with primary metal. An all aluminium motor car, developed by Audi in co-operation with Alcoa, will be commercially available this year. It will have substantially improved fuel economy and recyclability.

On the whole, recycling rates of metals are increasing. For non-ferrous metals these range presently between a quarter and just over a half of total consumption.

### Known Undeveloped Deposits

Numerous known but presently unworked bodies of mineralisation remain to be brought into production.

A recent study on copper[3], for example, listed in addition to 100 producing mines 52 known bodies of copper mineralisation which are potential producers, with copper the primary product. In nickel, there are at least 14 known but undeveloped orebodies around the world.

Extensive deposits of nodules containing copper and nickel, known to exist on the ocean floor, remain to be worked.

### New Discoveries

While recycling and known but undeveloped bodies of mineralisation will be an important source of future supplies, discovery of new orebodies remains vital in replacing mines becoming worked out and in meeting the growing demand for non-ferrous metals.

There is excellent potential for new discoveries. Large parts of the world, with high potential for mineral discoveries, remain virtually unexplored. Exploration technology has made great progress, making it increasingly possible to discover hidden orebodies which until recently had been a rare event.

Subject to the economies of mineral production being attractive and land being available for exploration, there is every expectation that the discovery rate will continue to be satisfactory.

[3] **Review of Current and Potential Copper Producers**, Pinnoch, Allen & Holt, Inc., 1992.

### Lower Economic Grades

Improved mining and mineral processing technology and better management are making lower and lower grade mineralisation economic, even while real prices of metals have been falling. This is greatly increasing the economically available resources.

Most bodies of metallic mineralisation can be diagrammatically represented by a pyramid. The highest grade mineral is present in limited quantity, equivalent to the small volume near the tip of a pyramid. As the grade decreases and we move from the tip towards the base, the quantities increase rapidly. The lower the grade the larger the quantity available.

Lowering the economic grade helps to reduce the dependence on new discoveries, because lower grade mineralisation around known orebodies becomes ore.

## TRENDS AFFECTING THE FUTURE

### World Population

The world's population, just over 5 billion in 1988, is estimated to grow to around 8.4 billion by the year 2025. This growth will have major consequences for world demand for minerals, particularly due to the fast growing population in the developing countries and their rapidly improving educational and living standards.

In 1988 the industrialised countries of the western world contained around 16 % of the world's population, with developing Asia and the Middle East accounting for 57 %, Africa for 11 %, Latin America for 8 %, and the former Soviet Union and Easten Europe for the remaining 8 %.

Between 1970 and 1988 Africa's population grew at 2.7 % per annum compared to world growth of 1.8 % per annum, and growth in industrialised countries of only 0.7 % per annum.

By the year 2025 the industrialised countries are expected to have a population share of only 11 %. Africa's share is exptected to rise to 18 %.

### World Economic Growth

World Gross Domestic Product in 1988 was estimated at $US19 trillion. Of this the industrialised world accounted for about 74 %, developing Asia and the Middle East for about 10 % and Africa a mere 1 1/2 %.

Over the period of 1970 to 1988 world GDP grew at around 3.2 % per annum, with growth in the industrialised world at 2.9 % and in developing Asia and the Middle East at around 5.5 %.

If similar GDP growth trends were to persist until the year 2025, the industrialised world's share of GDP would fall to about 62 %, that of developing Asia and the Middle East would rise to around 22 %, and that of Africa would actually fall to about 1 %.

### Location of Processing Plants

There is a general trend towards minerals processing being relocated in newly developing or industrialising countries. Primary aluminium smelter production in the industrialised countries of the western world fell from 93 % in 1970 to 74 % by 1991, whilst copper refinery production fell from 76 % in the industrialised world in 1970 to 64 % in 1991. There are various reasons for this. In the case of aluminium the overriding consideration is availability of electric power at a competitive cost.

### Limits To Growth

The limits to future growth of the non-ferrous metals industry will not be determined by lack of demand for the products, or the availability of resources, provided the market mechanism is allowed to function without excessive interference to regulate supply and demand. The limits will be set by access to land, by restrictions on development, and by the ability of technological progress to overcome technical, environmental, and economic constraints.

### Environmental Constraints

The minerals industry has an effect on the environment, as have all human activities.

The effect of **mining** is far less than the popular perception. Mining affects only a very small proportion of the total land area — in Australia only one fifth of one percent, less than is under railways and a fraction of the area under roads.

The techniques for rehabilitating mined areas now often restore mined land to a better condition than it was in before. Mining is therefore frequently only a temporary use of the land, which can be used for other purposes before and after mining. The most impressive example of this is brown coal mining in Rhineland in Germany.

In Australia the rehabilitation techniques developed in the mineral industry are increasingly applied to regeneration of degraded farmland, which is a much greater and more serious problem in that country.

Mining companies the world over are today taking their responsibilities for environmental care very seriously. In Australia, awards and recognition for environmental work are being won from respected world bodies, including the United Nations and the Wildlife Habitat Enhancement Council, as well as from Australian organisations.

In **smelting and refining**, increasing environmental restrictions are delaying or preventing plans for expansion, and increasing costs. Key issues are emissions, in particular sulphur emissions. Interestingly, improvements in technology with the main objective of achieving a satisfactory return on the capital invested often help to reduce emissions.

As an example, Mitsubishi recently abandoned a proposal to construct a 200,000 tonnes per annum copper smelter in Texas, which was considered to be the most likely new project to relieve the current capacity shortage for that metal. The reason was understood to be the delay and difficulties in obtaining environmental permits.

To overcome the problem of dealing with sulphur dioxide emissions, an innovative hydrometallurgical process to produce refined copper metal has been developed at the Escondida project in Chile. Ammonia is used to treat concentrate and the metal is recovered by electrowinning. This process is the first to apply leaching to a sulphide ore. The technology is presently only suitable to particular types of ore.

In the lead indusrty, a bill is before the US Congress, called the Lead-Based Paint Hazard Abatement Act, which seeks to impose a tax of US 75 cents a pound on primary lead metal production and imports, with a tax of 37 cents per pound on secondary production and imports. A recent study by the US Bureau of Mines estimated that if a tax of 80 cents per pound were introduced, the US domestic lead industry would be eliminated entirely, with co- or by-product output of zinc being decreased by 87 %, cadmium by 85 %, bismuth by 89 % and silver by 16 %.

### Access to Land

The potential for new discoveries is being diminished by the trend to exclude increasing areas of prospective land from exploration and mining. Taking Australia as an example, the Australian Mining Industry Council estimated in 1990 that about 26 % of Australia's land area was closed, or difficult of access to new exploration and mining. A possible further 22 % could move into this category under then current proposals.

The situation in Australia was complicated further by a recent High Court decision which has cast in doubt the title to large areas of the country. This could well become a very serious setback to future development of an industry where security of title is fundamental to making the necessary large long term investments in exploration and development.

### Supranational Restrictions

Supranational agreements and agencies which limit the conditions under which economic activity may take place in individual countries are a recent development. They introduce additional government intrusions and uncertainties into virtually every area of industry in the countries concerned.

The present trend is for such restrictions to increase.

## THE CHALLENGES AHEAD

Technological challenges will be as important in the future as in the past. We can never be content with our ability to discover orebodies, mine the deposits, extract the valuable minerals from the ore, produce the products our customers need, and recycle the scrap and used materials. The quest for always doing better is permanently with us.

The greatest challenge for the future is, however, non-technical: how to demonstrate to the community that we are working in their best interests, and that unnecessary restrictions are a burden not just on the companies, but on the whole community. It is no longer sufficient for the people in the industry to be doing a good job — in today's world it is also necessary to tell others about it. The personal qualities demanded of management are increasing. We must attract some of our best and brightest young people to careers in the industry.

The future professionals and leaders in the minerals industry must become as proficient and superior in the skill of communicating with the public as they need to be in technical and business matters. This is the key issue in the years ahead. The success or otherwise of the industry and the quality of life of the community literally depend on it.

The minerals industry the world over has succeeded in slaying many dragons in the past. I am certain that we are also capable of mastering the challenges ahead of us. The big advantage we have is that we are an absolutely essential contributor to the community.

## YHTEENVETO

## EI-RAUTAMETALLI — TULEVAISUUDEN HAASTEET

Tarkastellaan runsaisiin numero- ja tilastotietoihin nojautuen viiden tärkeimmän ei-rautametallin: kuparin, alumiinin, lyijyn, sinkin ja nikkelin kulutusta ja tuotantoa, näiden vaihtelua ja sen erilaisia syitä suhteuttaen väkiluvun kasvuun, maailman talouden kehitykseen, ympäristövaikutuksiin ym. tekijöihin.

Tulevaisuuden suurin haaste ei kuitenkaan ole tekniikassa, vaan siinä kuinka osoittaa ihmisille, että metallintuottajat toimivat heidän parhaakseen, ja että tarpeettomat rajoitukset eivät kohdistu pelkästään yrityksiin, vaan koko yhteisöön. Enää ei riitä, että työ teollisuudessa sujuu hyvin, vaan nyt on myös ulkopuolisille kerrottava teollisuudesta. Johdolle asetettavat henkilökohtaiset laatuvaatimukset korostuvat. Meidän on saatava parhainta ja älykkäintä nuorisoamme kiinnostumaan elämänurasta teollisuuden piirissä. Yritysjohdon kommunikointitaidon on oltava yhtä hyvä kuin heiltä edellytettävät taidot teknisten ja liiketaloudellisten ongelmien käsittelyssä.

# Steel in the Next Century: Challenge and Change

**Remarks of Lenhard J. Holschuh, Secretary General, International Iron and Steel Insitute, Brussels, Belgium at the 50th Anniversary Meeting of the Finnish Association of Mining and Metallurgical Engineers, Helsinki, March 19, 1993**

This is one of the few opportunities I have had to address such a large and impressive gathering of experts from the mining and metallurgical industries. It is indeed an honour and a privilege. I would like to start my remarks by saying that I am an unabashed optimist when it comes to talking about steel. I believe steel's story is a success story. Steel is the world's number one engineering material. Steel meets the widest number of engineering requirements in the most optimal manner. Steel is readily available, it comes in a diverse variety of grades and qualities, it offers excellent manufacturability, it has an outstanding price/performance ratio. Nearly all significant technological developments in construction, transport and communications were based on steel or depend on it for their realization.

But like other engineering materials, demand for our products is highly volatile, and we are traditionally whipsawed between the highs and lows of the economic cycle. Three years ago when the fall of the Berlin wall heralded high hopes for the future, we were in the midst of one of the longest cyclical upturns in the history of our industry. Western world finished steel production in 1989 had topped 437 million tons, exceeding both the 1974 and 1979 record levels.

Today we are experiencing a down cycle for steel. For some time profits generated have been far from levels which our shareholders have the right to expect and which we require to justify re-investment. The situation in West Europe is particularly acute — with announcements of consolidations and further reductions in steel production capacity. In part, the problems posed by the collapse of the Communist systems in Central and Eastern Europe have disrupted markets for steel and steel-based products and have caused steel producers to deeply review their business strategies.

When Berlin Wall came down there was hope that the adjustment of the former planned economies would somehow occur rapidly and with minimal upset. Despite some progress, the conversion often at best remains balanced between success and failure. The attempted shift to realistic prices has resulted in enormous inflation in some countries, while the sell-off and close-down of state owned firms has produced massive unemployment. There are as a result recurrent signs of political instability and in certain countries a return to some sort of semi-controlled economic system.

The changes in the Soviet Union and Eastern Europe have had a profound impact on countries like Finland whose trade was strongly toward these economies. Indeed throughout Europe key industries, struggling to adapt to international competitive pressures and new production technologies, are now facing additional concerns over low priced East European imports — the same imports which are often essential to the survival of those economies. Even hopes from the single European market have been tempered by a combination of recession, monetary troubles and concerns over future economic and political integration.

Developments in the East European steel sector underline the magnitude of change in those economies. In 1990 the first year after the wall came down apparent consumption of steel products in East Europe and the former USSR stood at 148.5 million metric tons; Two years later in 1992 it had fallen nearly 30 million tons to 120 million tons and could slide to 100 million tons by mid decade. Such a likely drop in consumption of nearly 50 million ton — about one third — reflects the enormous difficulties of raising the efficiency of these former planned economies.

You have asked me today to discuss the outlook for the steel industry, and its challenges and opportunities for the future. Challenge One certainly remains how our western industrialized countries can support the conversion of the planned economies while meeting their own economic concerns. If we are successful in managing this collective challenge, we will be rewarded with new and growing markets for steel and steel products. Putting aside for the moment the countries of the former Soviet Union, the combined population of Bulgaria, the Czech Republic, Slovakia, the former East Germany, Hungary, Poland and Rumania is equal to that of France and the United Kingdom combined. At the outset and for some years to come, development of these economies will most likely be steel intensive.

Our second challenge is how we as steelmakers identify the key strategies for each of our companies and our determination to see to their implementation.

I have already forewarned you that I am a confirmed optimist when it comes to the steel business. You may find this unusual at a time when we are experiencing not only a down cycle, but extensive close down of steelmaking capacity. But sometimes I think the cycle of business expectations in our own and related industries is much greater than the actual fluctuations in demand for our products.

So despite our significant short term problems, I say to you today that the future of steel is as exciting as ever. Indeed the pace of innovation we are seeing has never been faster. I have no doubt that it is possible for a steel business not only to grow but to achieve an acceptable level of profitability.

Let me indentify some of the strategic developments occurring in our industry which give me confidence for steel in the next century.

Interestingly, the dismantling of state control in East Europe has coincided with a trend away from public and toward private ownership of steel enterprises in countries as geographically spread as Italy, Mexico, India and Taiwan. Increasingly it has been recognized that public of private, the best long term interest of owners, employees and customers alike are served if an enterprise itself is free to make its own decisions on investment, pricing, new product development, and closures. The criteria for success in the steel business are not different to any other industry: long term profitability, growth, and financial self-sufficiency.

One outcome of the reduced political sensitivity of steel enterprises has been the development of genuine international strategies in our industry. This means developing strong competitive positions in several countries through acquisitions, joint ventures and other collaborative agreements. Here in Europe we have seen many mergers in the last two or three years, often with an international element. The current restructuring can be expected to accelerate that trend. We have seen major moves by Japanese steel producers into North America based on the strong logic that customers such as the automotive industry have global strategies and common requirements on product and quality to which steel suppliers must respond.

Our industry's globalization has also ended the old concept of each steel enterprise seeking to be the universal supplier of steel products. Steel managers no longer see as their duty to supply comprehensive national steel needs. Each company now carefully assesses its competitive strengths and weaknesses and seeks to identify those areas in which its market position, technology or particular skills give it a clear competitive edge.

This concept of no one steel company being the supplier of all steel products in a particular market quickly supports the growth in international trade in steel products with steel companies exporting significant volumes of material where their products have unique advantages, and conversely witnessing significant imports where this is not the case. No one can deny the friction that this process generates with its emphasis on dynamic competition and innovation, but this development is clearly in the longer term interest of the steel industry and its customers. I believe that not only in our discussion of east European trading relationships but in the wider discussions in the GATT, it is crucially important that we in the steel industry do not lose sight of this fact.

The next trend I would point out is our renewed focus on market and product development. The pace at which new grades of steel are now being developed has never been faster, and rightly so. Only throug close dialog with its customers can steel respond to their changing needs.

But what is most important, we are moving away from the old syndrome of viewing customer requirements solely in terms of steel products and instead are using the vast data base that exists on steel properties to improve customer manufacturing and steel application technologies. Increasingly today engineering materials costs are only a small part of the added value of manufactured product. Manufacturing costs and environment costs are often determining elements in the competition between engineering materials. Today's steels are sold not only as sophisticated or cost effective engineering materials but as components of highly efficient, increasingly complex technological systems.

This brings me to the last and perhaps most important development: the enhanced environmental awareness not only in our industry but generally throughout the world. Cut loose from state ownership in many countries and less dependent on national markets, steelmakers have a major role to play in this area where society collectively is imposing new requirements, increasingly on an international basis. Fortunately our environmental record is strong. Steelmakers have spent vast amounts of money on improving their environmental performance in the last 20 years, and the improvements have indeed been impressive.

Moreover, in a world preoccupied with the environment, steel's longstanding recyclability is critical not only in bringing about energy and resource savings and emissions reduction, but in reducing the waste disposal bottleneck which is fast becoming one of the restraints to economic growth. Whereas the environmental impacts of materials and products were once overlooked, today they are becoming an integral part of product cost — especially where manufacturers are obliged to take back and recover used products. Once manufacturers were held responsible mainly for the safety of their employees in the production plant and the safety of their hands of the public; today's responsibilities include safety of the environment. This translates to new emphasis on product design, materials choice, and implementation of total logistic systems for collection, separation and re-use.

The implications for engineering materials are dramatic. Steel — which has traditionally been recycled and which can be recycled again without deterioration of its properties — is a critical problem solver which aids customers in meeting new environmental demands. Moreover, the call for sustainable development, the need for cleaner industries, more efficient energy production, and more environment friendly transport cannot be met without steel technology. I am thinking of new heat resistant steels being developed for super critical high pressure power generation, improved electrical steels to cut power loss, and advanced cryogenic steels to aid transport of environment friendly fuels like natural gas, and eventually hydrogen.

For these reasons, I believe that the steel industries which emerge from today's rationalization will not only be leaner but will among the world's most effective. Hand in hand with restructuring, steelmakers all over the world have been making a continuing effort to improve the operational efficiency of plant and equipment. Over the last decade this has been a major objective: a considerable part of steelmaking investments have been devoted to further improving the cost effectiveness of our product so as to maintain its significant cost/performance advantage.

One characteristic of this development is a move toward new technologies which hold promise of shortening the steelmaking cycle and providing saving in capital investment, raw materials transformation and energy use. I am thinking especially of smelting reduction, new casting technologies such as strip casting and semi-solidified casting, and the application of artificial intelligence, which will put us in the next century on the threshold of continuous steelmaking with unprecedented control over costs and product properties. It has been said that developing smelting reduction technology — which by using raw materials more flexibly can replace the blast furnace process — is equivalent for steelmakers to putting a man on the moon.

So ladies and gentlemen, my message to you today is quite simple: do not let the urgent requirements for adaption and change presently underway in the steel industry make you lose sight of its longer term prospects. Steel is crucial to the needs and development of modern societies. Steel is one of the most dynamic advanced engineering materials. It will remain for all of us a critical factor in our future success.

## YHTEENVETO

### TERÄS ENSI VUOSISADALLA: HAASTEET JA MUUTOKSET

Läntisten teräksentuottajien ja hallitusten on terästeollisuuden rakennemuutoksen ja uudistamisen yhteydessä löydettävä keinot vähentää epätervettä tuontia Itäeuroopasta ja entisen Neuvostoliiton alueelta samalla kuitenkin huomioiden sen tosiasian, että pääsy läntisille markkinoille on tärkeätä aikaisempien suunnittelutalouksien muutosprosessille. Vain täten voidaan varmistaa näiden maiden muodostuminen vakaiksi markkina-alueiksi tulevaisuudessa. Suunnittelutalouksille muutos saattaa merkitä teräksen kulutuksen laskua v:n 1990 148 milj. tonnista 100 milj. tonniin 1995.

Länsieurooppalaisen terästeollisuuden pitkän aikavälin näkymät ovat nykyisestä lamasta huolimatta erittäin myönteiset. Teollisuuden vapautuminen valtion sääntelystä monissa maissa on johtanut globaalisiin strategioihin, erikoistumiseen ja ulkomaisiin sijoituksiin perinteisten kotimarkkinoiden ulkopuolelle. On tärkeätä välttää tarpeettomien kaupparajoitusten syntymistä, niin Itäeuroopan kuin GATTin neuvotteluissakin.

Viime vuosikymmenellä terästeollisuus on monissa maissa käyttänyt miljardeja dollareja tuotantomenetelmien ja -laitosten parantamiseen. Luonteenomaista on ollut pyrkimys uusien teknologioiden kehittelyyn ja käyttöönottoon, kuten esim. sulapelkistykseen, joka voi korvata masuuniprosessin, ja uusiin valumenetelmiin. Uudet teknologiat ovat edelleen tärkeitä pyrittäessä kestävään kehitykseen, puhtaampaan ja tehokkaampaan liikenteeseen ja kuljetukseen, energian tuotantoon ja valmistusmenetelmiin.

# Alternative Technologies in Iron and Steelmaking

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The speech presented at the 50th Anniversary Celebrations of the Finnish Association of Mining and Metallurgical Engineers in Helsinki on 19th March 1993

## INTRODUCTION

Prior to its 26th Annual Meeting in October 1992, the International Iron and Steel Institute (I.I.S.I.) carried out a survey in its affiliated companies and research institutes, concerning the technology that has to be developed for meeting the needs of the steel industry in the 21st Century.

This study[1] concluded that two important demands have to be satisfied:

- the steel market will ask seemingly contradictory things of the steel industry i.e. to deliver higher quality products at lower cost, to offer small lots of quality steels in a variety of sizes and grades while observing short delivery times,...
- steelmakers must expect to face increasing constraints over environmental issues such as minimization of emissions and effluents, recycling of resources and effective utilization of energy, by-products and waste,...

Various actions are presently developed for meeting these challenges; let us quote the following examples:

### Cost Reduction:

- to increase productivity of existing blast furnaces, steelworks and rolling mills,
- to develop new processes entailing lower investment costs,
- to suppress production steps.

### Quality Improvement:

- to eliminate tramp elements such as Cu, Sn, Cr from the liquid steel,
- to master surface quality and internal soundness of near-net-shape cast steels,
- to collaborate with the end-user to optimize product design.

### Environment Conservation:

- to reduce coke-oven and sinter plant emissions,
- to decrease $CO_2$ production,
- to recycle waste and valorize co-products.

The present paper reviews these new technologies and examines their impact on the type and on the location of steelworks in Western Europe at the beginning of the 21st Century.

## IRONMAKING TECHNOLOGIES

### Evolution of the classical blast furnace

The most recent development in blast furnace technology is the injection of steadily increasing amounts of pulverized coal (Fig. 1).

The main incentives are:

- saving investment costs by out-phasing obsolete coke plants,
- preserving the environment,

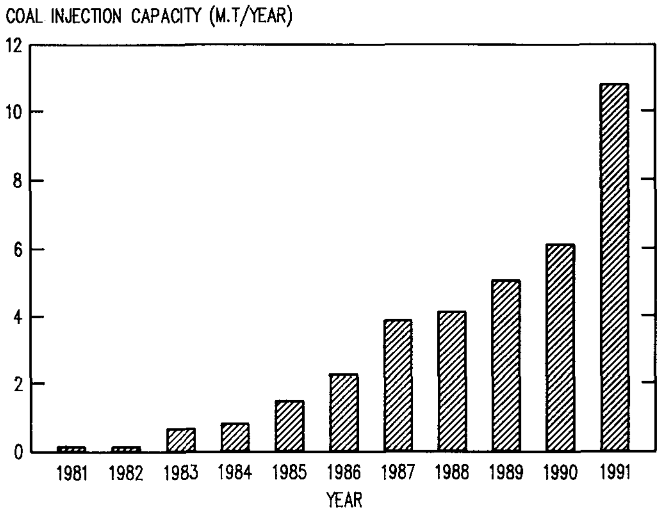


**Fig. 1.** Blast furnace coal injection capacity in Western Europe.
**Kuva 1.** Hiili-injektion kehitys Länsi-Euroopan masuuneissa.

- decreasing operating costs by replacing expensive coke by coal.

A world record concerning the coke rate has been recently achieved by HOOGOVENS. During November 1992, the blast furnace No. 6 (11 m hearth diameter) has operated with a mean coal injection rate of 204 kg/THM and an oxygen enrichment of 5 %; it needed only 240 kg/THM of metallurgical coke plus 36 kg/THM of nut coke[2].

Investigations are presentely persued to further decrease the coke rate while at the same time increasing productivity. A process which is being developed by C.R.M. for this purpose consists in the combination of a high coal injection rate (250 kg/t), the utilization of cold blast with very high oxygen contents (60—98 %) and the reinjection of the BF top gas — after decarbonation below 5 % $CO_2$ and reheating to 900—950°C — into the bosh of the blast furnace[3].

Such a practice allows to reach very low coke rates and to minimize $CO_2$ emissions. The blast furnace installations are simplified and thus investment and maintenance costs are reduced. It could double the furnace productivity which is obtained when the conventional coal injection and oxygen enrichment are applied. The suppression of the high temperature hot stoves will have a beneficial effect on the environment. Hot metal quality will be improved, as lower silicon and nitrogen contents will become possible, due to the high partial pressure of CO and the low nitrogen atmosphere at tuyère level.

The top gas produced has a very high calorific value and is suitable for many applications, expecially in the case of the nitrogen free operation (nearly pure oxygen), where the top gas has a composition similar to that obtained in many coal gasification processes.

A few years ago, IRSID had proposed another way for increasing the blast furnace productivity. The basic idea of its TOP (Tuyère Ore Plasma) process[4] is to inject iron ores into the tuyères in such a way that the counter-current operation in the bosh and the stack is not altered. The required supplementary energy was supplied by electricity (plasma). An injection of 205 kg of iron ore produces some 145 kg of extra hot metal. By injecting prereduced iron ore (60 % metallization), it was possible to decrease the electricity consumption. Recently, BRITISH STEEL and HOOGOVENS have declared their intention to test tuyère injection of iron ore on a blast furnace in Scunthorpe working with oxygen enriched hot blast.

Table 1 compares the main features of these three processes.

**Table 1.** Comparison of innovative blast furnace technologies.
**Taulukko 1.** Eräiden potentiaalisten masuuniteknologioiden vertailu.

| | | PCI | Cold $O_2$ + Gas Recycling | Coal + Ore Injection |
|---|---|---|---|---|
| COKE RATE (dry, 89 % C) | kg/THM | 300 | 173 | 287 |
| COAL/ORE | | | | |
| Coal inj. rate (1 % moist.) | kg/THM | 180 | 250 | 250 |
| Ore injection rate | kg/THM | - | - | 200 |
| Total primary coal rate | kg/THM | 555 | 466 | 609 |
| Coal/oxygen ratio | g coal/Nm3 $O_2$ | 777 | 1048 | 899 |
| BOSH GAS INJECTION | Nm3/THM | 0 | 525 | 0 |
| BLAST | | | | |
| Volume (wet) | Nm3/THM | 920 | 0 | 544 |
| Temperature | °C | 1200 | | 1200 |
| $O_2$ in hot blast | % | 25.5 | | 30.0 |
| $O_2$ injected (cold) | Nm3/THM | | 243 | 115 |
| PRODUCTIVITY | | | | |
| Productivity index | % | 100 | 200 | 112 |
| TOP GAS | | | | |
| Amount (dry) | Nm3/THM | 1411 | 1137 | 1222 |
| Temperature | °C | 169 | 171 | 173 |

## Ore Preparation

The survival of the blast furnace implies that appropriate ore preparation technologies are available. As pellet feed is scarce, it will not be possible to buy large amounts of pellets on the world market and it will be necessary to continue to prepare the ores on site, prior to charging them into the blast furnaces.

For this purpose, the agglomeration is the most convenient process, as sinter feed is abundant. Moreover, the sinter strand is most convenient for recycling the ferruginous by-products generated in the iron and steelworks. Present developments aim at reducing the $SO_2$ and $NO_x$ emissions of the sinter process. Recycling of fumes seems particularly promising in this respect (Table 2).

## Cokemaking

Classical cokemaking has reached its final stage of development e.g. large ovens, Jumbo coking reactor, pretreatment of the charged coal, etc... The problems faced by this process are its investment costs, the necessity to use expensive coking coals and the difficulty to cope with the environmental prescriptions.

Though the disappearance of coke ovens has been forecasted for a number of years, it can be observed that even today new coke batteries are being rebuilt and that the coke quality produced satisfies the stringent requirements of blast furnaces operating with very low coke rates.

Alternative cokemaking technologies such as formed coke production have been proposed and developments are still going on in this direction, mainly in Japan. It seems however that the quality of formed coke will not be able to meet the requirements of large blast furnaces with high coal injections. Another possibility is a continuous cokemaking process under gas pressure but it is clear that such a development will be lengthy and costly. A large collaboration between steel producers, coal suppliers and equipment builders is necessary to industrialize such a completely new cokemaking technology.

## Smelting reduction

The above considerations make it clear that ore preparation and cokemaking are very capital intensive and that they create most of the environmental problems which the steel industry has to face.

The dream of all steel producers is therefore to develop a technique allowing coal and ore to be directly transformed into liquid metal.

During the 1970s and 1980s a large number of smelting reduction processes have been investigated[5]. These processes use a variety of reactors fo the reduction and the smelting steps. Apart from the COREX-process, none of them has outpassed the pilot plant stage.

The COREX-process, which uses lump ore, pellets or sinter as well as lumpy coal as raw materials, now has been operating successfully for a couple of years at a scale of 300,000 t/y and a second plant, with an expected capacity of 700,000 t/y, is under construction. Nevertheless, many specialists consider this process as a first generation process which, because of its high degree of prereduction, prior to smelting, will always have a significantly higher fuel consumption and gas export than the blast furnace. Its economic viability depends very much on the possibility of valorizing the large amount of relatively lean export top gas. However, there seem to be at present some developments, which concern either top gas recycling or the injection of iron ore fines into the smelter (FINEX-process), that could reduce the gross energy requirements of the COREX process.

**Table 2.** Comparison of gas sream balances of sinter plants.
**Taulukko 2.** Sintraamon kaasujen kierrätyksen vaikutus kaasuvirtoihin.

| | COMBUSTION GAS (Nm3) | | | EXHAUST GAS TO BE TREATED (Nm3) |
|---|---|---|---|---|
| | Air | Oxygen | Recycled fumes | |
| Conventional Sintering Process (per ton of Sinter) | 1200 | - | - | 1400 |
| New Sintering Process (per ton of Sinter) | 40 | 60. | 900 | 300 |

The majority of the processes presently under development throughout the world use ore fines and coal fines as feedstock in order to avoid as well coking as the agglomeration of iron ores. They generally consist of two superposed reactors: a prereduction and a smelting vessel (Fig. 2). Many of them use high post-combustion (to $CO_2$ and $H_2O$) of the gases arising from the smelting vessel. The highly oxidized smelter gas has thus a very low reduction potential and in case of a linked operation, only moderate or low degrees of prereduction can be achieved in the reduction stage; the higher heat requirements in the smelter are largely compensated by the greater combustion efficiency and the overall result is a decrease in coal consumption and generally a simplification of the prereduction reactor.

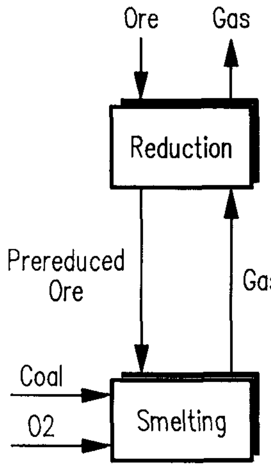


**Fig. 2.** The links between reduction and smelting.
**Kuva 2.** Kaksivaiheisen esipelkitys-sulapelkistys prosessin kaavio.

The JUPITER process of USINOR/SACILOR-THYSSEN tries to reach a high degree of prereduction of the ore by carbon in a circulating fluidized bed; to achieve this objective, it is necessary to abandon the linked operation and to recycle the top gas of the reduction reactor after eliminating the $CO_2$. If an economic solution for the $CO_2$-wash can be found, this process could lead to very low coal requirements.

The Cyclone Converter (CCF) proposed by HOOGOVENS, B.S. and ILVA could prove particularly interesting[6]. Prereduced ore with a prereduction rate of 20—25 % is fed into the smelting vessel (Fig. 3) where a low postcombustion rate is performed; the latter can be operated like a well known K(M)S converter. Its off-gases travel through the cyclone and react with tangentially injected ore and coal and lead finally to an excellent gas utilization (Postcombustion ratio: 70—80 %).

The process is still in an experimental stage but in case of success, it could become the most economical smelting-reduction process.

## STEELMAKING TECHNOLOGIES

### The LD Process

Refining of hot metal in LD converters is a mature technology. The iron yield as well as the consumption of raw materials have reached optimal levels; environmental problems are under control; productivity has been boosted to levels beyond 500 tonnes of crude steel per hour and per converter in operation. In certain Japanese works, the tap-to-tap times are lower than 30 minutes for 300 t converters.

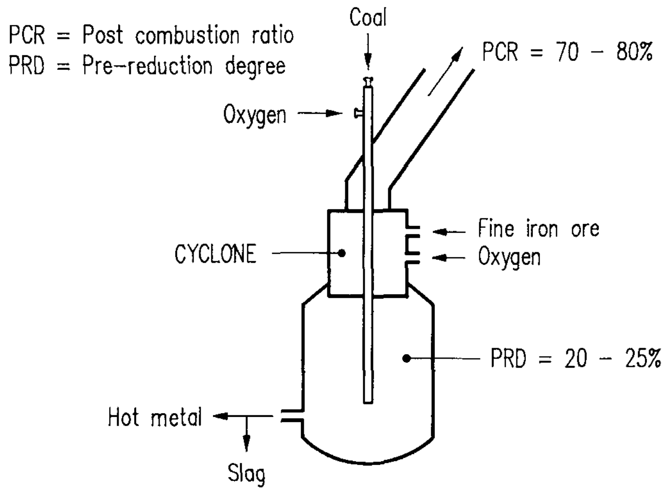


**Fig. 3.** Cyclone converter furnace (CCF).
**Kuva 3.** Sykloni-sulapelkistysprosessi (CCF).

In conjunction with subsequent ladle metallurgy, all impurities can be decreased to ppm levels.

For producing top quality flat products, the tendency is to use only hot metal and internal works scrap. Charging coated new scrap would prevent BOF dust from being recycled to the sinter plant; therefore processes for degalvanizing coated scrap are now under development.

External dephosphorization of the hot metal prior to converter refining is not used in Western Europe but this might become an issue, if the BOF productivity has to be further increased, if large quantities of extra low phosphorus steels are required or if the necessity to decrease the amount of LD slags arises.

### Continuous refining of hot metal[7]

The past saw an abundance of ideas and trials targeting the development of "continuous steelmaking" processes. Continuous refining of hot metal was expected to offer the following advantages:

- lower investment expenses,
- lower operating costs,
- favourable preconditions for automation,
- independence of heat sizes,
- improved thermal efficiency,
- smaller slag volume,
- higher yield.

Despite these potential advantages and despite the strong attraction of the term "continuous", these ideas have not reached industrial operation. The reasons involve a number of unsolved technical problems, and moreover, there are doubts about the basic approach. A number of steel types require an ever-increasing degree of cleanliness and closer analysis ranges. This requirement is met by the well-known secondary metallurgical processes. Continuous refining in conjunction with a batchwise secondary metallurgical treatment appears less attractive. Moreover, the production range often comprises a few hundred steel types, and frequent grade changes are well practicable batchwise, but hardly controllable on a continuous basis. Thus, a heat-by-heat secondary metallurgical processing is necessary, even if the melting unit operates continuously. As already stated, such processes have not won favour, although they offer certain advantages; they are not expected to gain acceptance in the near future.

### Present state of the electric arc furnace

During recent years, the technology for melting scrap in electric arc furnaces has made considerable progress. Furnace performance has i.a. been improved thanks to:

- the UHP furnace
- the direct current furnace
- the bottom bubbling with inert gas
- the pneumatic injection of powdered materials
- the post-combustion of the furnace gas
- the continuous furnace charging

— As fas as productivity is concerned, shorter tap-to-tap times are achieved, with record levels lower than 45 minutes per heat; the number of heats now exceeds 30 per day and per furnace.

— The negative impacts for the environment due to dust formation and fume emissions, to the noise level,... have been reduced. Most external scrap preheating facilities have been discontinued in order to meet the new specifications. The more and more severe restrictions on the deposit of the EAF dust in landfil might require a post-conditioning treatment for removing heavy metals and zinc.

— An important effort is devoted to the decrease of the electricity consumption by using alternative sources of energy (carbon, oxygen, natural gas) and by the recovery of the off-gas heat e.g.

— The **Consteel process** (Fig. 4) feeds continuously preheated scrap into an adapted furnace using the chemical heat of the furnace off-gas[8]. Scrap is preheated to about 600°C with an oxygen addition in the preheater of 25 Nm3/t while the temperature of the fume can reach 1000°C. The harmful emissions are reduced to levels required by the current regulations on environmental protection.

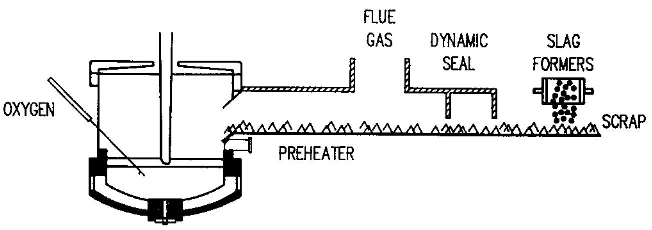


**Fig. 4.** The Consteel basic concept.
**Kuva 4.** Romun esikuumennus Consteel-menetelmällä.

Moreover, the dust emission is reduced by 60 % compared to a conventional EAF.

After pilot testing at NUCOR, a 54 t/h commercial plant operates since 3 years at FLORIDA STEEL (Charlotte). A 120 t/h plant went into operation in October 1992 at the Nagoya Works of KYOEI STEEL. The main advantages concern energy savings and productivity increase.

— The **Shaft furnace**[9] introduced by FUCHS SYSTEM TECHNIK involves one or two water cooled shafts mounted as an integral part of the furnace roof. The basic idea is to charge as continuously and directly as possible the scrap into the furnace without extra handling. In a normal heat practice, the first basket (cold crap) is charged directly into the furnace while the second and third baskets are charged into the shaft.

The hot exhaust gases are extracted through the shaft from the furnace. Coupled with oxyfuel burners located at the base of the shaft, they preheat the scrap before it falls down into the semi-molten bath. The scrap in the shaft acts both as a filter for the dust and as an efficient heat exchanger. The first trials on a prototype shaft furnace have been realized at DDS in Denmark. An industrial unit has been erected at SHEERNESS STEEL with a modified design compared to the DDS experience.

Started since March 1992, the shaft furnace has confirmed after more than 3000 heats that 60 % of the energy contained in the off-gas can be retrieved (40 % of scrap are shredded scrap), that the electrical consumption can be reduced by 20 % and that the productivity is increased by almost 20 %. No environmental problems have been mentioned.

## Alternative scrap melting technologies

a) Numerous efforts have been made during the past thirty years in order to increase scrap consumption in BOF converters with the aim of decreasing the metallic costs.

It seems however that this hybrid solution has a limited future because:

- for top quality products the steel purity is insufficient;
- for ordinary grades, cost considerations show that it is preferable to use 100 % scrap;
- it is no more possible to recycle the converter dust to the sinter strand.

b) When electricity is produced from fossil fuels, the yield of the primary energy is low. For this reason, new ways are permanently suggested for melting scrap entirely or partially with fossil energy.

The EOF process is now applied in PAINS, Brasil, as well as at TATA's in India. In this process, carbon and oxygen are injected below the bath level and the emerging $H_2$ and C0 gases are burned above the bath level; the sensible heat is then transferred to the scrap in a shaft furnace (Fig. 5)[10].

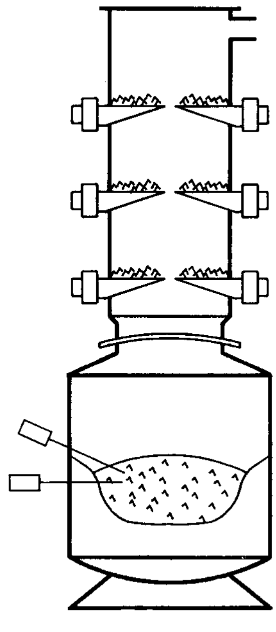

**Fig. 5.** EOF-process (10).
**Kuva 5.** EOF-prosessi (Energia-optimointi uuni).

c) At FERRIERE NORD[11], the aim is to decrease the electricity consumption of the EAF by a multiple balanced injection of gas and coal and to control the combustion process by operating burners and post combustion lances (Fig. 6).

The net result of these two actions is a decrease of the electricity consumption (present average 323 kWh/t; aim 200 kWh/t) (Fig. 7) and an increase of the productivity.

Further operational results are necessary for a thorough evaluation of the investment and operational costs of these alternatives. In any case, the environmental aspects must never be underestimated.

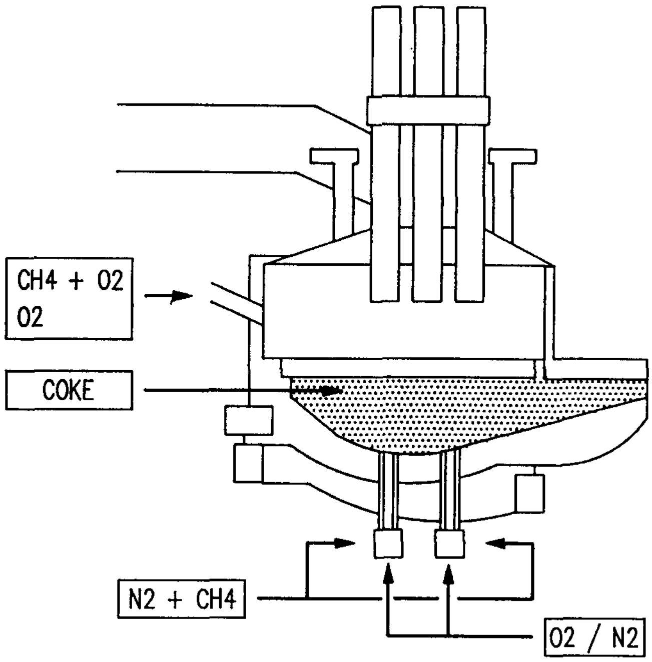


**Fig. 6.** The injection in the EAF at Ferriere Nord (11).
**Kuva 6.** Esimerkki happi-maakaasu-hiili-injektiosta valokaariuunissa (Ferriere Nord).

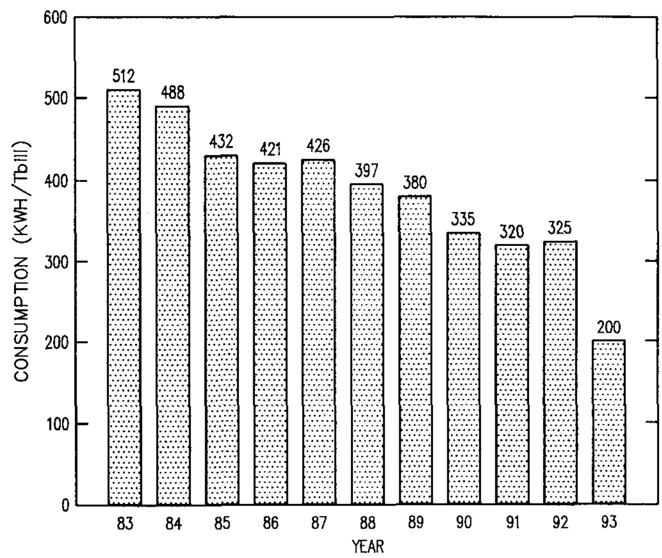


**Fig. 7.** Energy consumption in the E.A.F. Ferriere Nord (11).
**Kuva 7.** Sähköenergian kulutus Ferriere Nordin valokaariuunissa.

## THE $CO_2$ ISSUE

The iron and steel industry has almost halved its $CO_2$ emissions per ton of liquid steel during recent years. As indicated in Chapter 2, the classical blast furnace route has reached or will reach in the near future its lowest, theoretically possible $CO_2$ emission level.

The smelting reduction processes operating with coal generate equivalent or even higher amounts of $CO_2$ and they will not reduce the green house effect.

The question is therefore often raised whether for reducing iron ores there are alternatives to carbon e.g. hydrogen[12].

Direct reduction processes using $CH_4$ or $H_2$ have already reached industrial maturity. Until now, however, these processes are economically only viable in countries where natural gas or hydrogen are available at low cost.

### The "Nuclear steelmaking" study([13])

The European Nuclear Steelmaking Club (ENSEC), established in 1973, with the aim of selecting an appropriate strategy for the application of nuclear energy to steelmaking, investigated various steelmaking routes and evaluated their potentials to utilize heat and electric power from high temperature nuclear reactors (Fig. 8).

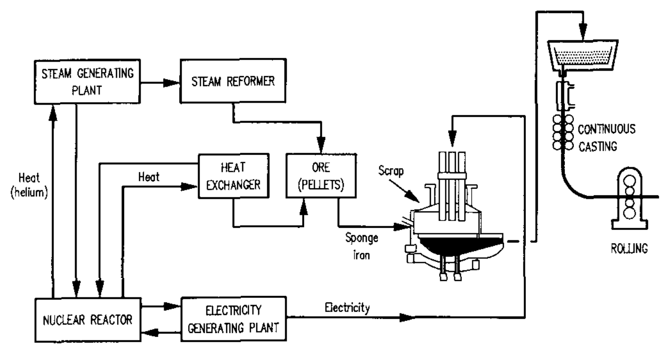


**Fig. 8.** Nuclear power applied to the D.R./E.A.F. route (12).
**Kuva 8.** Ydinvoiman, suorapelkistyksen ja valokaariuuniprosessin yhdistelmä.

The incentive for the development of high temperatur nuclear reactors was the possibility to use directly the heat coming from the nuclear reactor as process heat in chemical or metallurgical processes and to avoid, as far as possible, the more expensive and thermally relatively inefficient electricity generating cycle. The HTR (High-Temperature Gas-Cooled Nuclear Reactor) prepared by the O.E.C.D. Dragon project and the A.V.R. Pebble Bed High-Temperature reactor developed in Germany seemed capable of attaining temperatures high enough for this prupose. In the beginning, the high temperature heat supplied by the reactor was to be used to cover the heat requirements of a steam reformer transforming natural gas into hot reducing gas that could be used either for injection into blast furnaces or as reductant in DR-processes; the medium temperature enthalpy (350—700°C) was to be used for the production of electric power covering the requirements of the plant.

During the study, it appeared that hydrogen could be the better reductant in the case of a nuclear DR-plant because of the higher reaction rate at temperatures below 800°C, compared to reformer gas. Three ways of producing hydrogen were envisaged:

- conventional **steam reforming** of natural gas, followed by a shift conversion and subsequent $CO_2$-wash, the process heat being supplied by the nuclear reactor.
- production of hydrogen from water by **electrolysis.**
- thermochemical **"splitting of water"**. Various thermochemical processes for the production of hydrogen were investigated, especially that based on the reactions between iron chlorides and water at various temperatures ranging from 150°C to 800°C.

Apart from the problems concerning the HTR, a series of major problems stopped the investigations on nuclear steelmaking:

- first of all the **minimum** scale for an economic operation of

the HTR is about 2200 MW (thermal). In energy terms, this corresponds to a steel production of about 5 million tonnes relying on one single source of energy;
• the expected **availability** of the HTR was much too low for an economic operation of a steelplant;
• the problem of using the energy produced by the reactor when the **steelplant is down** for technical or other reasons;
• the **handling of the hot gas** leaving the core of the nuclear reactor, and the necessity to supply directly a large number of DR-modules entailed great problems;
• last but not least the presence of a large nuclear reactor within the limits of a steelworks, where a large number of people work and circulate entails very important **safety** problems.

These considerations led European steelmakers to abandon these ideas but some of them might be taken up again if the pressure to lower the $CO_2$ emissions becomes sufficiently strong.

### Elofoil

C.R.M., in collaboration with its affiliated companies ARBED/SIDMAR, COCKERILL SAMBRE and HOOGOVENS, has developed a new process enabling the direct and continuous production of iron foil from steel scrap by electroforming. The new process — **"ELOFOIL"** process — enables the transformation of an inexpensive raw material into a high value added product in a single continuous electroforming operation (Fig 9).

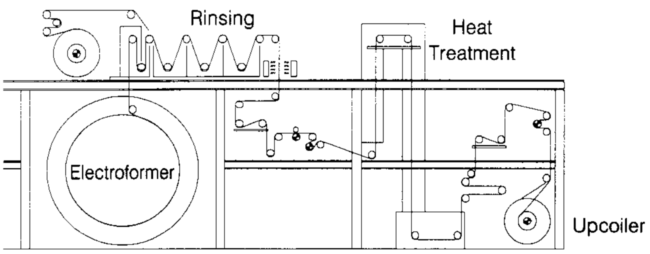


**Fig. 9.** Pilot line for electrofoil production.
**Kuva 9.** Pilot laitteiston kaavio rautafolion elektrolyyttiseksi valmistamiseksi.

The ELOFOIL process is based on the well known "rotating drum" principle that can be summarized as follows:

Iron is deposited on a rotating drum by an electrolytic process from iron chlorie electrolyte. For a particular point of the cathode entering the gap between cathode and anode, the thickness of deposited iron increases as the electroforming time increases. At the exit of the cell, the thickness of the iron deposit has reached its desired value and the foil is peeled from the drum and coiled. The stripping operation is facilitated by a special treatment of the surface of the rotating cathode.

Since the anodes used are insoluble, the composition of the electrolyte has a tendency to change during electroforming and a replenishment is necessary. The regeneration of the electrolyte is accomplished in a separate reactor by dissolution of steel scrap.

The ELOFOIL process introduces several technological innovations resulting in a major cost reduction of the produced foil. The more outstanding features of the new process can be summarized as follows:
• a new "high turbulence low pressure" anode enabling the realization of high current densities associated to a very narrow gap (2 mm) between anode and cathode. The practical result of this innovation is an increased production capacity and a decreased energy consumption per unit weight of produced foil;
• a special arrangement of the anodic modules renders it possible to use high cathode diameters and, hence, to increase in a large extent the production capacity of the line;
• an improvement of the electrolyte replenishing technique (reacting with steel scrap) permits high regeneration efficiency, reduced waste volume, simplified reactor construction and, finally, reduced investment and running costs.

The new process, after five years of laboratory trials, is presently tested on a large pilot line scale with, as a principal objective, the production of high value added thin iron foil (thickness 8 to 80 $\mu$ m).

Preliminary studies have demonstrated that it is possible to use, in the context of the ELOFOIL process, pyrite as raw material. In geographical areas where cheap electric energy is available, one could envisage a combination of the ELOFOIL process with well known processes of hydrometallurgical treatment of pyrite in order to produce steel without $CO_2$ formation.

## OUTLOOK

How will the technological progress in iron and steelmaking influence the future configuration of the steel industry in Western Europe? For carbon steels, the following trends can be expected:

a) the productivity of **large integrated steelworks** has dramatically increased during the past ten years: An almost unchanged total iron and steel output has been achieved with a decreasing number of blast furnaces from150 in 1978 to 65 in 1992 and LD converters from 180 to almost 100, respectively. It can be expected that this tendency will continue. Today it is possible to produce 6 million tonnes of top quality flat products with:
• two performant blast furnaces with high PCI and environmentally friendly coke and sinter plants;
• a 3-converter BOF shop with a hot metal pretreatment station and a performant ladle metallurgy;
• two classical slab casters;
• one hot strip mill.

In such a steelworks, the **quality** (regularity of the dimensional tolerances, high level of the mechanical properties, perfection of the steel surface) is superior to that obtained in any other process route. As far as **cost** is concerned, the degression effect of mass production is fully effective. It is clear that to profit from this situation, such large integrated steelworks have to receive very large orders; the latter represent only a limited portion of the total steel consumption and therefore the number of such large steelworks will be limited in the future.

b) Besides large plants, numerous smaller steelworks will produce steels for well defined **markets** in close contact with the steel user.

The production costs of integrated steelplants having a limited production are high and — except in favourable market or geographical conditions — the earnings of these works will not allow them to rebuild, in the future, production facilities incorporating the latest technological developments for cokemaking and agglomeration of iron ore, complying with the stringent ecological prescriptions.

c) Different options are available for producing liquid steel in market mills.

In the past, small size integrated steelplants have tried to decrease their operating costs by increasing the scrap rate in the converter (KMS, ALCI, TULA,...). It appears that the cost decrease due to an increasing scrap input in the metallic charge is outbalanced by the cost increase of the remaining tonnes of hot metal.

Therefore an increasing number of steelworks radically turn to the **electric arc furnace.**

This move optimizes the cost problem but raises questions concerning the steel quality. For the commercial quality steel grades, it may be assumed that the problem will be solved, thanks to an appropriate selection of the charged scrap.

For steel grades with a higher quality, the Cu, Ni, Cr, Sn,... contents have to be decreased. As means for eliminating these elements from the liquid steel are still to be found, an addition of virgin iron units in the metallic charge will be necessary in order to dilute the tramp elements and to improve the steel quality.

If direct reduced iron (Midrex, HIB, $Fe_3C$,...) or granulated pig iron cannot be bought at a competitive price on the market, the construction of a production facility on site will have to be considered.

Direct reduction from natural gas has not been economically feasable in Western Europe until now.

Low cost smelting reduction processes using coal are obviously of interest in this context, especially when $CO_2$ emissions will be minimized.

As an alternative, it might prove interesting to operate an "oxygen" blast furnace provided the small quantities of coke needed can be bought at a reasonable price on the open market.

In the field of casting and rolling, new routes are being actively investigated with the aim of reducing investment and operating costs in small production plants. Thin slab casting and beam blank casting are already in industrial operation.

Strip casting is approaching commercialisation for stainless steels and efforts are undertaken to extend its application to carbon steels.

In a shrinking steel market, the share of integrated mills and market mills could evolve during the coming years[14].

As a general conclusion, it may be said that the survival of the steel industry depends on its ability to adopt the technical solutions allowing it to further decrease the production costs, to respond to the global environment concerns and to satisfy the customer in a competing market.

The IISI study mentioned at the beginning of this paper underlines that for meeting these objectives, an international cooperation is necessary in coordination with other industries, research institutes and universities.

## ACKNOWLEDGMENT

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## YHTEENVETO

## UUSIA VAIHTOEHTOJA RAUDAN JA TERÄKSEN VALMISTUKSEEN

Terästeollisuudelta vaaditaan ensi vuosisadalla parempilaatuisia teräksiä pienissä erissä ja asiakasmitoissa entistä pienemmillä kustannuksilla. Lisäksi teräksen valmistajan pitää pystyä täyttämään kiristyvät ympäristövaatimukset, minimoimaan päästöt, toteuttamaan tehokas kierrätys ja hoitamaan sivutuote- ja jäteongelmat.

Kustannusten alentaminen voidaan toteuttaa lisäämällä nykyisten prosessien, masuunien, terässulattojen ja valssaamoiden tuottavuutta sekä kehittämällä uusia prosesseja, joilla on pienemmät investointikustannukset ja vähemmän prosessivaiheita. Tyypillisiä esimerkkejä nykyprosessien kehityksestä ovat masuunin hiili-injektio korvaamaan kallista koksia sekä raakaraudan esikäsittelyjen ja senkkametallurgian kehittäminen niin, että konvertteriprosessi keskittyy hiilen mellotukseen, jolloin tuottavuus voidaan maksimoida.

Uudet sulapelkistysprosessit tähtäävät masuunin korvaamiseen uudella prosessilla, joka tekisi rautarikasteen sintrauksen ja kivihiilen koksauksen tarpeettomaksi. Tällaisia prosesseja ovat mm. COREX, JUPITER ja CCF.

Romupohjaisessa teräksen valmistuksessa pyritään energiasäästöön käyttämällä hyväksi savukaasujen energiasisältöä (Consteel, Fuchs) sekä korvaamalla sähköä fossiilisilla polttoaineilla (KS, KVA ja EOF-prosessit).

On myös selvitetty teräksenvalmistusta ydinvoimalan yhteydessä.

CRM on yhdessä teollisuuden kanssa kehittänyt Elofoil-prosessin, jossa elektrolyyttisesti saostetaan ohutta rautafoliota kloridiliuoksesta.

Valumenetelmien kehitys johtaa ohutaihiovalun yleistymiseen ja pitemmällä aikajänteellä nauhavalun läpimurtoon.

Yleinen rakennekehitys terästeollisuudessa on kohti pienempiä, joustavia yksiköitä. Euroopassa on tapahtumassa siirtymistä malmipohjaisesta teräksenvalmistuksesta romupohjaisen sähköuunivalmistuksen suuntaan. Ongelmana nousee esiin romun epäpuhtaudet, mikä lisää mielenkiintoa puhtaisiin raaka-aineisiin, suorapelkistettyyn rautaan ja rautakarbidiin.

# The Golden Age of Extractive Metallurgy: 1950—?

**Professor Nickolas J. Themelis, Columbia University, New York, U.S.A.**

The speech given at the 50th Anniversary Meeting of the Finnish Association of Mining and Metallurgical Engineers in Helsinki on 19th March 1993.

## ABSTRACT

The fiftieth anniversary of the Finnish Association of Mining and Metallurgical Engineers coincides approximately with the second half of this century. One may be astonished to learn that, in this very short period, humanity has produced more metal than in the total of the thousands of years of history before it. This feat could not have been accomplished without a radical change in the ways that metals are made, that is the discipline of extractive metallurgy which blossomed in the second part of the 20th century. This paper traces the extraordinary developments of this period, starting with the introduction of high intensity smelting processes in two northern countries, Finland and Canada. It is clear that the fifties marked the beginning of the Golden Age of extractive metallurgy but the question remains as to whether this period of extraordinary achievement is near its end.

## INTRODUCTION

The author was truly honored by the invitation to present this paper at the fiftieth anniversary meeting of the Finnish Association of Mining and Metallurgical Engineers; Finnish metallurgists have contributed significantly to the story to be unfolded in this paper.

The history of extractive metallurgy goes back at least six thousand years, to the copper smelters of the Timna valley of Israel[1]. Copper, silver and gold were the first metals to be used by mankind, because they could be found, and sometimes still are, in their "native", metallic state. Those chunks of metal led man to use fire for processing minerals to metals and alloys. Metals have played such an important role in the development of our species that periods in the history of various peoples are marked by their initiation into the making and using of metals, such as the "bronze age" and the "iron age"[2].

In the history of mankind, there have been periods of time when particular arts and sciences flourished. One can mention Athens of Phidias and Sophocles and Florence of DaVinci and Michelangelo. It may be immodest of self-serving to compare one's times to some of the illustrious periods of western civilization, but if one examines the history of extractive metallurgy through the ages, it appears that in the early fifties, near the founding of the Finnish Association of Mining and Metallurgical Engineers, we entered the Golden Age of Extractive Metallurgy.

This hypothesis and, also, the question as to where we may be heading from now on are examined in this paper. To be manageable, the search will concentrate on one of the first metals to be extracted by man: Copper.

## COPPER CONSUMPTION AND STANDARD OF LIVING

Although copper has been used through the centuries for functional uses as well as for decorating structures and people, its principal uses at the present are functional: As a heat-exchanging and electricity-carrying metal in devices of all kinds. In contrast to gold and silver, which can be overused and hoarded by the rich, most of the copper consumption in a nation is by the majority of the people.

Therefore, one may consider that the copper consumption per person is a measure of the standard of living in a country. Of course, this refers only to the material standard of living and not to the overall quality of life, which also depends on cultural and societal values.

It is interesting to follow this line of reasoning and compare the copper consumption in some countries of the world, such as Canada, China, Finland, India, Japan, and U.S.A. However, the only available data by country are for refined copper consumption and should be corrected for copper contained in the products exported and imported by each nation. Unfortunately, this information is not being compiled presently[3].

In its absence, we can use the refined copper consumption data[5] by assuming that there is an approximate balance in the copper content of products imported and exported. As shown in Table 1, the per capita consumption of copper is as high as 15 kg/year in Finland and as low as 0.1 kg in a developing nation like India. The important message of Table 1 is that the world average consumption of copper is 1.88 kg/person, a figure which is considerably lower than in the developed nations as a whole, and much higher than what is available to the most populous nations. The level of copper production that would be required to bring the globe to a half-way standard, for example 6 kg/person, is beyond the wildest dreams of present-day copper producers. The role of extractive metallurgy technology in this task will be discussed later.

## GROWTH OF PRODUCTION AND CONSUMPTION OF COPPER

It has been stated[4] that until the beginning of the nineteenth century academia was all hypotheses but no facts and industry all facts but no understanding. Although copper had been through the ages the most important functional metal to man, next to iron, the rate of its production and consumption by the end of the first decade of the nineteenth century was only about 16,000 tonnes[4].

By the end of the so-called industrial revolution[5], in the middle of the nineteenth century, the world's annual copper production had doubled to about 35,000 tonnes and by 1875 to 100,000 tonnes. At the entry of the twentieth century, copper production was about 500,000 tonnes. By 1929, the production and consumption of copper had quadrupled to 2 million tons and then there was a modest increase to 2.5 million by 1950[4]. Then, in the next forty years, the refined copper consumption quadrupled to a maximum of about eleven million tonnes in 1989 and has hovered around that level since then[6]. These data are shown in graphical form in Figure 1. The great jump in copper production

**Table 1.** Annual consumption of refined copper.
**Taulukko 1.** Raffinoidun kuparin vuotuinen kulutus.

| Country | Population million[7] | Refined copper consumption thousand tons/y[8] | Per capita consumption of refined Cu, kg/y |
|---|---|---|---|
| Australia | 22 | 114.6 | 5.2 |
| Brazil | 135.6 | 136.9 | 1.0 |
| Canada | 25.4 | 226.1 | 8.9 |
| Chile | 11.3 | 24.5 | 2.2 |
| China | 1057.2 | 425.9 | 0.4 |
| Finland | 4.9 | 74.4 | 15.2 |
| Germany, East (1986) | 16.6 | 115.3 | 6.9 |
| Germany, West (1986) | 61.1 | 787.5 | 12.9 |
| India | 685.2 | 75.5 | 0.1 |
| Italy | 57.3 | 377.2 | 6.6 |
| Japan | 121 | 1363.6 | 11.3 |
| Sweden | 8.4 | 111.6 | 13.3 |
| United States | 250.1 | 2126.4 | 8.5 |
| WORLD TOTAL: | 5236.0 | 9859.6 | 1.88 |

in the second half of this century is evident. What is more astonishing is that in this brief period, humanity consumed more copper than in the total of sixty centuries before it.

One may read in the curve of Figure 1 some messages to our society: For example, is the levelling off in the eighties a sign of a temporary economic recession, as believed by some economists? Or is it an indication that we have actually reached the limits to growth prophesied by others? In either case, how will

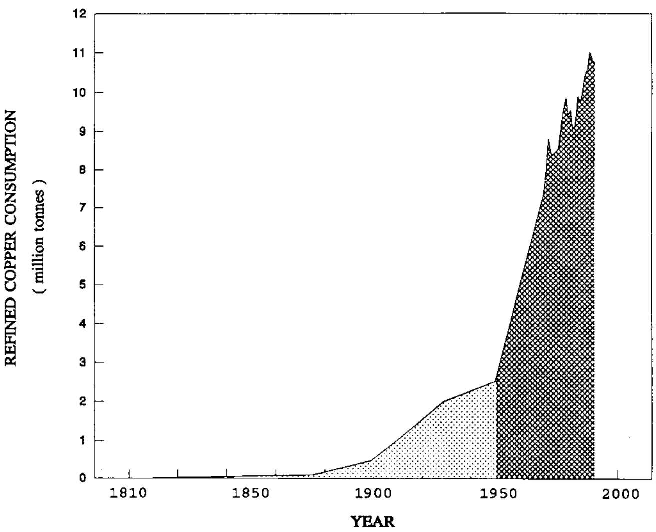


**Fig. 1.** World copper consumption in the 19th and 20th centuries.
**Kuva 1.** Maailman kuparituotanto 19. ja 20. vuosisadalla.

it be possible for the billions of the developing countries, whose annual per capita consumption is less than one kilogram of copper, to reach, even halfway, the material standard of the highly developed countries?

In the following sections we will contain ourselves in examining how, since 1950, the science and technology of metal extraction made it possible to provide humanity with its ever increasing needs for metal; and whether, in the foreseeable future, minerals engineers may help to bridge the gap between the haves and the have-nots.

## ADVANCES IN SCIENCE

The two major branches of the science of extractive metallurgy are chemical thermodynamics and rate phenomena which encompass chemical kinetics as well as mass and heat transfer. Both of these branches literally blossomed in the last four decades.

In thermodynamics, one can cite the contributions of Chipman, Darken, Elliott, Kellogg, Kubaschewski, Rosenqvist, Schuhmann, Tikkanen and Wagner amongst the many academic and industrial researchers who have provided thermodynamic data for thousands of reactions. Some of the most relevant publications of Kelley[9] ushered this era and the first comprehensive compilation of data, the JANAF Tables[10] was published in 1964, four years later than the first volume of "Thermochemistry for Steelmaking" by Elliott and Gleiser[11] and seven years before the series of monographs on "The Metallurgy of Copper" published by the International Copper Research Association[12]. In recent times, the advent of the computer has led to the development of extensive compilations of data such as that by Ihsan Barin and co-workers[13] and the computerized HSC program developed by Outokumpu Research[14].

With regard to the rate phenomena of metal extraction reactions, the advances made were even more spectacular, simply because the scientific base in this area, before the fifties, was very limited. King, Levenspiel, Pawlek, Peters, Turkdogan, Richardson, Szekely, Wadsworth and some of the academic metallurgists named earlier were amongst the many to shed light on the rates of chemical reactions, on transport phenomena, and on metal extraction reactors in general. In turn, their work inspired industrial engineers to pilot and test new processes which would produce metals much faster and at a lower energy and environmental cost.

Again, the rapid development of computers was of great value in the interpretation of experimental data and the development of mathematical models which simulated metallurgical processes with a certain degree of accuracy.

## PYROMETALLURGY AND HYDROMETALLURGY

Some years back, extractive metallurgists were neatly divided into pyrometallurgists and hydrometallurgists and the arguments raged as to which route is the preferred one. In one case, this argument was settled nearly eighty years back when the Hybinette hydrometallurgical process was tested and tried by Outokumpu[14]. However, as the science and technology advanced rapidly, metallurgists found themselves dealing with both routes in order to get the desired result. For instance, copper may be produced pyrometallurgically but the recovery of its fellow-travellers, such as selenium and tellurium, depend on hydrometallurgy. Also, the production of zinc starts in a fluidized bed roaster but ends in an electrowinning cell.

One thing that has become very clear is that although pyrometallurgy requires high temperatures, the energy required to produce a unit of metal may be substantially lower than via the aqueous route. In this respect, the work by Kellogg and his introduction[15] of the Process Fuel Equivalent (PFE) did much to dispel certain pre-conceptions and misconceptions. In brief, by processing feed materials of high metal content, pryometallurgical processes offered an energy advantage over hydrometallurgical systems which usually dealt with dilute aqueous solutions.

However, in other cases where a low grade material is processed, such as ore "waste", there is no alternative to hydrometallurgy. An example of this is the substantial production of copper from dump leaching and from the vat leaching of oxidic ores.

Although most of the new processes of the "Golden Age" in Table 2 are pyrometallurgical, hydrometallurgy also took a great leap forward since the fifties. The most spectacular advances were in the development of solvent extraction, pressure leaching and in novel electrowinning and electrorefining processes.

## ADVANCES IN TECHNOLOGY

In the second part of this century, there have been so many innovations in the methods for metal extraction that it would take many pages just to list them. Nevertheless, the author has attempted to list some of the most important developments in Table 2. This tabulation does not include the advancements made to existing processes, such as the tremendous increase in the capacity and productivity of the iron blast furnace. In pyrometallurgy, the major advances were in the utilization of industrial oxygen and the growth of gas-solids reactions, such as flash smelting and fluidization and gas-liquid reactions, such as the basic oxygen furnace and ladle refining. In hydrometallurgy, dump leaching, in-situ leaching, pressure leaching, solvent extraction and electrowinning contributed much to the overall production of metals.

**Table 2.** Some of the most important developments since 1950.
**Taulukko 2.** Kehityksen eräitä tärkeimpiä tapahtumia sitten vuoden 1950.

| Process | Metal |
|---|---|
| Basic Oxygen Converter (LD. BOF) | Steel |
| Bottom-injected Oxygen Converter | Steel |
| AOD Refining Process | Stainless steel |
| Outokumpu Flash Smelting | Copper, nickel |
| Noranda Continuous Smelting Process | Copper |
| El Teniente Converter | Copper |
| INCO Oxygen Smelting Process | Copper, nickel |
| Mitsubishi Process | Copper |
| Vanyukov Furnace | Copper |
| Imperial Smelting Process | Zinc |
| Fluid Bed Roasters | Zinc |
| Kivcet Process | Lead |
| QSL Process | Lead |
| Isasmelt Process (Csirosmelt) | Cu, Pb, Sn |
| Sherritt Gordon Pressure Leaching | Nickel, cobalt |
| Electrorefining of nickel matte | Nickel |
| Dump Leaching- Iron Cementation | Copper |
| Solvent Extraction-Electrowinning | Copper |
| In-situ leaching-Ion exchange | Uranium |

### Iron and Steel

Starting with the production of steel, the most significant development in ferrous extractive metallurgy was the replacement of the open hearth by the basic oxygen furnace for steelmaking. This process, based on the injection of an oxygen jet through the surface of the iron melt, truly revolutionized the conversion of high-carbon iron into steel and reduced the time of processing from hours to minutes. After its introduction in Austria in 1952[16], the basic oxygen furnace was improved further by the injection of inert mixing gas though the bottom[17].

However, the introduction of industrial oxygen through a bottom tuyere had to await the invention of the Savard/Lee gas-shielded tuyere.[18] This simple but important development made possible, in 1967, the injection of oxygen through tuyeres in the bottom of the steel converter. In 1992, oxygen steelmaking accounted for 540 million tonnes of which about 91 % was by the LD-BOF process and the rest by the OBM-QBOP process[18].

Another important innovation in this period was the AOD (Argon-Oxygen-Decarburization) process for producing stainless steels, which is based on the bottom injection of argon. This process is the most prominent of a whole family of gas-injection, ladle-refining operations for steel and other metals.

### Copper

In copper, the midpoint of the twentieth century found most of the copper industry using the age-old reverberatory furnace. This process, which by now is used in very few places in the world, consumed large amounts of fuel oil or coal and produced a gas that was very low in sulfur dioxide content and was usually exhausted to the atmosphere through a stack: approximately one tonne of sulfur was emitted for each tonne of copper produced.

Some companies were using electric furnaces instead of reverberatories and the costly electric power accounted for a large part of the cost of producing copper. For example, the Harjavalta smelter of Outokumpu could consume as much power as one half of the city of Helsinki[19]. For this principal reason, the Outokumpu engineers developed a radically new smelting technology which was implemented at Harjavalta in the early fifties.

This was the Outokumpu flash smelting furnace[20] which became the first and most successful of the family of **flash-smelting** processes, that is processes in which the concentrate particles were entrained in a gas stream and reacted mainly while in flight[21].

Next to the basic oxygen furnace for steelmaking, the Outokumpu process is the most successful extractive metallurgy process in this period, with nearly forty installations around the world[22]. This and other important metallurgical innovations by Outokumpu, such as flotation cells and automation of sampling and analysis have placed Finland in the forefront of extractive metallurgy R&D.

Nearly the same time as Outokumpu, International Nickel introduced another flash smelting process, the INCO oxygen smelting process, at Sudbury, Ontario. In that case, the impetus to use industrial oxygen instead of air was provided by the need to produce a very high $SO_2$ gas, suitable for the production of liquid sulfur dioxide. It is interesting to note that the INCO process appears to be the first one of many processes to use pure oxygen. The INCO process was very successful in the INCO operations but took nearly thirty years before the first "outside" installation, at Hurley, New Mexico.

The seventies saw a flurry of activity in the development of processes based on the **bath-smelting** principles[21]. The most succesful of these are the Noranda continuous smelting process and the El-Teniente Converter (Figure 2) developed by CODELCO in Chile. Both of these reactors are somewhat similar to the Peirce-Smith copper converter and at this time account for a total of about 20 % of the world's copper production.

$$Cu_2S \setminus FeS_2 \setminus FeS + O_2 \longrightarrow Cu_2S + FeO + SO_2$$

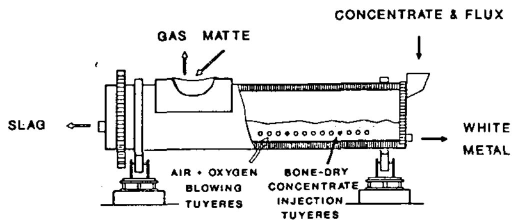


**Fig. 2.** The El Teniente smelting converter.
**Kuva 2.** El Teniente sulatuskonertteri.

The most automated copper smelting process is the Mitsubishi process (Figure 3) which produces copper continuously in three interconnected furnaces (smelting, converting, slag cleaning).

$$Cu_2S \setminus FeS_2 \setminus FeS + O_2 \longrightarrow Cu^0 + FeO + SO_2$$

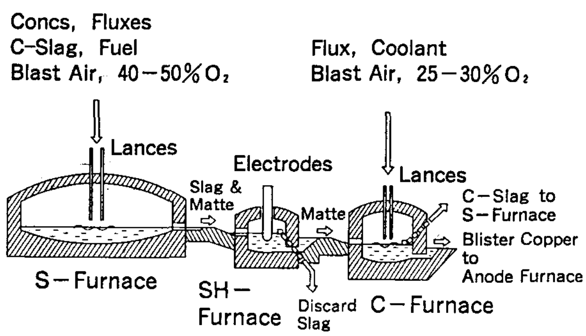


**Fig. 3.** The Mitsubishi continuous smelting process.
**Kuva 3.** Mitsubishi jatkuva sulatusprosessi.

Another important copper smelting process, developed in Russia, is the Vanyukov furnace (Figure 4[23]). It is a bath-smelting process in which the oxidizing gas is injected into the slag instead of the matte layer, as in the Noranda process. This process was commercialized in Norilsk in 1977 and presently there are six furnaces in operation[23].

Over the years, as the cost of industrial oxygen decreased, copper companies realized the advantages of oxygen enrichment: lower energy consumption and lower cost of gas-handling and sulfuric acid production, both of which related to the decreased amount of input nitrogen. As an illustration, Figure 5 shows the potential for decreasing the inside dimensions of the Outokumpu flash smelting reactor by means of oxygen enrichment. In the eighties, a number of new high-intensity smelting processes have been proposed which are based on the use of pure oxygen instead of oxygen-enriched air[24]. Of these, the only one that has reached the industrial stage is the Isasmelt process.

$$Cu_2S \setminus FeS_2 \setminus FeS + O_2 \longrightarrow Cu_2S + FeO + SO_2$$

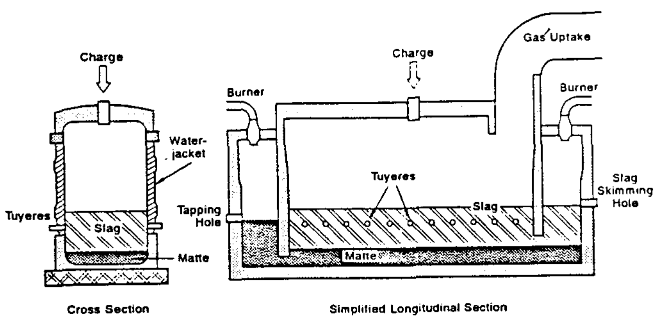


**Fig. 4.** The Vanyukov smelting process.
**Kuva 4.** Vanjukov prosessi.

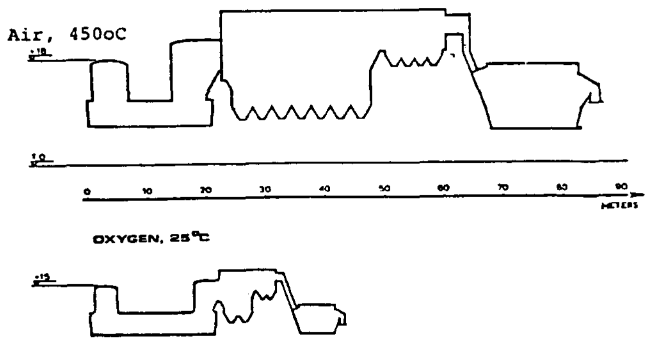


**Fig. 5.** Comparative sizes of Outokumpu furnace using air and industrial oxygen.
**Kuva 5.** Ilmaa ja teknistä happea käyttävän Outokumpu liekkisulatusuunin uunin kokovertailu.

## Zinc

In zinc production, the development of the Imperial Smelting Process made possible, starting in 1951, the direct processing of lead-zinc concentrates in a blast furnace. However, advances in concentration technology and the comparatively high cost of coke have reduced the availability of lead-zinc "bulk" concentrate, which is the feed material for this furnace. The principal method for zinc production is presently the fluidized roasting of zinc sulfides (Figure 6[25]) followed by leaching and electrowin-

$$ZnS + O_2 \longrightarrow ZnO + SO_2$$

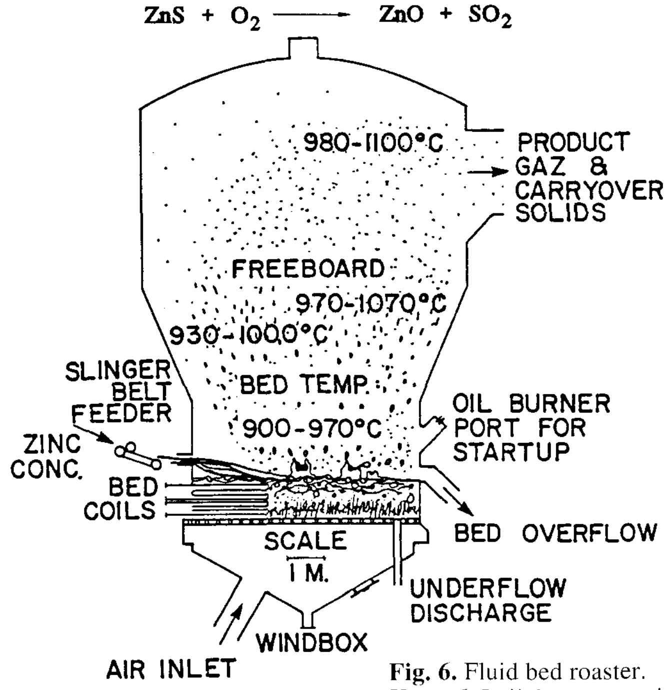


**Fig. 6.** Fluid bed roaster.
**Kuva 6.** Leijukerrospasutin.

ning. However, this semihydrometallurgical route has the disadvantage of disposing large amounts of tailings and iron precipitates. Therefore, some zinc companies are actively searching for potential pyrometallurgical alternatives.

With reference to fluidized bed roasting, it is interesting to note the growth in roasting capacity of industrial installations by Lurgi, the principal engineering firm in this area, from zero in 1950 to about 18 million tons in 1983[25].

## Lead

A number of new processes have been developed for the direct processing of lead sulfides to metallic lead. The only ones in commercial operation are the Kivcet process (Figure 7) and the QSL process (Figure 8). The former is a flash-smelting process and the latter belongs to the bath-smelting class. Both of them are based on the use of industrial oxygen.

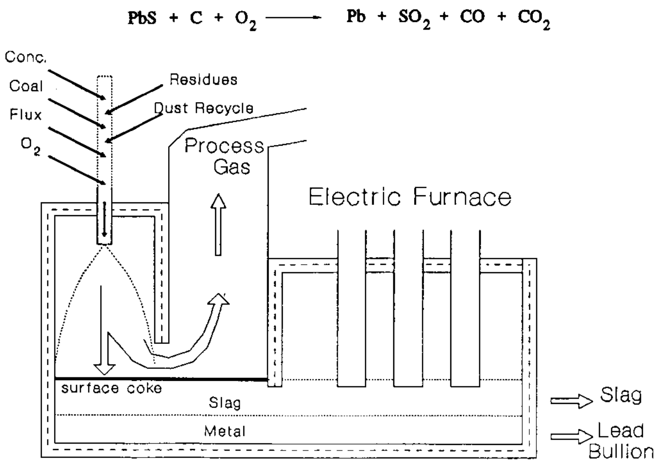


**Fig. 7.** The KIVCET process for smelting lead concentrates.
**Kuva 8.** Lyijyrikasteiden sulatukseen kehitelty KIVCET-prosessi.

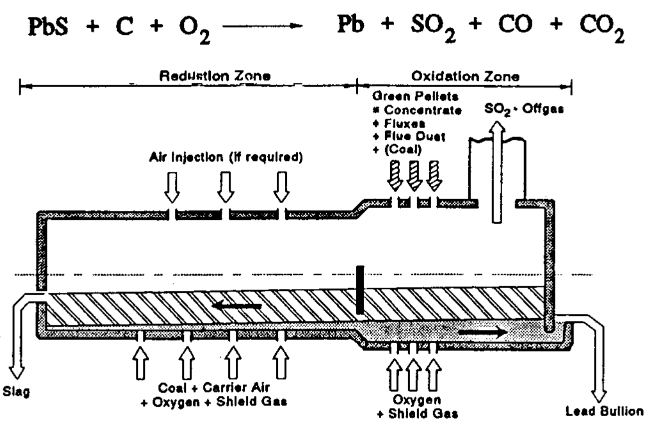


**Fig. 8.** The QSL smelting process for lead concentrates.
**Kuva 8.** QSL-prosessi lyijyrikasteiden sulatukseen.

## Nickel

The Outokumpu flash smelting and the INCO oxygen smelting processes, mentioned above, have been used successfully for the smelting of nickel sulfide concentrates. The technology of pre-reduction and electric furnace smelting of lateritic materials, to produce ferronickel, was advanced greatly in the last forty years but economic reasons have reduced nickel production via this route. Important hydrometallurgical developments were the Sherritt-Gordon pressure leaching process, the chloride electrowinning process of Falconbridge, and the electrorefining of nickel from nickel matte anodes.

## Aluminum

In the last hundred years, man succeded in harnessing electricity to produce aluminum and other metals, such as magnesium and calcium. There have been attempts since the fifties to replace the electrolytic Hall-Heroult process, for example by means of carbothermic reduction of alumina, but they were not successful. Nevertheless, there have been great improvements, as witnessed by the decrease in power consumption from about 26 Kw/kg Al in the forties to 13 Kw/kg in the most efficient Hall cells today[26].

## THE FUTURE

It can be seen from the foregoing that in order to satisfy the enormous appetite for metals of the last two generations, extractive metallurgists have come up with a cornucopia of theories and new technologies, such as had never been witnessed before. The question remains: Can this pace be maintained or have we come near the end of the Golden Age of Metallurgy? To answer this difficult question, we need to look into a number of factors.

A global industry that expands four-fold in less than forty years obviously must have the resources and the markets to do so. In the case of the mineral industry, these resources were mineral deposits, capital investment and human resources. The human resources, including the R&D component, were motivated by the opportunities offered by the rapid expansion and the influx of capital.

Today, the developed nations of the world, roughly 20 % of humanity, use about ten times more copper than the developing nations (roughly 80 % of humanity). To bring up the developing nations to the level of the developed ones would require nearly a 400 % increase in copper production, to the level of 50 million tons per year. Therefore, taking an optimistic view, there is a large potential market for increased metal production.

However, the mineral resources, despite the large sums spent and the great advances in exploration technology, on a **constant ore grade** basis, are constantly dwindling. As a result, the average grade of mined ore has decreased by a factor of two or more since 1950. In consequence, the amount of energy and other costs required to produce a unit of metal have increased, despite the great strides in technology.

In his 1978 TMS/ASM Lecture in Materials and Society, Kellogg[27] pointed out that the threat to global mineral supplies was not their eventual exhaustion but that the cost of recovering metal from progressively lower-grade minerals would become prohibitive. He illustrated this point by means of Figure 9 which shows that the energy consumption, per unit of metal produced, increases logarithmically with decreasing ore grade.

The ores we have mined until this day (middle band, Figure 9) contain discrete grains of valuable minerals which can be recovered by concentration; however, processing of the ores of the future (uppermost band, Figure 9), by means of direct pyrometallurgical or hydrometallurgical treatment, may require ten to one thousand times as much energy per unit of metal. Kellogg aptly called these effects the tyrannies of ore type and ore grade.

Because of this unavoidable trend, the mining and processing of the future ores will be less profitable than today. Yet, the present day mineral industry, with few notable exceptions, apparently can hardly scrape together the funds needed to support industrial and academic research. As a result, most centers of excellence on extractive metallurgy have been shut

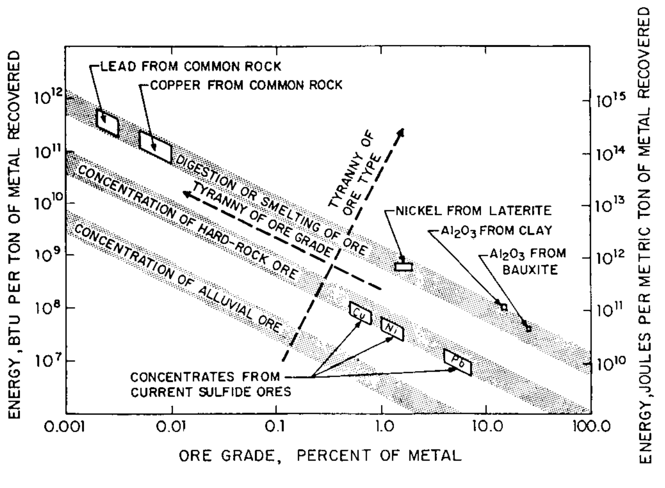


**Fig. 9.** Estimated energy consumption for mining and primary processing of metallic ores (H.H. Kellogg, ref. 27)
**Kuva 9.** Louhinnan ja metallimalmien primääriprosessoinnin arvioitu energiankulutus.

down or changed their names and goals to loftier subjects, such as "advanced materials" or the like.

To look on the optimistic side, since the fifties, the need to conserve energy and to improve environmental control have been two powerful levers for research and development in extractive metallurgy. It is possible that, as the pressures on both of these fronts increase in the decades to come, extractive metallurgy may be nurtured once again to shine as it did in the second half of the twentieth century. The scientific and technological basis is certainly there and, in the foreseeable future, the hunger of mankind for metals will be second only to that for energy sources.

## CONCLUSIONS

The tremendous growth in metal production since 1950, and in the scientific and technological base which supported it, appear to qualify this period as the Golden Age of extractive metallurgy.

If one considers

a) the aspirations of nearly 80 % of humanity for a higher standard of living,

b) the diminishing ore reserves and increasing energy costs per ton of metal,

c) the increasing global need for environmental control,

it would appear that the world's need for education, research and development in metal extraction is greater than ever. However, industrial and government commitment in this area have declined severely during the last decade. The R&D keywords now seem to be "computers, communications, advanced materials". Will the conditions ever be as favorable for extractive metallurgy as they were during its Golden Age of 1950—1980? As the philosopher said: "All is possible in this best of all possible worlds."

## ACKNOWLEDGMENTS
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## YHTEENVETO
## PROSESSIMETALLURGIAN KULTAINEN AIKAKAUSI: 1950—?

Vuorimiesyhdistyksen viisikymmenvuotistaival sattuu suunnilleen tämän vuosisadan toiselle puoliskolle. Joku voi hämmästellä todetessaan ihmiskunnan tuottaneen tänä lyhyenä aikavälinä enemmän metalleja kuin koko sitä edeltäneen historiansa vuosituhansien kuluessa. Tämä saavutus ei olisi ollut mahdollinen ilman radikaalia muutosta niissä menetelmissä, joilla metalleja valmistetaan, so. prosessimetallurgiassa, joka on puhjennut kukkaansa kahdennenkymmenennen vuosisadan toisella puoliskolla. Tämä esitelmä jäljittää kyseisen aikakauden erikoislaatuista kehitystä, joka alkaa intensiivisulatusmenetelmien käyttöönotolla kahdessa pohjoisessa maassa, Suomessa ja Kanadassa. On selvää, että viisikymmenluku merkitsi prosessimetallurgian kulta-ajan alkua, mutta voimme asettaa kysymyksen, onko tämä erinomaisten saavutusten aikakausi lähestymässä päätepistettään.

# Trends of the Automotive Industry in Recycling Technology — Its Challenges and Opportunities for the Base Metals Industry

**Professor Dr.-Ing. Ulrich Seiffert, Board Member of Volkswagen AG, Wolfsburg, Germany**

The Speech Given at the 50th Anniversary Meeting of the Finnish Association of Mining and Metallurgical Engineers by Marina Congress Center in Helsinki on 19th March 1993.

## INTRODUCTION — REQUIREMENTS OF THE AUTOMOBILE

In recent years, the automotive industry has had to face up to processes of great change, which will, in the future, still intensify. The main reasons for this are: the demands on the product, which include the questions of recycling and traffic technology; competitiveness with regard to the vehicle development process; and productivity in the field of production, including associated logistics and customer orientation of marketing, sales and service.

Automobiles now account for more than 80 % of all personal transportation. Their development has become increasingly complex. The largely contradictory demands placed on the automobile are high levels of vehicle safety with low weight; high degree of comfort, low fuel consumption, minimal exhaust and odour emissions, high quality and unchanged transportation performance.

The most important development points today are:
— Safety
— Fuel consumption and emissions
— Environmental protection and recycling
— Alternative drive systems and energy sources
— New vehicle and traffic concepts
— Vehicle electrics/electronics

In the last few years, environmental protection has gained significance in public debate. We can even assume that in sensitive markets the acceptance and thus the commercial success of an automobile is influenced by the environmental compatibility expected of the vehicle.

This does not however mean that we regard environmental protection as purely a marketing function. We conscientiously accept our responsibility for the environment in the interests of quality of life in the future.

This is no new idea at Volkswagen. Plans for coupling the energy and heat from power stations were made and realized as early as 1938.

## ENVIRONMENTAL STEPS IMPLEMENTED IN VOLKSWAGEN PRODUCTS

The manufacture, operation and after-use treatment are discussed under the heading "Environmental Compatibility". The latter will be addressed in detail later.

Environmental steps which have already been implemented <u>in production</u> include:
— Further reduction of power generation emissions
— Water management with separate supplies for utility and drinking water
— Solvent-free cavity conservation since 1979
— Increasing use of water-soluble paints, new paint shops in Emden, Hanover and Wolfsburg.

**Steps taken on the vehicle** include:
— Engines with low fuel consumption and emission levels, especially catalysed Diesel, TDI, engine/gearbox management with increased application of electrics/electronics
— Reduced resistances (drag coefficient, rolling resistance, weight). This has led to a 25 % reduction in fuel consumption in our vehicles in Germany.
— Development of alternative vehicle concepts and drive systems, alternative energy sources (Eco-Golf, Hybrid Golf, E-Golf, Multi-fuel etc.)
— Development of new traffic systems for improved networking of private and public transport, parking information systems
— Use only of CFC-free air conditioners, asbestos-free brake and clutch linings, no use of cadmium.

The third aspect is the treatment of the vehicle **after** use.

## THE VOLKSWAGEN RECYCLING CONCEPT

An offensive recycling strategy, as practised at Volkswagen, demands an optimization of the process of product design > manufacture > utilization > disposal. In this, recyclable construction and material selection are just as necessary as other important criteria like low fuel consumption or vehicle safety.

These influencing factors, together with the following criteria, must be taken into account in the recyclable construction of automobiles:
— Components must be easily dismantled from scrap vehicles and a low cost sorting of materials by type must be possible.
— Recyclability must be taken into account when selecting materials. This will be discussed in more detail in the section: Choice of materials. It is necessary to mark the materials, especially the plastics.
— Critical materials must not be used for the disposal, thermal reprocessing etc. or they must be easily and cheaply separated.
— To guarantee the economic feasibility of utilizing scrap vehicles, it must be considered when, how many and for which components recycled materials (or factory-reconditioned components from scrap vehicles) can be used in the production of new vehicles.

Starting from this framework, the recycling objectives given in Figure 1 are arrived at.

### Legal position

In August 1992 the German Minister for the Environment published a white paper for the "Directive on avoiding, reducing and utilizing waste from vehicle disposal". Thus the legal basis for the future recycling of scrap vehicles in Germany has been made clear and this should be seen as the standard for the development of vehicle in the future. Legislation is planned to ensure:

- For existing cars the rejection process has to be established such that the environment and resources are protected
- New cars must be designed for good recycling
- Recycling of materials
- Techno – economic assessment of recycling processes; establish economic infrastructures for scrapped automobiles

**Fig. 1.** Recycling goals.
**Kuva 1.** Kierrätyksen tavoitteet.

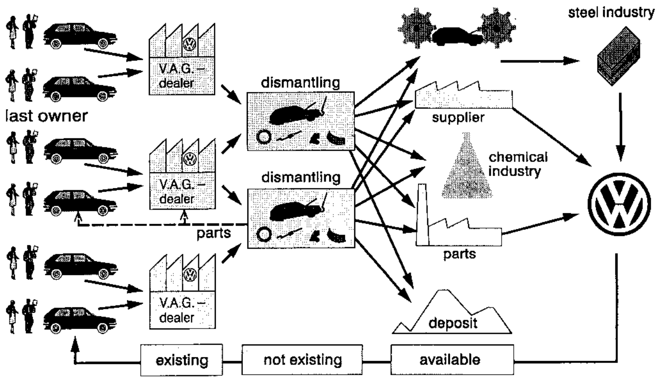


**Fig. 2.** Future recycling periphery.
**Kuva 2.** Kierrätyksen tuleva vaikutuspiiri.

— Vehicles have to be developed, constructed and produced so that they have maximal life expectancy, can be easily dismantled and the components, so far as it is technically feasible, can be reused or materially reprocessed.
— The materials used must make material reprocessing easier, have a uniform identification system and be environmentally disposable.
— The directive applies to vehicles and to replacement and exchange parts and accessories.
— Manufacturers must accept vehicles back from the last owner.
— Manufacturers must therefore establish a vehicle return mechanism for their respective products. "Other utilizers" are still permitted.
— Return of vehicle must be free of charge for the last owner, except in the following cases: the disposal of the vehicle is made difficult through the addition of foreign materials and parts; the vehicle has been involved in an accident, making dismantling technically impossible; the vehicle came onto the market before the directive became law, and the costs of reprocessing exceed the gains from material reprocessing.
— Manufacturers must, so fas as it is technically possible, subject returned scrap vehicles to reconditioning or material reprocessing. All operating materials and other parts which hinder recycling are to be removed. Components whose materials can be utilized must be dismantled.
— The directive contains quotas as percentage-by-weight for all recycled materials.
— Manufacturers must document their reprocessed material.
— The last owner must return the scrap vehicle to the manufacturer in such a condition that it can be environmentally disposed of.
— Manufacturers may employ third parties to carry out these commitments.

The automotive industry assumes they will be able to establish reprocessing plants themselves, i.e. reprocessing plants will be created for a particular vehicle manufacturer, and will then be supported accordingly. Furthermore, guarantees must be found that scrap vehicles can also be returned at the appropriate places. Voluntary activities on this basis are also feasible without legal directive.

For Volkswagen this means a future recycling strategy, as illustrated in Figure 2.

## Steps taken by Volkswagen

In order to test the concepts described, Volkswagen, together with their dealers, ran a pilot project on the utilization of scrap vehicles. Volkswagen was the first automobile manufacturer to undertake such a project. The basic objective of the pilot project was to develop methods of reprocessing materials and vehicle fluids by type. The economic feasibility of the material circuits to be installed depends on this. This study into dismantling vehicles led directly to the take-back guarantee given in Germany since September 1991 for all third generation Golf vehicles. This was possible because material expertise was available from the project, and initial constructional details could be considered into the vehicle during development.

Furthermore, during the pilot project various material circuits were established for plastics. Recycled material from scrap bumpers has been used since May 1991 in manufacturing new bumpers for the VW Polo. This was extended in July 1992 to include the VW Golf. This made Volkswagen the first automobile manufacturer to succeed in using old plastics in the same components from which they were obtained.

Further parts made from recycled material are wheel housing liners, V-belt covers, battery covers (e.g. AUDI 80, introduced in 1990, the first production component anywhere in the world made from material obtained from scrap vehicles), and of course noise-damping mats.

The pilot project was concluded at the beginning of April 1992. The knowledge gained from the project gave rise to the world's first semi-automatic industrial disassembly plant for scrap vehicles. This plant is sill being run independently by the industrial materials specialists Heeren. The Volkswagen Group Research Division also has a disassembly and recycling centre at the same location, where all Group vehicles, VOLKSWAGEN, AUDI, SEAT, and SKODA are examined regarding the necessary dismantling techniques and possible weak points concerned with this (Figure 3).

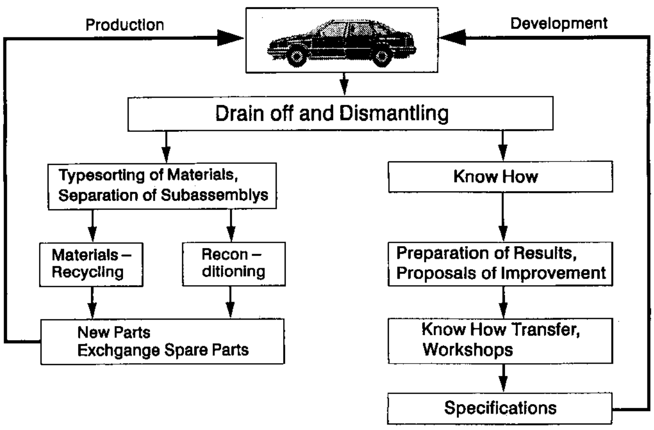


**Fig. 3.** Results of car dismantling at VW Research Recycling and Dismantling Centre.
**Kuva 3.** Autojen purkauksen selvitys ja tutkimuskohteita VW:n tutkimuskeskuksessa.

This guarantees that in the future all vehicles of the Volkswagen Group will not only be examined in the conventional test cycles, which has been the practice up until now, but will also be examined for their recyclability. The relevant disassembly handbooks will also be available shortly.

Volkswagen is also involved in the work of Project Group of the German Automotive Industry for Scrap Vehicle Recycling (also known as PRAVDA from the German acronym). The first recycling plants were licenced by the automobile manufacturers in the course of this work. In this way it is possible to gather expertise in both conventionally operating companies and in semi-automatic large-scale companies. Individual companies are supported through the respective disassembly handbooks, from which material, weight and approximate disassembly time of the assembly groups which can be sensibly dismantled can be taken. The materials obtained are passed on to the raw materials industry as test material.

The individual work steps for recycling the materials illustrated in Figure 4 are shown in Figures 5 and 6.

The ultimate objective of this is to obtain large quantities of material of a single type. Apart from when removing aggregates (these have been reconditioned at Volkswagen since 1948), some parts are destructive dismantled on removal for increased economy. Disassembly is thus not simply assembly in reverse.

**Nonferrous Metals**

**Aluminium**
The aluminium from engine, transmission and motorized devices is recovered up to 90 percent

**Copper**
The copper from electrical systems and cable harnesses is recovered to more than 90 percent

**Platinum/Rhodium**
Platinum and rhodium are two of the Earth most valuable noble metals. Each catalytic contains 1,5 to 2 g platinum and 0,3 to 0,5 g rhodium. Recovery of these valuable metals begins with the separation of the monoliths from the metal housings.

**Iron and Steel**

The recycling of the car-body is effected in a two-stage shredder operation. The steel pellets so recovered have a purity of more than 99.4 percent iron. They are a high-grade starting material, and are used in the steel industry as scrap for cooling.

**Plastics**

Today's cars contain 10 percent plastics on the average. In cooperation with the chemical and plastics processing industries, plastics recycling processes have been involved.

**Fig. 4.** Recycling: nonferrous metals, iron and steel, plastics.
**Kuva 4.** Kierrätys: ei-rautametallit, rauta ja teräs, muovit.

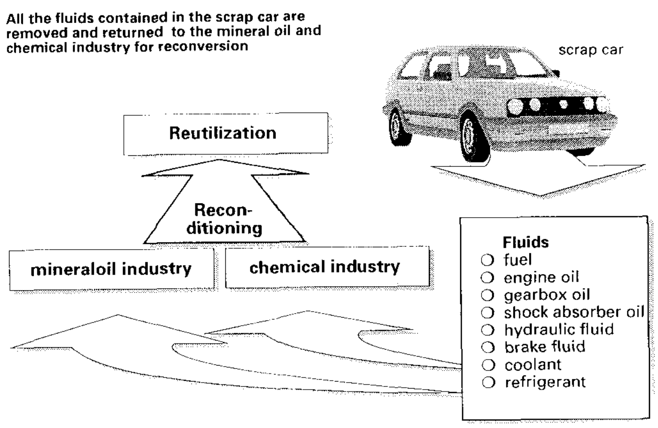


**Fig. 5.** The draining process.
**Kuva 5.** Nesteiden poisto.

**Systematic disassembly of the vehicle makes possible:**
❍ **recycling and reconditioning of drive units**
❍ **separation of materials by types**
❍ **original recycling**

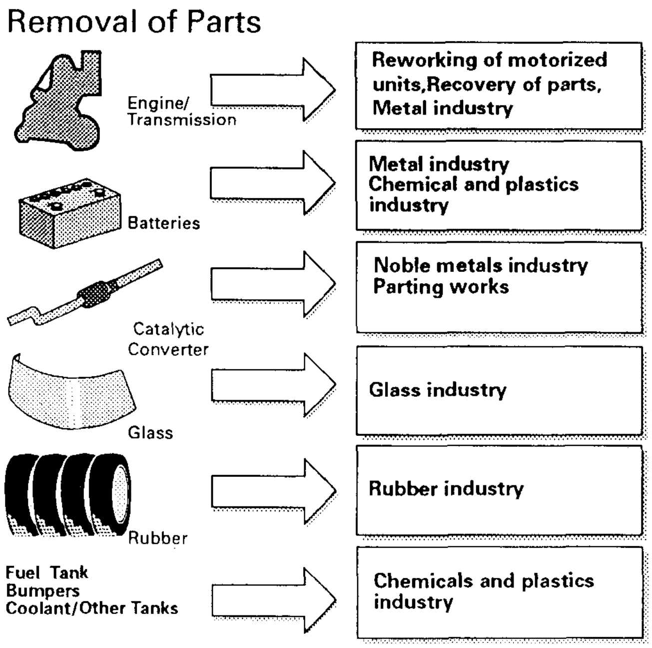


**Fig. 6.** Scrap car disassembly and re-use.
**Kuva 6.** Romutettavien autojen purku ja uudelleenkäyttö.

## CHOICE OF MATERIALS

The weight proportions of the materials used in the current Golf are compared in Figure 7 to the two previous Golf generations.

With regard to the recyclability, the following consequences and prognoses are arrived at:

Steel and other metals can already be recycled easily. In the new construction, the selection of non-metallic materials also to be made to make recycling to original quality possible.

Materials which can be easily recycled to a high quality, such as polypropylene, will in future replace other plastics which are not so recyclable. Other points of consideration in the selection of plastics for new vehicles in the future are:

— Thermo-plastics are preferable to duro-plastics.

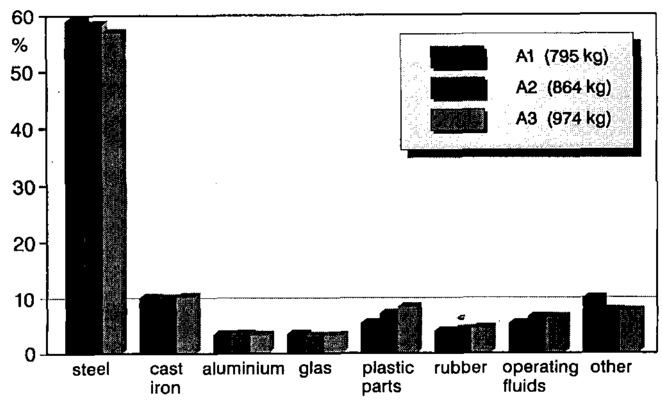


**Fig. 7.** Materials in the VW Golf CL.
**Kuva 7.** Materiaalien painosuhteiden vertailu VW:n kahdessa aikaisemmassa ja nykyisessä mallissa.

— Use of PP, PE, ABS/ASA, PA, PMMA, PPE, and PS preferred.
— Exotic thermo-plastics (e.g. PC blends etc.) must be avoided. (Quantities insufficient for economical processing).
— Long-fibre reinforced components only have to be used if they give significant functional advantages, as recycling to original quality is only possible to a degree of 20 % and secondary applications are very limited.

Aluminium will gain significance as light-weight material for construction due to the ease, efficiency and extreme economy with which it can be recycled. The same also applies to other expensive materials, such as titanium, which ease light-weight construction and can later be recycled at low cost to the same quality.

The above priciples were applied when selecting materials for the new Golf III. In the recycling classification of the plastic parts of the new Golf III it is clear the majority of the components can be reprocessed to a very high quality. A bumper can be made into a new bumper; a tank into a new tank. This has been achieved by adjusting the proportions of plastics in favour of more easily recyclable types. Thus the proportion of polypropylene in the total plastic content has been increased from some 20 % to almost 45 %.

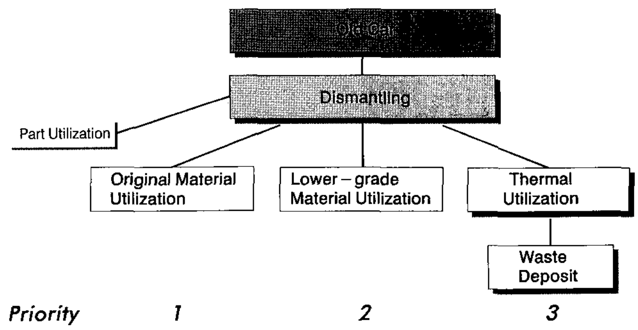


**Fig. 8.** Recycling procedure.
**Kuva 8.** Kierrätysprosessi.

## SUMMARY AND PROSPECTS

In the future, recycling will only be practised if it can be proven to be economical, and even then it is only sensible if waste is really avoided and resources maintained. The latter is also the reason for it being more sensible to build cars to the highest possible technical level from old materials than to leave old vehicles on the roads indefinitely (so-called "long-life vehicles"). Such a car would certainly consume more fuel than newer vehicles because, for example, its fuel injection system would not be as technically refined. The same would apply to emissions. Thus nothing would have been done to protect the environment.

The ultimate objective (Figure 8) in materials recycling in the Volkswagen Group is the re-use of materials from scrap vehicles, whereby the aim is to obtain materials of the highest possible quality. The materials should, when it is sensible to do so, be re-used in the same components from which they were obtained. If this is not possible, alternative applications must be sought.

Another quick glance at relevant legislation is needed here: in a market economy, legislation provides the framework for balancing the special (even egocentric) interests of the individual and the interests of the community. In order to guide the economy towards prosperity while simultaneously guaranteeing ecological compatibility, suitable laws are needed which do not hinder technical progress, but even reward the use of technically advanced vehicles, i.e. appropriate tax legislation. For the automobile manufacturer, who operates all around the world, it is particularly important to have clear and predictable regulations.

We believe, that an environmentally compatible vehicle is only possible through interacting development, production and recycling/disposal in a process of simultaneous engineering within the framework of appropriate legislation.

## YHTEENVETO

## AUTOTEOLLISUUDEN TRENDIT KIERRÄTYSTEKNOLOGIASSA — HAASTEITA JA MAHDOLLISUUKSIA PERUSMETALLITEOLLISUUDELLE

Käsitellään autoteollisuudelle nykyisin asetettavia mm. energiataloudellisia ja ympäristönsuojelullisia vaatimuksia sekä etenkin käytöstä poistuvien ajoneuvojen purkausta ja niiden materiaalien kierrätystä. On optimoitava koko prosessiketju tuotteen suunnittelusta ja valmistuksesta käyttöön ja käytöstä poistoon. Kierrätysmyötäinen tuotesuunnittelu ja materiaalien valinta ovat yhtä tärkeitä kuin pieni polttoaineenkulutus ja ajoturvallisuus. Romutettavien autojen materiaalien kierrätyksestä on Saksassa säädetty maan ympäristöministeriön antamalla ohjeistolla v. 1992. Sen on katsottava muodostavan pohjan laajalle tulevalle lainsäädännölle. Volkswagen AG on ensimmäisenä autonvalmistajana aloittanut pilot-projektin autojen purkauksesta ja romutuksesta tavoitteena kehittää menetelmiä kiinteiden materiaalien ja nesteiden uudelleenprosessointiin. Tämä tutkimus johti kolmannen polven Golf-autojen takaisinottotakuuseen. Teräs ja muut metallit ovat helposti kierrätettäviä. Muovien kierrätettävyyteen on VW:llä pantu paljon huomiota: uusiomuovia käytetään samoihin komponentteihin, joista se on saatu. Autoteollisuuden piirissä kaivataan kansainvälisesti mahdollisimman yhtenäistä ja kehitysmyönteistä lainsäädäntöpohjaa kierrätysvelvoitteille.

# Outokumpu's Mining Strategy

**DI Juhani Tanila, Managing Director of Outokumpu Mining Oy, Espoo, Finland**

An abridgement and translation of the speech given at the 50th Anniversary Meeting of the Finnish Association of Mining and Metallurgical Engineers in Helsinki on 19 March 1993

## INTRODUCTION

Here, as when charting visions for the future in general, it is worthwhile considering the recent past. As this occasion marks the 50th anniversary of the Finnish Association of Mining and Metallurgical Engineers, 50 years seems a suitable time frame.

## HISTORY

The roots of Outokumpu Oy's mining operations lie deep below the present-day city of Outokumpu. The mining tradition there is older even than that of the Finnish Association of Mining and Metallurgical Engineers. It has enabled Outokumpu to build diverse activities in Finland and abroad. The growth and increasing versatility of the mining industry itself has been a part of this development.

The path of development has been winding, but with hindsight it looks logical, as though it had been planned. Its main target areas can be characterized, decade by decade, as follows:

**1940s** = war and war reparations

Production was maximized using all possible means. However, it was necessary to resort to old equipment and methods.

**1950s** = exploration and expansion

New mines were constructed and new mineral deposits were discovered. Faith in the continuity of the industry was strengthened.

**1960s** = technology breakthrough

Equipment and automation systems were devised and developed. Excelling in these fields gave us world class stature. Selfconfidence in our own expertise was born.

**1970s** = productivity and profitability

The significance of continuous rationalization and optimization of operations was evident in the mines' balance sheets.

**1980s** = internationalization

Offered the opportunity to apply elsewhere what had been learned in Finland. At the same time, it offered plenty for us to learn.

Over these decades, Outokumpu's mining tradition has thus developed into technically and economically competitive expertise. In conjunction with countless projects in Finland, we have developed exploration, mining technology and process technology methods and equipment to their current high level. While outside technology has not been shunned, most of the development work has been homegrown. In addition to technology, economic thinking has also become a part of the working routines at every level of the organization.

The generations of miners who have participated in this evolution have themselves adopted the basic prerequisites of competitiveness in modern mining, i.e. technical expertise and profit-oriented management.

This human resource has been Outokumpu's most important success factor, particularly in the company's internationalization, as the depletion of ore reserves in Finland forced it to broaden the base of its mining operations.

The history I have related here includes an explanation of the high-level competence which provides us with the faith to plan future operations.

## STRATEGIC STARTING POINTS

The strategic starting points for international mining operations are decisively more favorable now than they were a decade ago.

I have already touched on the most important prerequisite, human resources. It is self-evident that the last decade in particular has created the readiness for international operations. In addition, traditional technical and financial competence has increased continuously.

An entirely new starting point is at our disposal in the form of our corporate structure and organization. By this I mean our subsidiaries, which operate in nine countries, and the support they offer us in these areas.

The third important starting point is found in Outokumpu's ore reserves abroad, which have grown extremely well as a result of the efforts of recent years. This growth is based on both mineral exploration and the acquisition of mineral deposits. Proven nickel, copper and zinc reserves owned by Outokumpu totalled 550 million tonnes as of December 31, 1992. As a point of comparison, I would like to remind you that the sum total of all the ore ever excavated by Outokumpu in Finland is less than 200 million tonnes.

Thus far, international mining operations have aimed strictly at securing the raw material requirements of Outokumpu's metallurgical plants. Now this goal has been reached. Freedom from raw material dependency offers us new possibilities to target operations geographically and with an emphasis on several metals.

## MINING AS A BUSINESS

Mining is a business just as is metals production. This is also the case within the Outokumpu Group. Indeed, the risks inherent in mining are greater, but just as much positive as they are negative. However, from a business point of view mining has special characteristics which are worth considering before starting to make strategic conclusions.

Mining makes a significant contribution to the value-added in metals. In zinc it is about half, in nickel some 70 percent and in copper as much as 75—80 percent. The greater this share is, the greater the impact of internal measures, in other words competence.

Nowadays the life of a mine is shorter, generally under 20 years. Throughout that time, operations are under constant construction. This renewal of a mine means that the above-mentioned possibility to make an impact is multiplied.

Thus, the high degree of value-added and rapid modernization of fixed capital offer plenty of scope for technical expertise and the adding of value based on that, especially in mining operations.

It is still worth noting that the majority of the world's mines are not in particularly skillful hands. Furthermore, the desire to develop them is often lacking. While we are accustomed to trimming the operations of a mine for its entire lifetime, this is the exception elsewhere.

The concentrates produced by a mine are not always easy to market. For the most difficult concentrate even the best mining expertise proves insufficient. Help can be found from marketing specialists or especially from metallurgical expertise along the refining chain. For a group active in versatile metallurgy, there may be a ready solution available.

Arranging financing for mining projects is a field of expertise in its own right. Finance may also be supported by the Group's other operations. In addition to standard financing packages, financing against concentrate purchases or equipment deliveries, for example, is very suitable for a versatile group which encompasses these businesses.

Rapid changes in the world economy have taught mining companies to take advantage of metal trading and foreign currency exchange in marketing their production. Stakeholdings in mines and mining projects are also world commodities. Various option systems and pre-emptive rights bring a casino feeling to the mining business, but that too can be learned.

These examples depict the multifaceted competence required in international mining and the opportunities it offers. The business areas in question would feel very fitting for a group of Outokumpu's calibre, whose synergies are clear and for whom versatility is a hallmark.

I can confirm that interest in this business and our capabilities have been recognized, and that international mining operations will in any case remain an integral part of Outokumpu's operations. Unfortunately, it is too early to elaborate further on the long-term arrangements for our activities. Especially from the financing point of view, the current tranquil and expectant economic situation demands a little waiting.

However, I dare put forth some dinstinct strategic directions for your consideration.

## MINING'S STRATEGIC DIRECTIONS

Traditional technical know-how will be used as a general tool in mining projects. In all important subordinate areas we will strive to raise our expertise to a level of supremacy. In our own mines, this tool is at our unlimited disposal. But in big projects the scale of financing and risks may force us to be content with partial ownership. Even in that case we will seek to ensure that we have sufficient influence.

Mineral reserves will be increased further. There will be no delay in exploiting these mineral reserves. Depending on our own needs, stakeholdings in mines and mineral deposits will also be sold. Base metals still remain our main target, but the glitter of precious metals will not be systematically ignored.

Geographically, our targets are already visible. Operations in many of our present target countries are only just starting up, nor is it wise to spread our resources too thin. Nonetheless, developments in other mineral-rich countries will also be monitored.

Despite its internationalization, Outokumpu is always ready to open new mines in Finland should the opportunity arise. The best guarantee of preserving this readiness lies in our own active and renewable mining operations — wherever they might be located.

For understandable reasons, operations will be steered by the scarcity of capital in the next few years. This means smaller investment targets, joint venture projetcts and the sale of less important units or their parts in order to finance new investments.

In other words, we will have to add value through innovative work rather than by investing large sums of money for a long period of time. The focus of attention will more frequently be exploration and project development instead of acquisition of ore deposits or mines. We can even consider getting an operating mine into efficient shape, as a turnaround project.

As the commitment of capital will be minimized, the input of human resources will be maximized. I believe that this emphasis suits all involved and will prove a good guiding principle over the long term for a Finnish mining company which is poor but capable and eager to grow.

## MINING SKILLS ARE IN DEMAND

Outokumpu's mining operations are always Finnish mining operations, even though the site may be far away. As I asserted earlier, there is sufficient readiness and a clear penchant for large-scale operations in Finland. But if there are no mineral reserves to be found, then they must be found elsewhere in order to secure the future of this industry.

Finnish mining engineer's expertise has been needed and will still be required in Outokumpu's internationalizing mining operations. This can best be illustrated by the fact that 70 percent of this competence still has Finnish roots, even though only 35 percent of all those employed in mining are Finnish.

Both of the percentages I just quoted are changing swiftly. Competent experts in this field can be found in every country. This growing potential pool of expertise signifies a richness we have to be able to harness regardless of language problems, cultural differences and the bureaucracy of work permits. In practice, it is only possible through traditional assignment rotations, which now more than ever imply crossing national boundaries.

Those currently studying in this field and those who will do so in the future must thus be prepared to work in environments where their colleagues are not Finns or even citizens of the country in which they are stationed. Even so, we must ensure that everyone understands Outokumpu's expertise as to what has been learned in Finland so far.

In this sense, the planned internationalization of the Helsinki University of Technology's mining engineering curriculum is welcome. The University's motive is to secure the continuation of teaching with the help of a broader student body. Hopefully this will also come to mean that Finnish technology and international adaptation will be studied simultaneously. This would better prepare future generations for Outokumpu's "international rotating school".

Outokumpu has built its expertise in mining technology above all with the help of the Helsinki University of Technology's many-sided education and will continue to rely on it. The above-mentioned applies just as well to other schools, even though our contact with them is narrower.

## CONCLUSION

I apologize that Outokumpu's mining strategy in this changing situation is still partly in the draft stage. At this point in time it may even be good that our level of amibition and concrete targets are not dimensioned just now. I have, however, tried to describe the more fundamental elements of our strategy. At the same time, I hope I have succeeded in adding some faith in the new possibilities we face in our mining activities.

## YHTEENVETO

## OUTOKUMMUN KAIVOSTOIMINNAN STRATEGIA

Outokummun kaivotoiminnan perusta on luotu Suomessa viimeisten 50 vuoden aikana. Vaikka perinne on vanhempi, on tämä aika ollut merkityksellisin modernin teknologian kehittymiselle. Mukana olleet vuorimiespolvet ovat omaksuneet nykyaikaisen kaivostoiminnan kilpailukyvyn perusedellytykset, teknillisen osaamisen ja tuloshakuisen johtamisen.

Malmivarojen ehtyminen Suomessa on pakottanut Outokummun etsimään laajempaa pohjaa kaivostoiminnalle. Edellä mainittu henkinen resurssi on ollut tärkein menestystekijä kansainvälistymisessäkin.

Tähänastinen toiminta ulkomailla on kohdistunut tiukasti Outokummun metallurgisten tehtaiden raaka-ainehuollon turvaamiseen. Tämä tavoite on nyt saavutettu. Samalla on kasvatettu malmireservejä sekä tunnettujen malmivarojen että lupaavien tulevaisuuden löydösten muodossa.

Konsernin tarjoamat synergiaedut, käytettävissä olevat henkiset resurssit, raaka-ainesidonnaisuudesta vapautuminen, lupaavat malmireservit, hankittu ulkomaankokemus ja monessa maassa jo toimivat tytäryhtiöt antavat nyt uuden mielenkiintoisen lähtökohdan Outokummun kaivostoiminnan strategialle.

Kaivostoiminta on liiketoimintaa siinä kuin metallien valmistuskin. Kaivostoiminnan riskit ovat suurempia, mutta yhtä hyvin positiivisia kuin negatiivisia. Kaivosten rakentamiseen liittyvä teknillinen haaste tarjoaa toistuvia mahdollisuuksia osaamiseen perustuvalle lisäarvon tekemiselle. Väheksyttävä ei myöskään ole kaivosten tuotannosta tuleva kassavirta ja itse tuoteen strateginen arvo varsinkin suotuisissa konjunktuurivaiheissa.

Ymmärrettävistä syistä on toimintaa lähivuosina ohjattava pääomaniukkuuden ehdoilla. Se merkitsee pienempiä investointikohteita, joint venture -projekteja, strategisesti vähemmän tärkeiden yksiköiden myyntiä uusien investointien rahoittamiseksi jne. Samalla kun pääoman sitoutumista minimoidaan, tullaan henkisten resurssien panosta kaivosprojekteissa maksimoimaan.

Kaivostoiminnan kehittämisessä pääpaino säilyy edelleen perusmetalleissa. Maantieteellisesti tärkeissä kohdemaissa liehuu jo Outokummun lippu. Kehitystä muissa mineraalirikkaissa maissa seurataan. Kansainvälistymisestään huolimatta Outokumpu on aina valmis käynnistämään uusia kaivoksia myös Suomessa tilaisuuden tullen. Tämänkin valmiuden säilyttämisen paras tae on aktiivinen ja uudistuva kaivostoiminta — missä tahansa.

Outokumpulainen kaivostoiminta on aina suomalaista kaivostoimintaa, vaikka kohde olisikin muualla. Tämä kannattaa alalla opiskelevien ja opiskelemaan tulevien pitää mielessä. Teknillisen korkeakoulun suunnittelema vuoritekniikan opetuksen kansainvälistäminen on tervetullut siirto sekä opetuksen soveltuvuuden että sen jatkuvuuden varmistamiseksi. Outokumpu on rakentanut teknillisen osaamisensa TKK:n peruskoulutuksen varaan ja tulee luottamaan siihen vastakin.

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**VUORIMIESYHDISTYS — BERGMANNAFÖRENINGEN r.y:n**

**VUOSIKOKOUS**

pidetään Helsingissä 25.—26.3.1994

Kokouksesta ilmoitetaan tarkemmin myöhemmin postitettavassa kutsussa.

**VUORIMIESYHDISTYS — BERGMANNAFÖRENINGEN r.y:s**

**ÅRSMÖTE**

hålls i Helsingfors den 25.—26.3.1994

Närmare uppgifter meddelas i inbjudan som postas vid en senare tidpunkt.

# Milestones in Finnish Ore Dressing Technology

**By Professor emeritus Toimi Lukkarinen**

This article* primarily reviews the most important developments — the milestones — in the evolution of Finnish ore dressing practice. The secondary purpose is to try to relate these developments to the common knowledge and practice of the time.

In most cases, the Finnish ore deposits available for processing have been small and low grade. The few big deposits located have seldom proved rich but almost always risky; furthermore there were no really comparable ores worked in other countries to serve as models. Innovation has thus been a necessity as much as a virtue.

## EARLY CONCENTRATORS

### Orijärvi

The complex sulphide Orijärvi ore was discovered in 1757[1]. Exploitation started immediately and lasted, discontinuously, until 1954, when stoping ceased. Two years later the mine was allowed to flood.

At first the ore was concentrated by hand-picking which, together with washing in launders, was the only method available at that time. In 1911, the newly establised Finnish American Mining Company installed a concentrator (Fig. 1) and after that only sphalerite was hand sorted, the galena and chalcopyrite being concentrated by shaking tables. Soon after, in 1912, Orijärvi tested the new flotation method, using wood-tar as a reagent. Although the trial was not a success, it was — as one of the first attempts at flotation in Europe — a messenger for this new technology. (Ahead of Orijärvi was the Russian Dzanzul copper concentrator, owned by the Caucasus Copper Co.[2], which tried flotation in 1910 with similar results.) Some years later flotation was tested again at Orijärvi but the method was only finally adopted by the mine in 1932. Meanwhile, the company which erected this first milestone had been declared bankrupt in 1912.

### Outokumpu

The old concentrator at the Outokumpu Mine (Fig. 2) was erected in 1928 and the flotation route adopted simultaneously. Five years later, the last shaking tables — used for iron sulphides — were finally taken out. As a collector, the mine used xanthate, for which the primary patent had been granted in 1925[3]. The flotation machines included both Minerals-Separation (Fig. 3) and MacIntosh cells[4]. Later on, Forrester cells were also adopted and some of them were also used in the Keretti plant until 1967[5] (Fig. 4).

Some difficulties were experienced with the flotation process in the old concentrator, but that is hardly surprising given the fact that the method was then based purely on practical knowledge. Indeed, operating problems were rather common in flotation circuits everywhere. Identification of the theoretical principles involved only started with the research results published by the Australians Wark and Cox[6]. The studies by Gaudin[7] and Taggart et al[8] threw further light on the mysteries of flotation.

Dr. Mäkinen, the President of Outokumpu Oy, called in consulting engineers from Noranda Mines and the Canadian company dispatched Messrs McLachlan and Ames to Finland. As a result of their visit, the selective flotation system was adopted with the ore floated in the order copper, zinc and sulphur[4]. Later on, during World War II, Outokumpu used home-made xanthate "cooked" on the concentrator hill. Mr McLachlan refreshed his memories of Outokumpu in 1959.

**Fig. 1.** Orijärvi concentrator in 1956.
**Kuva 1.** Orijärven rikastamo 1956.

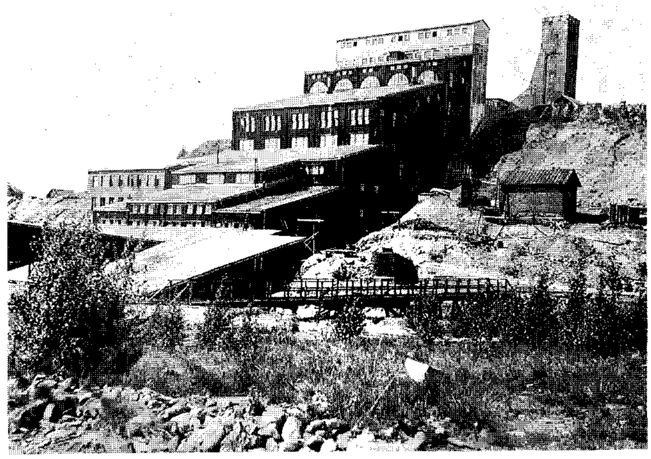

**Fig. 2.** Outokumpu concentrator in 1938.
**Kuva 2.** Outokummun rikastamo 1938.

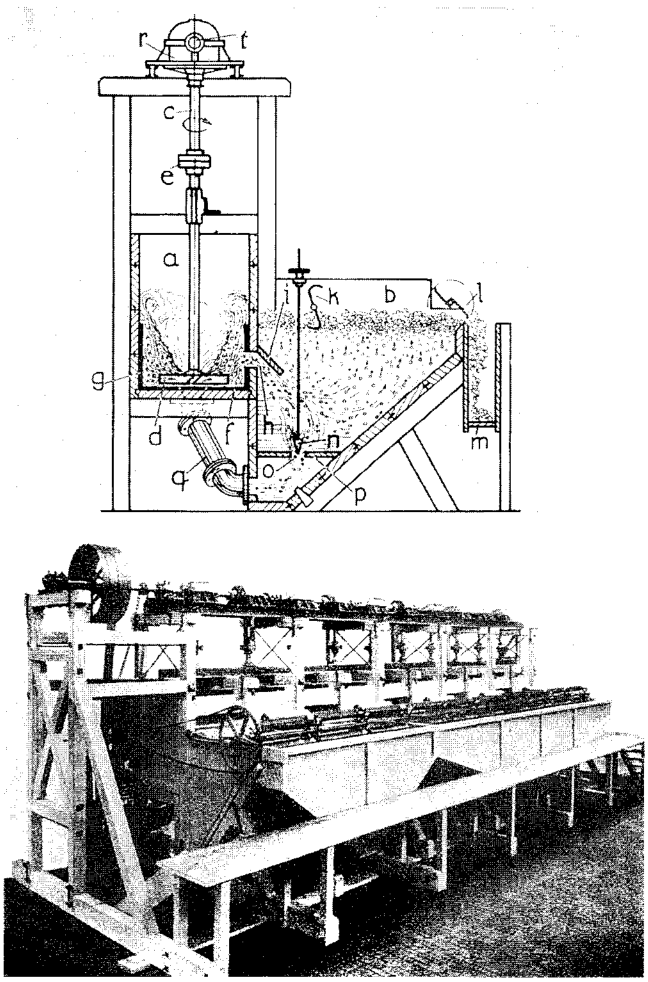


**Fig. 3.** Minerals Separation flotation machine.
**Kuva 3.** Minerals Separation vaahdotuskone.

## TEACHING ORE DRESSING

Once the teaching of mining and metallurgy started at The Helsinki University of Technology in the autumn of 1937, the institution was faced with a continuing shortage of competent teachers. The Outokumpu Oy Foundation promised to pay for some engineers to make a study tour of America for three years.

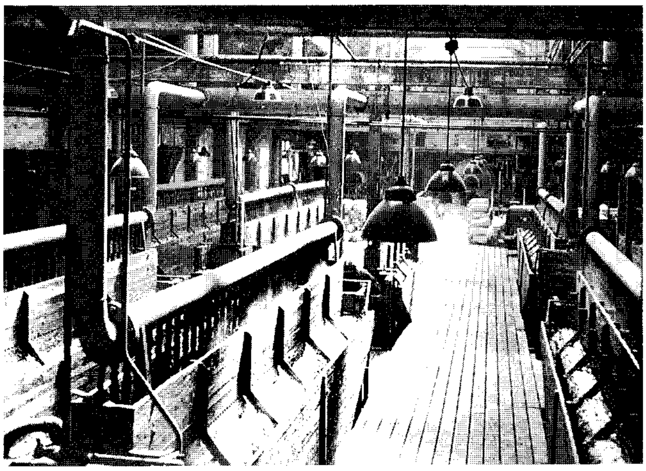

**Fig. 4.** Forrester flotation machine.
**Kuva 4.** Forrester vaahdotuskone.

One of the engineers involved was Risto Hukki. As a result of the World War his trip extended to six years, but the experience and vision he gained were also expanded. During a professional teaching career spanning 1945 to 1977, Hukki educated 32 age classes of engineers in the secrecies of mineral processing. He also passed on his ideas concerning modern technology to the mining industry in Finland[9] — during the war our country had been in total technical isolation, without for instance the American mining magazines.

## GRINDING

Outokumpu ore was found to be hard and abrasive. It contained approximately 11 % chalcopyrite, 1,5 % sphalerite and 46 % iron sulphides. Total silicates content was over 41 % and the amount of quartz was about 38 %[10].

In the old concentrator only ball mills were used and ball consumption averaged about 2.5 kg per ore ton. The educational work of Professor Hukki, together with the articles of Tennessee Copper Co. mill superintendent Jack Meyers[11,12] led to the introduction of rod mills in our concentrators.

As early as 1951, the mill superintendent of the Outokumpu concentrator, Mr Heikkinen, decided to test ore pebbles as a grinding medium for secondary grinding instead of balls. Primary testing was carried out on a small scale and the final switchover was made at the Keretti plant in 1955[13]. The rod mills were then replaced by lump mills in 1963. The results of this pioneer work were enjoyed in the company's other mills either totally or as a rod-pebble grinding system.

This milestone erected by Heikkinen, together with his assistant Mr Lehtonen, is in no way diminished by the fact that Bunting S. Crocker simultaneously introduced the same technology at the Lake Shore concentrator in Canada[14].

## CLASSIFIERS

In connection with the planning of Kotalahti's nickel concentrator, a home-made hydrocyclone was tested as an alternative to the rake classifier in a ball mill circuit at the Aijala concentrator in 1957—58. The cyclone was installed over the rake classifier and, to avoid any possible harmful effects, both the sand and overflow were passed to the rake classifier during the initial tests. Later on, the rake classifier was replaced by the cyclone. On the basis of the test results obtained, Mr Erkki Koskela developed his formulae for the calculation of a wet cyclone classifier[15]. It is a pity that Koskela's method is rather unknown to younger engineers.

When Kotalahti Mine started up in fall 1959, the home-made hydrocyclones calculated by Koskela were the only classifiers installed[16] even though the plant had been visited by numerous sceptics during the installation work. It is an established fact that Dorrclones were already in use, for instance in US taconite concentrators.

## BMU

Professor Hukki developed the so-called Base-Mill concept for measuring as well as for comparing tumbling mills[17]. He presumed that the tumbling mill capacity is proportional to the power$^{2.5}$ of the mill diameter as well as to the mill length. Since the Base-Mill itself is defined as a mill with diameter and length both of one metre, the number of Base-Mill Units (BMUs) in a given mill can be calculated from the formula:

BMU = $D^{2.5}$ x L, where
D = mill diameter, inside the lining, in metres, and
L = mill length, inside the lining, in metres.
This simple method for mill calculations has remained too little known.

## FLOTATION

### Kotalahti

Kotalahti ore was found to contain approximately 2.5 % pentlandite, 1 % chalcopyrite, 8 % pyrrhotite and various silicates. From the metallurgical point of view it was necessary to separate the chalcopyrite from pentlandite, creating two concentrates. This proved difficult in early testwork. However, it was observed that nickel recovery was a little lower in those rougher flotation tests where dextrin was used as a slime depressant than in those where it was not. This gave rise to the idea of testing dextrin in the copper-nickel separation.

The first such separation test was intended to be carried out in a limealkaline pulp of pH about 12 and the conditioning time with dextrin was to be 15 minutes. However, not long after the test got underway the operator was called to the telephone and forgot the flotation for an hour. Thus the beneficial effect of a long conditioning period was discovered, for the results of this test were excellent. In a few hours the Head Office of the company also knew that copper-nickel separation was feasible. These first results were confirmed by a test series but the main problem was nevertheless solved by accident[18].

Inco adopted the same process at the new Thompson Lake concentrator in 1960, as a result of a visit by Inco's President Roy S Gordon to Kotalahti in 1959. This separation technique was different from the company's conventional cyanide method[19]. Thirty years later, writing in the fall of 1992, Professor J Laskowski from the University of British Columbia again found this dextrin method interesting.

### Copper slag

Slag refining by flotation, as practiced at the Harjavalta Works, is also an interesting method from a wider point of view[20], while Inco uses flotation in the separation of nickel from copper matte[21].

In addition to metallic copper, the slag contains the valuable minerals (Fig. 5) chalcopyrite, $CuFeS_2$; chalcocite, $Cu_2S$; digenite, $Cu_9S_5$, and bornite, $Cu_2S.CuSFeS$. The prerequisite for the refining process to be successful is a so slow cooling of the slag that the sulphide minerals have time to grow large enough for flotation. This is also the case with the Inco matte treatment. In spite of the slow cooling, a fine grind is necessary to deliver at least 98 % under 270 mesh (53 micron). Other prerequisites are a large amount of collector and a rather long flotation time. Whereas copper recovery achieved by electrorefining was about 77 %, flotation recovers 94–95 %. And, while the electric process used about 90 kWh energy per slag ton, flotation needs only about 60 kWh per ton.

In connection with slag flotation, we had the opportunity to repay Noranda Mines whose metallurgists wanted an explanation of the bad results they were experiencing with slag flotation. Their information showed very clearly that they had made exactly the same mistakes that we had made at first, so we kindly recommended they follow our experience.

### Hitura

We have succeeded in developing a suitable flotation process for normal sulphide ores. There exists, however, one splendid exception to this rule: Hitura's nickel ore. In addition to pentlandite and chalcopyrite the ore contains maccinawite, (Fe,Ni)S; violarite, $(Ni,Fe)_3S_4$; and vallerite, $CuFe_2S_3.2Mg(OH)_2.4.H_2O$, which is very difficult to float[22]. The milestone of Hitura lies deep in the surrounding esker sand.

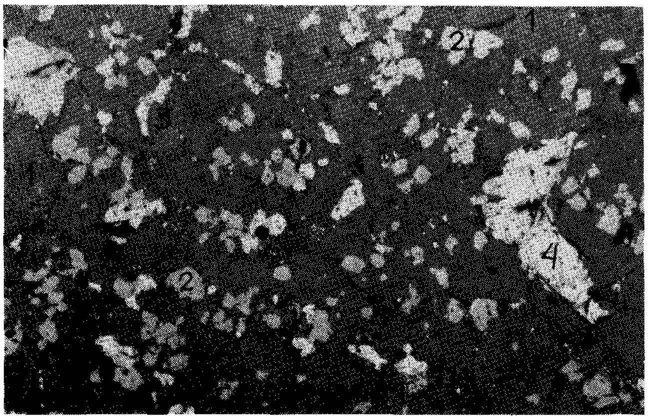


**Fig. 5.** Slowly cooled flash furnace slag. The basic material consists of gray coarse-grained fayalite (1) with light ferrite as intergrowths (2) and often lined by tearsheaped concealed glass material (3). Big, deformed, light-gray grains are solid solution of bornite-digenite (4) with copper wires in it. The glass contains small sulphide mixture grains.
**Kuva 5.** Hitaasti jäähdytettyä liekkiuunin kuonaa. Perusmateriaali sisältää harmaata karkearakeista fayaliitia (1), jossa on vaaleaa ferriittiä sulkeumina (2) ja usein pisaramuotoista jäähtynyttä lasia (3). Suuret deformoituneet vaaleanharmaat rakeet ovat jähmeänä liuoksena olevaa borniitti-digeniittiä (4), jossa on kuparilankoja. Lasi sisältää pieniä sekasulfidirakeita.

### Siilinjärvi

Successful flotation is the key to exploiting the Siilinjärvi apatite deposit. This ore was discovered in 1950 but its real exploration began 20 years later when Kemira Oy got the rights to work the deposit. The ore contains approximately 10 % apatite, 16 % calcite, 3 % dolomite, 65 % different micas and 6 % other silicates[23]. The similar cation in the lattice of apatite and calcite causes difficulties in the separation of these minerals by flotation, while the flotation characteristics of the anions of the two minerals also show some similarities. Apatite flotation at Siilinjärvi is successful only in very strictly and carefully controlled conditions. The research work to determine these conditions was painful and took a rather long time. Numerous tests and test series were needed both in the laboratory and at the pilot plant built in the mine area. There was also a small tailings disposal area near the pilot plant. However, as a result of this work, Siilinjärvi is now the biggest mine ever developed in our country. At the time the plant was erected no other concentrator beneficiating such low grade ore was known.

In this connection, the ore quality control method developed by the geologist Mr Heikki Kauppinen[24] should be mentioned. Thanks to his method, the concentrator has rather good advance knowledge of the quality and concentrating characteristics of the incoming ore.

### Lahnaslampi

The soapstone deposit in Lahnaslampi, Sotkamo, was the subject of a long period of exploration and research work carried out by the exploration company Suomen Malmi Oy. The general manager of the company at that time, Mr Heikki Raja-Halli, had a strong belief in the future of the talc business. He persuaded the paper industry to test and then to use talc as a paper filler. In May 1969 talc concentrate was produced and some years later on production of finely ground microtalc started[25]. This pioneering work opened the way for talc utilisation in North Karelia and increased talc use by the paper industry.

## OTHER CONCENTRATION METHODS

After flotation, magnetic separation has been the most commonly used method in our country. Adaptations of methods based on density differences between minerals form the third most popular technique.

### Otanmäki

The Otanmäki ore contained about 35 % magnetite, 1 % pyrite and 28 % ilmenite[26]. The magnetite was concentrated by low intensity magnetic separators but both pyrite and ilmenite were floated. The design brief for the Otanmäki concentrator specified that the products must be very pure, near the theoretical maximum. This was especially true for the ilmenite concentrate in which the residual iron and sulphur must both be kept to a minimum.

### Kemi

Diver Matilainen's discovery of chromite ore lumps in the fall of 1959 triggered an immediate and broad-based research effort on the geological and processing fronts. This activity led to the development of a significant industrial chain.

Eight different orebodies form the Kemi deposit. Processing behaviour of the mineral assemblages varies even within the one orebody[27, 28]. The $Cr_2O_3$-content of the ore is about 26 % and the Cr:Fe ratio is as low as 1.6, when the metallurgical demand is 3.0. To eliminate this adverse factor the metallurgists developed an upgrading method[29].

True to Outokumpu Oy tradition, separation by flotation was tested first in the process development. The results obtained promised a moderately successful end result. However, all the mineral values of this ore can be floated simultaneously with one and the same collector. For environmental reasons we wanted to test other methods as well. The results obtained with Humphreys spirals, tables, etc were reasonable but the capacities of these machines were too low. Then the Reichert cone solved this particular problem and has become the most important concentration unit in the Kemi plant.

At first, however, the ore was beneficiated with dry high intensity magnetic separators, these being replaced by large capacity WHIMS units once they became available. Later on, use of magnetic separators was reduced in favour of the Reichert cones.

The middlings, that is the olivine grains within chromite particles (Fig. 6) have continued adversely to affect all processing methods, while the presence of fine magnetite disseminated almost everywhere in the ore remains a nuisance. Even so, by using different methods simultaneously, the Kemi concentrator has produced nearly 25 years' supply of raw material for the Tornio Works. In addition, Kemi has produced foundry sand for the steel industry[30]. On the other hand, after a promising start, the marketing of sauna-stones was abruptly halted by the company's Head Office.

## CONTROL

In the 1960s, systematic development work started on the instrumentation and automation of the process industries, mineral concentration included. At the Otanmäki concentrator a rather simple X-ray analyzer was developed, though insufficient financing evidently prevented completion of the project. Outokumpu Oy's Courier X-ray analyzer was, after some preliminary difficulties, made available for industrial use towards the end of the 1960s[31]. The variations of this unit developed later are very suitable for small concentrators as well. Exact sampling and automatic analysis have also made possible the development of control systems such as Proscon, etc.

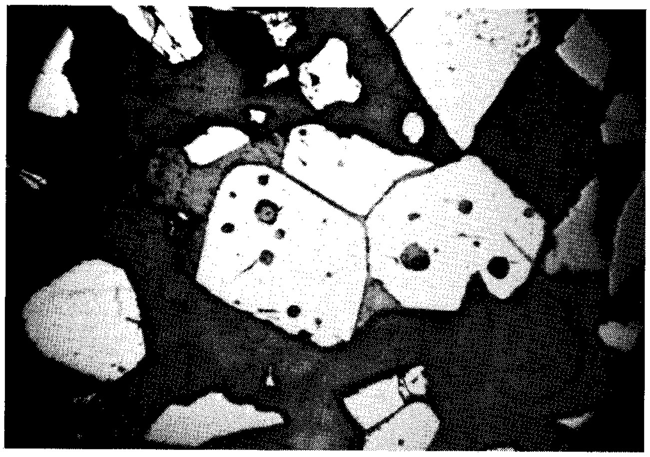

**Fig. 6.** Olivine inside chromite.
**Kuva 6.** Oliviinisulkeumia kromiitissa.

Control of the concentration process is now on a level that no ore dressing engineer could have even dreamed of 50 years ago as he stood beside a flotation cell with a pack of pH-papers in his back pocket.

## MACHINERY

The machines used in concentrators 50 years ago were small compared with those of today. Everywhere, including in our country, both design and manufacturing technology have advanced powerfully. There are numerous examples of successful development work on machines such as crushers and screens, mills and classifiers, pumps and dewatering devices, and many others.

Within Outokumpu Oy, a committee was established 23 years ago with responsibility for developing a new flotation machine. The result is the OK Flotation Machine (Fig. 7). Its rotor-stator assembly is an innovation by Dr Kai Fallenius[32]. The series of these machines now ranges from 0.5 to 100 $m^3$ in size (Fig. 8) — in 1958 the biggest mechanical flotation cell had a volume of three $m^3$.

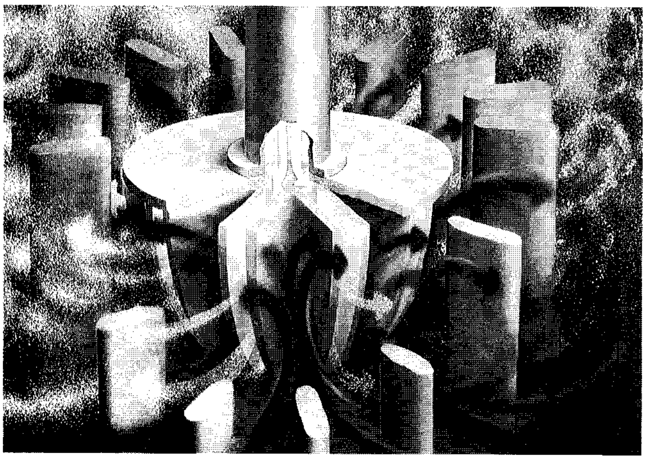

**Fig. 7.** The impeller of OK flotation machine, the product of Outokumpu Oy.
**Kuva 7.** OK-vaahdotuskoneen roottori. Outokumpu Oy:n tuote.

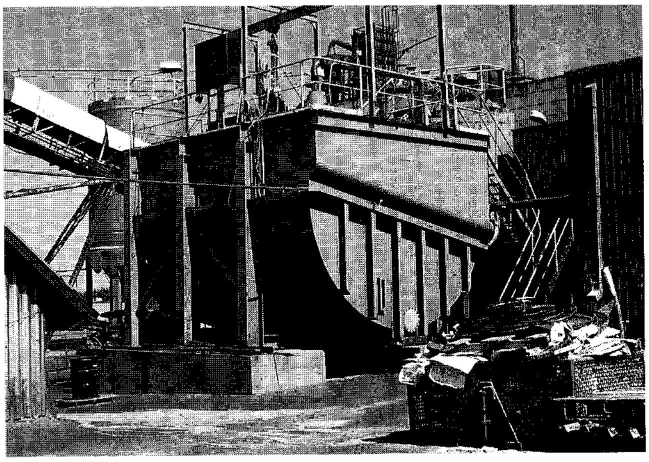

**Fig. 8.** OK 100, the flotation machine of 100 cu m, the product of Outokumpu Oy.
**Kuva 8.** OK 100, 100 m$^3$:n vaahdotuskone. Outokumpu Oy:n tuote.


## SUMMARY

The facts presented above can be recorded as examples of the important developments which the Finnish mineral processing industry has introduced. Of course, many equally considerable achievements have been omitted from this discussion, for instance in the field of concentrator design and construction, as well as in the research department. But it would have been quite possible to prepare a full paper on each of the topics that were mentioned.


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## YHTEENVETO

## SUOMEN RIKASTUSTEKNIIKAN VIRSTANPYLVÄÄT

Suomalaisen rikastustekniikan muutamia tärkeitä kohtia on lyhyesti käsitelty ja yritetty verrata niitä kunkin ajan yleiseen alan tietämykseen.

Ensimmäinen mainittava asia oli Orijärven rikastamossa 1912 toteutettu, tosin epäonnistunut vaahdotuskokeilu. Outokummun vanhassa rikastamossa vaahdotus otettiin käyttöön 1928. Teknillisessä korkeakoulussa 1937 aloitettu yhtenäinen kaivosinsinöörien ja metallurgien koulutus oli maamme vuoriteollisuudelle ensiarvoisen tärkeä.

Outokummun malmin autogeenijauhatuksen kokeilut ja toteutus ovat vaikuttaneet lähes kaikkiin maamme rikastamoihin ja alentaneet niiden jauhatuskustannuksia. Kotalahden rikastamo otti ensimmäisenä maassamme hydrosyklonit käyttöön ainoina luokittimina. Tapa levisi nopeasti kaikkiin uusiin rikastamoihin. Vaahdotuksen alalla toteutettiin uusia oivalluksia mm. Kotalahdessa, Siilinjärvellä ja Harjavallan kuonarikastamossa. Lahnaslammen talkin rikastuksen onnistuminen on vaikuttanut maamme paperiteollisuuden täyteainevalintoihin ja uusien talkkiesiintymien hyödyntämiseen.

Jatkuvatoimiset automaattiset analysaattorit ja prosessien säätöjärjestelmät sekä uusiin ideoihin perustuvat suuret vaahdotuskoneet on mainittu esimerkkeinä laitteiden ja koneiden kehityksestä.

On valitettavaa, että monta arvokasta ja kiinnostavaa kohdetta on ollut pakko jättää tarkastelun ulkopuolelle.

# In Memoriam

## OLAVI ANTERO AURANEN
## 3.9.1937 — 8.1.1993

Filosofian kandidaatti, toimialapäällikkö Olavi Antero Auranen kuoli 8.1.1993.

Olavi Auranen syntyi Kiskossa 3.9.1937 ja tuli ylioppilaaksi Salon yhteiskoulusta 1957. Hän opiskeli geologiaa ja mineralogiaa Turun yliopistossa ja valmistui filosofian kandidaatiksi 1970. Sotilasarvoltaan hän oli luutnantti.

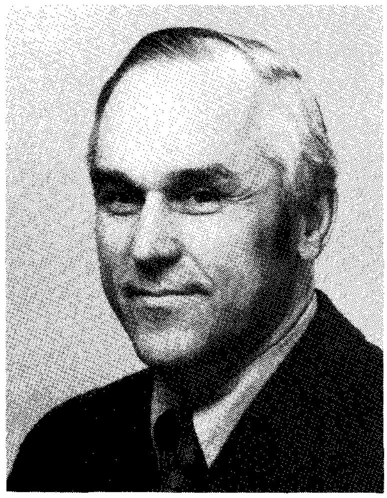
Malminetsintägeologin uransa Olavi Auranen aloitti jo opiskeluaikanaan silloisen Geologisen tutkimuslaitoksen palveluksessa toimien kesäajat harjoittelijana. Noihin aikoihin sisältyy myös vuoden mittainen matematiikan ja luonnonhistorian opettajatoiminta Pudasjärvellä. Valmistumisensa jälkeen hän tuli Geologian tutkimuskeskuksen malmiosaston geologiksi vuonna 1970 ja muutti seuraavana vuonna ensimmäisten joukossa Rovaniemelle Geologian tutkimuskeskuksen Pohjois-Suomen aluetoimistoon. Vuodesta 1979 lähtien hän toimi tutkimuskeskuksen Pohjois-Suomen malmitutkimusryhmän vastuullisessa päällikön tehtävässä ja myöhemmin vastasi koko raaka-ainesektorin toiminnasta toimialapäällikkönä sekä toimi aluejohtajan sijaisena. Olavi Aurasen lukuisista luottamustoimista mainittakoon jäsenyydet Geologiliiton hallituksessa ja Vuorimiesyhdistyksen geologijaoston johtokunnassa. Suomen Geologisen Seuran jäseneksi hän tuli vuonna 1966.

Olavi Aurasen malminetsintätyö kohdistui Pohjois-Suomeen. Hän työskenteli Inarissa Ylitorniolla, Näränkävaarassa, Koitelaisessa, Riikonkoskella, Kilpisjärvellä ja monissa muissa kohteissa. Johtajana hän vastasi Pohjois-Suomen alueen malminetsinnöistä hyvällä tuloksella. Hänen aikaansa on sisältynyt useiden kultamalmiesiintymien menestyksellinen löytäminen ja selvittäminen ja aivan viimeaikojen mittavia näköaloja antavat uudet esiintymälöydöt. Näitä voidaan pitää selkeänä osoituksena Olavi Aurasen johtamistaidoista. Asiallisen ja rauhallisen johtajan takana oli myös eloisa, mielenlaadultaan avara työtoveri.

Olavi Auranen tunnettiin tasapainoisena ja sosiaalisesti ajattelevana henkilönä työyhteisössä. Perusluonteentaan vaatimattomana hän ei tuonut esille avujaan, mutta hän tunsi varmasti parhaiten Lapin malminetsinnän moninaiset ongelmat ja oli myös oikea mies niitä ratkomaan. Hänen kuolemansa juuri nyt, malminetsinnän menestyksen hetkillä, on valitettava menetys tällä tärkeällä geologisen tutkimuksen saralla.

Vuorimiesyhdistys r.y.:n geologijaoston jäsen Olavi Antero Auranen oli vuodesta 1973 lähtien.

Toimitus



## AATTO JOHANNES LAITAKARI
## 23.3.1923 — 2.4.1993

Aatto Johannes Laitakari syntyi Ähtärissä 23.3.1923, tuli ylioppilaaksi Jyväskylässä 1942 ja valmistui filosofian kandidaatiksi Helsingissä 1954. Hän oli jatkosodan veteraani, yliluutnantti, aiemmin pioneerijoukkueen johtaja, "Poika". Aaton kuten ikätovereittensakin nuoruus hävisi sodan melskeisiin. "Kaveria ei jätetä" -periaate säilyi hänen rauhanajan toimissaankin osoittaen sitä inhimillistä lämpöä ja iloa mitä hänessä runsaasti oli.

Rintamajoukoista kotiutuminen toi eteen opiskelun ja ylioppilasyhteisön, jossa Aatolla oli "tuhat tehtävää" edessä, kuten HYY:n edustajistossa Domus Academican ja Kaivokadun kiinteistön rakennusvaiheissa (1948—51), SYL:n hallituksessa (pj. 1955), Tiedekuntien keskusjärjestössä (pj. 1953), Keskisuomalaisessa osakunnassa (isäntä 1945—46, kuraattori 1954-57) ja Vasarassa (pj. 1952). Kaiken tämän hän teki itseään säästämättä ja valmistuikin geologiksi ns. kupparikurssilta vuonna 1954. Valmistumisen jälkeisestä järjestötoiminnasta mainittakoon Keski-Suomen Seniorit (pj. 1958—82), VMY:n geologijaosto (pj. 1962) ja Geologiliitto (pj. 1964—69). Myös veteraanityö oli hänelle läheistä. Sodan ja rauhanajan ansioistaan Aatto on palkittu lukuisilla kunnia- ja ansiomerkeillä.

Geologisen tutkimuslaitoksen palveluksessa Aatto aloitti jo vuonna 1949 harjoittelijana ja edelleen tutkimusassistenttina. Malmigeologin ura alkoi vuonna 1956 ja jakaantui kolmeen vaiheeseen: Malminetsintä ja kansannäytetoiminta keskisessä Suomessa, valistus- ja kansannäytetoiminta koko maassa ja ennen eläkkeelle siirtymistään Ni-kriittisyyden kartoitus Mikkelin läänin alueella. Hänen malminetsintäperiodinsa merkittävimmät löydökset olivat Säviän ja Kangasjärven Zn-Cu -esiintymät, joista viimeksimainittu on hyödynnetty Pyhäsalmen kaivoksella. Valistustoiminnan suorina tuloksina mainittakoon Pyhäsalmen ja Lieksan malmiesiintymät ja lukuisat ovat ne lohkareet, malmi-indikaatiot, joita kansannäytetoimistot ovat vastaanottaneet ja jotka vielä ratkaisuaan odottavat. Valistustoimintaan liittyi opetus- ja tiedotustoimintaa yhteiskunnan eri tasoilla, ideointia ja taustatyötä. Tähän sektoriin voidaan lukea ne monet epämetallisten malmien kuten rakennus- ja korukivialan yritykset, joita hänen avustuksellaan on polkaistu käyntiin. Vielä eläkkeellä ollessaankin, vuoden 1986 jälkeen, hän toimi alan taustavaikuttajana.

Alaisilleen Aatto J. Laitakari oli "Pomo". Pomo, joka nautti alaistensa luottamusta ja alaiset hänen. Kiireinen työrytmi kuljetti häntä ympäri maata, pysähdykset työpisteissä jäivät pakostakin lyhytaikaisiksi. Pomon tulo tukikohtaan oli aina juhlahetki. Silloin käytiin lävitse tapahtuneet ja suunniteltiin uudet työtehtävät. Joskus tietenkin voitiin lyödä korttia ja kirkkaana kaikui Pomon nauru, kun sai pennin tikin kotiin. Epävirallisiin asioihin kuului myös alaisten, jopa kyläläistenkin henkilökohtaiset "murheet". Aatto hoiti runsaasti epäoikeudenmukaisesti kohdeltujen ja väärinymmärrettyjen asioita, jopa kihlakunnanoikeudessa ja raastuvassa. Usein kun muut olivat jo uneen vaipumassa kuului Pomon huoneesta vielä kirjoituskoneen tasainen naputus.

Viime maaliskuun 23. päivänä Aatto J. Laitakari täytti 70 vuotta. Vain viikko ehti tästä kulua, kun hän illalla nukkumaan mennessään tarttui Riitta-vaimon käteen sanoen "rakas" ja sitten ummistaen silmänsä ikuiseen uneen. Aaton maallinen vaellus päättyi Hietaniemen hautausmaan Veteraanilehtoon.

J.T., M.H., LKK

Vuorimiesyhdistys r.y.:n geologijaoston jäsen Aatto Johannes Laitakari oli vuodesta 1955 lähtien.

Toimitus

## ERNST BORIS ALANDER
## 16.6.1903 — 8.4.1993

Ernst Boris Alander gick ur tiden den 8 april 1993. Han föddes i Willmanstrand den 16 juni 1903 och blev student från Viborgs svenska lyceum 1920. Han avlade diplomingenjörsexamen vid Tekniska högskolan i Finland, Maskiningenjörsavdelningen, Studieriktningen för maskinbyggnad, redan år 1925.

Ernst ingick äktenskap med Eva Hildegard Henriksson och tillsammans fick de tre barn Brita, Ernst Olof och Klas.

Vid Kymmene Ab. Kuusankoski fick Ernst sin första anställning som verkstadsingenjör och assistent vid verkstaden och ång-avdelningen 1925—1928. Under åren 1930—1935 funktionerade han som rationaliseringsingenjör, åren 1935—1941 som chef för verkstaden, fabriksbyggnadsavdelningen och ritkontoret, allt hos samma företag. Sedan flyttade Ernst till Karkkila där han verkade som överingenjör vid Högfors Bruk åren 1941—1966 samt såsom disponent för företaget åren 1966—1968, varefter han gick i en välförtjänt pension.

Ernst Alander hade en lång rad av olika förtroendeuppdrag av vilka vi här skall nämna följande: Verkstadsingenjörsföreningen i Finland, styrelsemedlem 1935—1961, Finlands Gjuteritekniska Förening, styrelseordförande 1948—1952, Bergsmannaföreningen, styrelsemedlem 1950—1952.

Bland de medlemskap som Ernst dessutom innehade i olika föreningar kan nämnas: Tekniska Föreningen Finland (1927), Lämpö- ja Vesijohtoteknillinen yhdistys, Sveriges Gjuteritekniska Förening, VVS-tekniska föreningen, American Foundrymen's Society.

Ernst Boris Alander var medlem i Vuorimiesyhdistys — Bergsmannaföreningen r.y.:s metallurgisektion från och med år 1945.

Studieresor företog Ernst till de flesta europeiska länder och USA. Walter Ahlström stiftelsens stipendium erhöll Ernst 1928—1929. Han utnämndes även till hedersledamot i Gjuteritekniska föreningen.

Ernst deltog i både vinter- och fortsättningskriget som ingenjörskapten. Han tilldelades förtjänstecken och civila ordnar för sina insatser: Kommendör av Finlands Lejons Orden, Riddare av Finlands Vita Ros Orden, Frihetskorset 4, Minnesmedaljerna för deltagande i 1939—1940 års krig, och 1941—1945, Förtjänstmedalj för deltagande i befolkningsskyddsarbetet, Frihetsmedalj 2 för medborgerliga förtjänster.

Av Ernsts särintressen kan vi minnas jakt och fiske men i synnerhet hans stora hobby, biodling.

Ernst Boris Alander var en lingvist av mått, han behärskade förutom sitt svenska modersmål även finska, tyska, engelska och ryska.

Vi alla föreningsmedlemmar gör honnör för den gode Ernst.

## PAUNU JUHANI OIVANEN
## 22.1.1930 — 10.5.1993

Filosofian kandidaatti, geologi Paunu Juhani Oivanen kuoli 10.5.1993. Paunu Oivanen syntyi Helsingissä 22.1.1930 ja tuli ylioppilaaksi Kallion yhteiskoulusta 1950. Hän opiskeli Helsingin yliopistossa maantiedettä sekä geologiaa ja mineralogiaa valmistuen filosofian kandidaatiksi 1956.

Pitkän malminetsintäuransa Paunu Oivanen aloitti jo koululaisena malminäytteiden lähettäjänä ja kesäapulaisena silloisessa Geologisessa tutkimuslaitoksessa. Hänen malmi-innostuksensa ei varmaankaan vähentynyt opintomatkasta Sulitjelman kaivoksille 1948 ja Luontoliiton kultaisesta harrastusmerkistä 1949, mikä myönnettiin hänelle "Helsingin seudun malmikaivokset" -kultamerkkityöstä. Valmistumisensa jälkeen Oivanen toimi malmiosaston tutkimusassistenttina ja apulaisgeologina sekä vuodesta 1962 geologina malmiosastossa ja Etelä-Suomen aluetoimistossa. Vuodesta 1984 Oivanen toimi malmiosaston Etelä-Suomen tutkimusryhmän sekä aluetoimiston malmitutkimusryhmän vastuullisena päällikkönä ja vastasi aluetoimiston kansannäytetutkimuksista eläkkeelle siirtymiseensä tammikuuhun 1993 saakka.

Paunu Oivasen malminetsintätyö keskittyi aluksi Pohjois-Savon malmitutkimuksiin ja myöhemmin Pohjanmaalle tina- ja antimonitutkimuksiin. Pääkaupunkiseudun geologia ja malmiaiheet olivat hänen erityisen mielenkiintonsa kohteena samoin kuin vulkanologia. Oivasen erinomainen makroskooppinen mineraalituntemus muistetaan hyvin. Hänen lukuisilla ulkomaanmatkoillaan geologiset kohteet olivat usein tärkeällä sijalla.

Paunu Oivasen luottamustehtävistä mainittakoon Helsingin yliopiston ylioppilaskunnan edustajiston jäsenyys 1954—1955 ja Geologisen tutkimuslaitoksen henkilöstöneuvoston puheenjohtajuus 1978—1979. Tutkimuskeskuksen suojelujohtajana hän teki mittavan työn vuosina 1984—1992.

Paunu Oivasen luontoharrastus ei rajoittunut geologiaan. Lähiystävät saivat nauttia hänen kasvi- ja eläintuntemuksestaan sekä matkoilta tuomistaan kasviharvinaisuuksista. Ralliautoilu oli hänen nuoruuden harrastuksiaan.

Paunu Oivanen tunnettiin työyhteisössä huumorintajuisena ja huolehtivana isähahmona. Perusluonteeltaan vaatimattomana hän ei tuonut esille avujaan, mutta hänen pitkään kokemukseensa ja asiantuntemukseensa saattoi aina turvautua.

Esko Räisänen

Suomen Geologisen Seuran jäseneksi Oivanen tuli 1950 ja Vuorimiesyhdistys r.y.:n geologijaoston sekä Geologiliiton jäseniksi 1958.

Toimitus

# HERMAN EMIL STIGZELIUS
## 14.8.1917 — 10.5.1993

Geologian tutkimuskeskuksen entinen ylijohtaja, professori, tekniikan tohtori, kunniakullankaivaja, teollisuusneuvos Herman Emil Stigzelius kuoli pitkällisen sairauden murtamana 10.5.1993. Hän oli syntynyt Helsingissä 14.8.1917.

Herman Stigzelius syntyi monilapsisen perheen kuopuksena itsenäistyvään Suomeen. Isä-insinööri hävisi Venäjän vallankumouksen pyörteisiin. Tästäkö johtunee, että kuopuksesta kasvoi itsenäinen, usein jyrkästikin asioihin kantaaottava persoonallisuus. Hersyvä huumori ja laaja lukeneisuus onneksi pehmensivät itsenäisyydestä ja itsepäisyydestä väkisinkin johtuvia yhteenottoja.

Hän valmistui diplomi-insinööriksi 22- ja tekniikan tohtoriksi 27-vuotiaana, ja nimitettiin teollisuusneuvokseksi 29-vuotiaana nuorimpana Suomessa; tämä kertoo nuoren miehen tahdonvoimasta. Hän aloitti ammattiuransa Oy Vuoksenniska Ab:n Haverin kaivoksella 1940-45, jossa tuotettiin sotavuosina kipeästi tarvitsemiamme kuparia ja kultaa. Kauppa- ja teollisuusministeriön päällikkönä 1946—70 Herman Stigzelius vaikutti paitsi malmietsinnän ja kaivoslainsäädännön myös kaivostoiminnan ripeään kehittymiseen maassamme. Hänen tarkastusvierailunsa louhoksille ja kaivoksiin aiheuttivat pientä värinää niskanahassa. Kokonaan toisenlainen oli tunnelma silloin, kun hän saapui kaivokselle harjoittelijaporukan kanssa. Hän opetti nimittäin sivutoimenaan kaivosmittausta Teknillisessä korkeakoulussa.

Herman Stigzelius toimi useaan otteeseen Yhdistyneiden Kansakuntien malminetsintä- ja kaivosalan asiantuntijatehtävissä. Vuosina 1961—62 ja 1963—64 Boliviassa, vuodet 1967—70 New Yorkista käsin useissa kehitysmaissa ympäri maailman. Sieltä hän saapui Geologisen tutkimuslaitoksen ylijohtajaksi 1.4.1970. Hänen aikanaan GTK kasvoi noin 400 henkilön laitoksesta yli 800 henkilön keskusvirastoksi.

Ensimmäiset eläkevuotensa 1980—83 hän vietti YK:n palveluksessa: Bandungissa, Indonesiassa, Aasian maiden kaivosteollisuutta edistämässä. Hän värväsi useita nuorempia suomalaisia ammattimiehiä samantapaisiin tehtäviin luoden näin perustaa kansainvälistymisellemme. Hänen aikanaan geologinen yhteistyö niin idän- kuin lännenpuoleisten naapureidenkin kanssa sai vakiintuneet muodot, mm. Nordkalott-projekti aloitettiin.

Herman Stigzeliuksen monipuolisuus ja värikkyys kuvastuvat hänen harrastuksissaan: maalauksessa, näyttelemisessä ja kirjoittamisessa. Mm. Bandungissa hän toimi kansainvälisen asiantuntijakaartin näytelmäkerhossa. Osa hänen virkamiehenä tarvitsemaansa neuvottelutaitoa, mm. Neuvostoliitto-yhteistyössä, varmaankin pohjautui osaltaan näyttelijänkykyihin.

Parhaiten "Hermanni" kuitenkin tunnetaan Lapin kullan ystävänä. Jo Haverissa ja sittemmin Lemmenjoen tarkastusmatkoilla hän rakastui kultaan. Tämän aistii elävästi lukiessaan hänen bestselleriksi muodostunutta kirjaansa Kultakuume. Lapin kullan historia. Sitä kirjoittaessaan hän varmaan nautiskeli, kun hänen luonteensa kaksi jyrkästi erilaista puolta — eksakti, pikkutarkka historioitsija ja virkamies sekä hulvaton boheemi, nautiskelija ja seikkailija — taistelivat keskenään. Huumori ja hauskanpito ottivat aina voiton.

Tankavaaran kultakisat hänellä oli tapana avata Kultamuseossa säilytettävä hattureuhkansa päässään ja kaikkia osaamiaan kieliä käyttäen; hän oli seuramies ylitse muiden.

Herman Stigzeliuksen asiantuntemusta hyödynnettiin hyvin monissa elinkeinoelämän luottamus- ja neuvottelutehtävissä, mm. Otamäki Oy:n, Suomen Malmi Oy:n ja Suo Oy:n johtokunnissa, Vuorimiesyhdistyksessä ja Geologisessa seurassa. Hän oli Vuoriteollisuus — Bergshanteringen -lehden päätoimittaja vuodet 1948—67. VMY palkitsi hänet Eero Mäkinen -mitalilla ja GS kunniajäsenyydellä. Hänestä tehtiin myös Lapin Kullankaivajain Liiton kunniakullankaivaja ja Outokummun kunniakaivosmies ja hänelle myönnettiin SVR:n komentajamerkki.

Herman Stigzelius löysi kesämökkinsä kupeesta Romsarbystä 1500—1600-luvuilta peräisin olevia malminetsinnän ja kaivostoiminnan merkkejä. Niiden keskellä hän eli ja samoissa maisemissa hän sai päättää rikkaan elämänsä.

Kalevi Kauranne

Vuorimiesyhdistys r.y.:n geologijaoston sekä kaivosjaoston jäsen Herman Emil Stigzelius oli vuodesta 1943 lähtien.

Toimitus

## VEIKKO OLAVI VÄHÄTALO
## 4.8.1909—4.6.1993

Outokumpu Oy:n Malminetsintäosaston perustaja, filosofian tohtori Veikko Olavi Vähätalo kuoli Helsingissä 4.6.1993. Hän oli syntynyt 4.8. 1909 Hollolassa, Salpausselän etelärinteellä maanviljelijän perheeseen. Keväällä 1918 8-vuotias poika näki elämän kovuuden Hennalan kasarmin vaiheilla liikkuessaan. Myöhemmin Salpausselän hiihdot olivat koulupojan mielenkiinnon kohteena, eikä Lahdessa ollut mies eikä mikään, joka ei hyppyrimäestä laskenut.

Tuleva tohtori pääsi ylioppilaaksi Lahden Yhteiskoulusta 1930 ja valmistui filosofian kandidaatiksi Helsingin yliopistosta 1939 pääaineena orgaaninen kemia. Geologia oli alkanut kiinnostaa Salpausselän kasvattia opiskeluaikana, ja hän oli jo kesällä 1935 Pohjois-Karjalassa "suurta malminuottaa" vetämässä sekä sen jälkeen kesäisin Outokumpu Oy:n kenttätöissä.

Valmistumisensa jälkeen Vähätalo toimi Geologisen toimikunnan vt. vuori-insinöörinä. Talvisodan päätyttyä hän siirtyi Outokumpu Oy:n palvelukseen johtamaan keskeytyneitä Ylöjärven kuparimalmin tutkimuksia. Kun kaivos päätettiin perustaa, Vähätalo hoiti parin vuoden ajan isännöitsijän tehtäviä muiden töiden ohella. 1943 tuli siirto Outokummun kaivoksen kaivosgeologiksi. Tämän yli kahdeksan vuotta kestäneen kauden aikana alettiin suunnitella uutta louhintamenetelmää ja tuotannon siirtämistä malmin länsiosaan.

Kun Outokumpu Oy perusti 1951 Malminetsintäosaston, Vähätalo nimitettiin sen johtajaksi. Kahta vuotta myöhemmin hän suoritti filosofian lisensiaatin tutkinnon ja väitteli tohtoriksi Outokummun malmin geologiaa käsittelevällä väitöskirjallaan. Tohtori jatkoi entisessä tehtävässään ja kehitti osastostaan 15 vuoden kuluessa maamme suurimman malminetsinnän organisaation. Käyttöön otettiin uusia geofysikaalisia ja geokemiallisia menetelmiä ja hankittiin niiden vaatimia laitteita. Tulokset olivat sen mukaisia. Lukuisia uusia kaivoksia avattiin tohtori Vähätalon johtaman osaston tutkimusten tuloksina. Hänen työnsä vaikutti kauan myös oman organisaation ulkopuolella. Tohtori Vähätalo siirrettiin yhtiön apulaispäägeologiksi 1966, jolloin näköalat avartuivat. Eläkkeelle hän jäi 1974. Joko Vähätalolla oli onni mukana tai sitten hänellä oli Kiven mukainen "silmä joka katsoo läpitse kallion".

Salpausselän harjanteilla näkee kauas eteläisen Suomen yli, ja Veikko Vähätalosta oli kehittynyt avarakatseinen, pääasiat ja mitättömyydet erottava mies. Malmien ja niiden komponenttien tutkiminen on tarkkuutta ja kärsivällisyyttä vaativaa työtä, jossa pettymyksiltäkään ei voi välttyä. Tohtori Vähätalo oli valettu tähän muottiin. Ihmisenä hän oli vakaa, kuivan ja nasevan huumorin käyttäjä. "Siirrettiin jäähypenkille" oli toteamus nimityksestä apulaispäägeologiksi.

Kun Vuorimiesyhdistys ry täytti tänä vuonna 50 vuotta tohtori Vähätalo sanoi osallistuneensa kaikkiin vuosijuhliin yhdistyksen perustamisesta 1943 alkaen. Muita hänelle läheisiä yhdistyksiä olivat mm. Suomen Geologinen Seura, Suomen Mineraloginen Seura ja Rotaryt. Helsingin yliopiston geologian ylioppilaiden yhdistystä Vasaraa hän oli ollut perustamassa ja oli sen ensimmäinen puheenjohtaja.

Veikko Vähätalon harrastuksiin kuului urheilukalastus, jossa hänellä oli taitajan maine. Toinen harrastus, nikkarointi, tuotti kauniita tuloksia. Moottori- ja purjeveneen teko ei kuulu joka pojan käsitöihin, mutta tohtori teki nekin. Outokummun kauden harrastuksia oli myös kuorolaulu.

1987 tohtori Vähätalolle myönnettiin Otto Trüstedt -mitali, jonka Outokumpu Oy perusti 1985 Outokummun malmin löydön 75-vuotismuistoksi ja malmin löytäjän, fil.tri hc. Otto Trüstedtin kunniaksi. Tohtori Vähätalo oli nimitetty myös Outokumpu Oy:n kunniakaivosmieheksi.

Suuren malminuotan veto on Veikon osalta päättynyt.

Sib tibi, terra levis!

Toimi Lukkarinen

Vuorimiesyhdistys r.y.:n geologiajaoston jäsen Veikko Olavi Vähätalo siis oli perustamisvuodesta 1943 alkaen.

Toimitus

## PERTTI HEIKKILÄ
## 28.4.1950—6.8.1993

Kalliotekniikan vs. professori, tekn.tri Pertti Heikkilä poistui odottamatta keskuudestamme syyskesällä 1993. Pertti oli syntynyt Virolahdella 28.4.1950 ja suorittanut ylioppilastutkinnon Virolahden yhteislyseossa vuonna 1969.

Pertin hyvin alkaneet opinnot Teknillisen korkeakoulun Vuoriteollisuusosaston kaivostekniikan opintosuunnalla keskeytyivät diplomityövaiheessa kesällä 1974 vakavaan moottoripyöräonnettomuuteen. Sisullaan Pertti kuitenkin kuntoutti itsensä, hoiti diplomityönsä eri kovametallityyppien käyttäytymisestä porauksessa loppuun, ja valmistui diplomi-insinööriksi vuonna 1977.

Toimittuaan louhintatekniikan laboratoriossa tutkijana ja assistenttina Pertti siirtyi vuonna 1980 Tampereelle Oy Tampella Ab Tamrockin tutkimusinsinööriksi. Kahta vuotta myöhemmin hänet nimitettiin tutkimuspäälliköksi.

Perheenlisäys toi Pertin takaisin pääkaupunkiseudulle vuonna 1987. Työpaikka oli myös tuttu, kalliotekniikan laboratorio Teknillisessä korkeakoulussa. Vanha lempiharrastus, kallion särkeminen, sai nyt käänteisiä muotoja, kun piti saada aikaan mahdollisimman kestävää mursketta tiepinnoitteisiin. Asfalttipinnoitteiden tutkimusohjelmasta tuli materiaali väitöskirjaan, jota Pertti puolusti kunnialla kevättalvella 1991.

Hoidettuaan vuodesta 1989 alkaen kalliotekniikan yliassistentuuria Pertti määrättiin hoitamaan kesästä 1993 kalliotekniikan professorin viransijaisuutta, työtä, jota hän ei ehtinyt tuskin aloittaa ennen poismenoaan.

Pertin kuiva englantilaistyylinen huumori ja oman alansa kiistaton asiantuntemus säilyivät kaikkien hänet tunteneiden mielissä pitkään. Hänen työkapasiteettiaan ja asioiden tekemistä valmiiksi saakka ei tule olemaan helppoa korvata. Ajaessamme entistä kestävämmin päällystettyjä teitä tai katsellessamme entistä suorempia porareikiä näemme myös Pertin käden jäljen.

Tiinan ja lasten suruun osallistuen, Perttiä muistaen.

Pekka Särkkä

Vuorimiesyhdistys r.y.:n kaivosjaoston jäsen Pertti Heikkilä oli vuodesta 1980 lähtien.

Toimitus

# Vuorimiesyhdistys — Bergsmannaföreningen r.y.

## TOIMINTAKERTOMUS VUODELTA 1992

### Vuosikokous

Vuorimiesyhdistyksen sääntömääräinen 49. vuosikokous pidettiin Messukeskuksessa Helsingissä 20.3.1992. Puheenjohtaja Raimo Matikainen avasi kokouksen ja esitti katsauksen maamme vuoriteollisuuden kehitykseen vuonna 1991. Yhdistyksen puheenjohtajaksi valittiin prof. Raimo Matikainen ja varapuheenjohtajaksi TkT Aulis Saarinen.

— Eero Mäkinen -ansiomitali ojennettiin DI, KTK Pertti Voutilaiselle tunnustuksena hänen vuoriteollisuuden ja Vuorimiesyhdistyksen hyväksi tekemästään arvokkaasta työstä.

Virallisten kokousasioiden jälkeen pidettiin seuraavat esitykset:

— Ylijohtaja Markku Mäkinen, Kauppa- ja teollisuusministeriö:

Euroopan yhdentymisen merkitys Suomen perusmetalliteollisuudelle

— Pääjohtaja Jyrki Juusela, Outokumpu Oy:

Eräiden perusmetallien tuotannon kilpailukykyyn vaikuttavia tekijöitä.

Jaostot kokoontuivat iltapäivällä omien erikoisalojensa merkeissä.

Illallistanssiaisissa ravintola Kalastajatorpalla vastasi isännyydestä Outokumpu Oy.

### Toimihenkilöt

— Puheenjohtaja: prof. Raimo Matikainen
— Varapuheenjohtaja: TkT Aulis Saarinen
— Hallituksen jäsenet:

| | |
|---|---|
| TkL Hans Allenius | DI Heikki Rusila |
| DI Eelis Eskelinen | DI Ville Sipilä |
| DI Matti Heiniö | DI Timo Välttilä |
| DI Jorma Kemppainen | TkL Matti Tyni |
| Prof. Veikko Lappalainen | |

— Rahastonhoitaja: LuK Marjatta Parkkinen
— Sihteerit: TkT Heikki Laapas
DI Erkki Tyni
TkL Martti Veistaro

### Yhdistyksen toiminta

Hallitus kokoontui toimintakauden aikana viisi kertaa. Kokouksissa ovat olleet läsnä myös jaostojen puheenjohtajat, rahastonhoitaja ja tutkimusvaltuuskunnan puheenjohtaja.

Yhdistyksen lehti Vuoriteollisuus — Bergshanteringen on ilmestynyt kaksi kertaa. Lehden päätoimittajana on toiminut prof. Martti Sulonen ja toimitusneuvoston puheenjohtajana DI Matti Palperi.

Hallitus päätti perustaa yhdistyksen 50-vuotisjärjestelyiden koordinointia varten ohjausryhmän, johon kutsuttiin hallituksesta puheenjohtaja, varapuheenjohtaja, sihteerit ja jaostojen puheenjohtajat sekä Suomen Teräksen- ja Metallintuottajien yhdistyksestä joht. Sirpa Smolsky, Oy Fundia Ab:sta TkL Pertti Kostamo, Outokumpu Oy:stä TkL Tapio Tuominen, Imatra Steel Oy Ab:sta TkT Kari Tähtinen ja Finnminersista ins. Erkki Matikainen. Ohjausryhmä on kokoontunut toimikauden aikana neljä kertaa.

Yhdistyksen historiikia laatimaan kutsuttiin prof. Toimi Lukkarinen.

### Jaostot

Pääosan yhdistyksen jäsentoiminnasta on muodostanut jaostojen aktiivinen toiminta eri muodoissa.

Jaostot ovat järjestäneet koulutus- ja esitelmätilaisuuksia sekä ammatillisia retkiä jäsenistönsä alalta. Tarkemmin jaostojen toiminta on esitetty kunkin omassa toimintakertomuksessa.

### Jaostojen toimihenkilöt

Geologijaosto: puheenjohtaja, FL Elias Ekdahl; sihteeri, FK Sirkku Halonen.
Kaivosjaosto: puheenjohtaja, DI Kimmo Kekki; sihteeri, DI Tommy Grahn.
Metallurgijaosto: puheenjohtaja, TkT Kalevi Nikkilä; sihteeri, TkL Lars Helle.
Rikastus- ja prosessitekniikan jaosto: puheenjohtaja, DI Jouko Kallioinen; sihteeri, DI Jukka Karhunen.

### Yhdistyksen jaostojen jäsenmäärät

Yhdistyksen jäsenmäärä 31.12.1992 oli 2017, jossa lisäystä edellisvuodesta on 38. Uusia jäseniä hyväksyttiin 75, joista nuoria 26. Kuoleman kautta poistui 4 ja erosi 33.

Jaostojen jäsenmäärät olivat seuraavat: Geologijaosto 448, Kaivosjaosto 441, Metallurgijaosto 1075, Rikastus- ja prosessitekniikan jaosto 290.

### Tutkimusvaltuuskunta

Tutkimusvaltuuskunnan sääntömääräinen vuosikokous oli 14.2.1992.

Tutkimusjohtokunta kokoontui vuoden 1992 aikana viisi kertaa. Tutkimusvaltuuskunnan puheenjohtajana on toiminut DI Paavo Eerola ja varapuheenjohtajana DI Juha Pajari. FT Jyrki Parkkinen toimi valtuuskunnan ja sen toimikuntien sihteerinä.

Toimikuntien puheenjohtajat:
— Geologinen toimikunta: prof. Heikki Niini.
— Kaivosteknillinen toimikunta: DI Pekka Lappalainen.
— Rikastusteknillinen toimikunta: DI Jarmo Aaltonen.

Suoraan tutkimusjohtokunnan valvonnassa olivat seuraavat projektit:
— Edunvalvonta
Tarkoituksena on vuoriteollisuuden yleisten toimintaedellytysten edistäminen.
— Kaivosten jälkihoito
— Kaivosten ympäristöasiat
— Kiven fragmentointi
— Malmgränsbestämning med borrhålsmätningar i gruvor.
— Kaivosympäristön suojelukongressi 1993
— Vuoriteollisuus 2000 teknologiaohjelma
— Analys av tremolit i dolomit

Toimikunnilla oli käynnissä yhteensä 10 projektia.

Pohjoismaisessa yhteistyössä on osallistuttu seuraaviin kokouksiin:
— Nordiskt Geokommittémöte Falunissa 14.—15.5.1992.
— Nordiskt Gruvforskningsmöte Trondheimissa 24.—26.8.1992.
— Nordiskt Mineralteknik-Möte Outokummussa ja Siilinjärvellä 20.—21.8.1992.

FM Esko Lundén edusti tutkimusvaltuuskuntaa neuvotteluissa, joissa tutkittiin yhteispohjoismaisten EC-projektien mahdollisuuksia.

Muista pohjoismaista on saatu 7 tutkimusraporttia.

Espoossa 27. tammikuuta 1993

**VUORIMIESYHDISTYS
— BERGSMANNAFÖRENINGEN R.Y.:n
HALLITUS**

| | |
|---|---|
| **Raimo Matikainen** | **Heikki Laapas** |
| puheenjohtaja | sihteeri |

## TULOSLASKELMA 1.1.92—31.12.92

### VARSINAINEN TOIMINTA

| | | | |
|---|---|---|---|
| **VMYN HALLINTO** | | | |
| TUOTOT | | | |
| KULUT | | | |
| Palkat | 37.350,00 | | |
| Muut kulut | 44.866,90 | | |
| Vuosikokous | 62.456,00 | | |
| Avustukset | 13.781,00 | | |
| Jaostot | 9.306,30 | -167.760,20 | **-167.760,20** |
| **TUTKIMUSVALTUUSKUNTA** | | | |
| TUOTOT | | +5.878,04 | |
| KULUT | | | |
| Hallinto | 95.797,00 | | |
| Matkat | 5.737,00 | | |
| Muut kulut | 11.108,20 | | |
| TJ-proj | 157.701,28 | | |
| Toimikunnat | 112.015,60 | -382.359,08 | **-376.481,04** |
| **JULKAISUT** | | | |
| TUOTOT | | | |
| A-sarja | 10.000,90 | | |
| B-sarja | 1.150,00 | | |
| Muut tuotteet | 840,00 | +11.990,90 | |
| KULUT | | | |
| Jäsenluettelo | | -5.483,30 | **+6.507,60** |
| **VUORITEOLLISUUSLEHTI** | | | |
| TUOTOT | | +136.155,50 | |
| KULUT | | -156.715,80 | **-20.560,30** |
| **MUUT TUOTOT JA KULUT** | | | |
| TUOTOT | | | |
| Korkotulot | | +35.450,93 | |
| KULUT | | | |
| Vakuutukset | 4.312,80 | | |
| Muut kulut | 47.831,25 | -52.144,05 | **-16.693,12** |
| | | | **-574.987,06** |

### VARAINHANKINTA

| | | |
|---|---|---|
| Jäsenmaksut | 143.369,40 | |
| Tutk.valt.k.kannatusm. | 267.500,00 | |
| Lahjoitukset | 5.000,00 | **+415.869,40** |

### TILIKAUDEN YLI/ALIJÄÄMÄ

**-159.117,66**

## TASE 31.12.1992

| | | |
|---|---|---|
| **VASTAAVAA** | | |
| **RAHOITUSOMAISUUS** | | |
| Rahat ja pankkisaamiset | 389.088,25 | |
| Tilisaamiset | 5.000,00 | |
| Siirtosaamiset | 75.881,50 | **469.969,75** |
| **VASTATTAVAA** | | |
| **LYHYTAIKAINEN VIERAS PÄÄOMA** | | |
| Tilivelat | 122.137,60 | |
| Siirtovelat | 340,73 | |
| **OMA PÄÄOMA** | | |
| Yli-/alijäämä edell.v. | 506.609,08 | |
| Yli-/alij. tilik. | -159.117,66 | **469.969,75** |

## SALDOT 31.12.1992

| | | |
|---|---|---|
| **TUTKIMUSVALTUUSKUNTA** | | |
| Saldo 31.12.1991 | +306.660,77 | |
| v. 1992 alijäämä | -103.981,04 | |
| | | **+202.679,73** |
| **YHDISTYKSEN TOIMINTA** | | |
| Saldo 31.12.1991 | +199.948,31 | |
| v. 1992 alijäämä | -55.136,62 | |
| | | **+144.811,69** |
| **KOKO YHDISTYKSEN SALDO 31.12.1992** | | **+347.491,42** |

## TALOUSARVIO VUODELLE 1993

Talousarvio perustuu jäsenmaksujen säilyttämiseen vuoden 1992 tasolla. Tutkimusjäsenten kannatusmaksut puolitetaan.

| | | | |
|---|---|---|---|
| **VARSINAINEN TOIMINTA** | | | |
| **VMYN HALLINTO** | | | |
| TUOTOT | | | |
| Jaostot | — | | |
| KULUT | | | |
| Hallinto | 85.000 | | |
| Vuosikokous | 150.000 | | |
| Avustukset | 20.000 | | |
| Jaostot | 30.000 | -285.000 | -285.000 |
| **TUTKIMUSVALTUUSKUNTA** | | | |
| TUOTOT | | | |
| Osall.tutk. | — | | |
| KULUT | | | |
| Hall.&johtok. | 115.800 | | |
| Tutk.&esiselv. | 78.000 | | |
| Edunvalvonta | — | -193.800 | -193.800 |
| **JULKAISUT** | | | |
| TUOTOT | | | |
| A&B-sarjat | 5.000 | | |
| Jäsenluettelo | 1.500 | +6.500 | |
| KULUT | | | |
| A-sarja | 10.000 | -10.000 | -3.500 |
| **VUORITEOLLISUUSLEHTI** | | | |
| TUOTOT | | | |
| Ilmoit.myynti | 135.000 | | |
| Tilausmaks. | 6.600 | +141.600 | |
| KULUT | | -160.000 | -18.400 |
| **MUUT TUOTOT JA KULUT** | | | |
| TUOTOT | | | |
| Korkotulot | | +13.000 | |
| KULUT | | | |
| Pankkipalv.m. | 7.000 | | |
| Vakuutukset | 4.500 | | |
| Tulotappiot | 10.000 | -21.500 | -8.500 |
| | | | -509.200 |
| **VARAINHANKINTA** | | | |
| Jäsenmaksut | 135.000 | | |
| Tutk.jäs.v.m. | 111.250 | | |
| Lahjoitukset | 5.000 | | +251.250 |
| **TILIKAUDEN ALIJÄÄMÄ** | | | **-257.950** |

## GEOLOGIJAOSTON TOIMINTAKERTOMUS 1992

### Toiminta

Geologijaoston päätapahtumat toimintavuonna 1992 ovat olleet vuosikokous, Suomen kallioperän kehitys ja raaka-ainevarat -päivät, ja malmiarvioseminaari. Jaoston johtokunta kokoontui 5 kertaa.

Geologijaoston vuosikokous pidettiin Vuorimiespäivien yhteydessä 20.3.1992 Messukeskuksessa Helsingissä. Kokouksessa oli läsnä 96 jaoston jäsentä. Kokouksen jälkeen kuultiin seuraavat esitelmät:

— Apul.prof. Tauno Piirainen, Oulun yliopistn Geologian laitos, aiheesta "Suomen malmipotentiaaliset vyöhykkeet"

— FM Markus Ekberg, Outokumpu Mining Services Oy, aiheesta "Pienten malmien hyödyntäminen". Esitelmän muut tekijät olivat DI Heikki Oravainen ja DI Risto-Matti Toivanen, Outokumpu Mining Services Oy.

— Toimitusjohtaja Heikki Kauppinen, ProduMinCon Oy, aiheesta "Kaivosammattilaisten yhteiset ongelmat malmiesiintymiä hyödynnettäessä".

Suomen kallioperän kehitys ja raaka-ainevarat-päivät järjestettiin Oulussa 1.–2.10. yhdessä Suomen Geologisen Seuran ja Geologiliiton kanssa. Päiville osallistui yhteensä 162 henkilöä ja niiden aikana pidettiin yhteensä 20 esitelmää. Järjestelyistä vastasi työryhmä: Martti Lehtinen, Suomen Geologinen Seura, Pentti Hölttä, Geologiliitto ja Elias Ekdahl ja Sirkku Halonen VMY:n geologijaosto.

Malmiarvioseminaari järjestettiin yhdessä VMY:n Geologijaoston ja Geologisen toimikunnan kanssa Otaniemessä, TKK:n materiaali- ja kalliotekniikan laitoksella 26.11. Seminaariin osallistui noin 80 henkilöä. Päivien järjestelyistä vastasi työryhmä: Jyrki Parkkinen, Geologian tutkimuskeskus, Juhani Astala, Partek Industrial Minerals Oy Ab ja Jouni Reino Outokumpu Mining Services Oy.

### Toimihenkilöt

Toimintavuonna 1992 vuosikokouksesta lähtien on johtokunnan kokoonpano ollut seuraava: puheenjohtajana FL Elias Ekdahl, Geologian tutkimuskeskus, varapuheenjohtajana FM Tuomo Korkalo, Outokumpu Finnmines Oy, sihteerinä FK Sirkku Halonen, Geologian tutkimuskeskus ja muina jäseninä FM Juhani Astala, Partek Industrial Minerals Oy Ab, FM Jaakko-Pekka Perttula, Saxo Oy ja DI Timo Rekola, Outokumpu Finnmines Oy.

### Jäsenmäärä

Geologijaoston jäsenmäärä oli vuoden 1992 lopussa 448. Uusia jäseniä liittyi 19. Kuoleman kautta jaostostamme poistuivat DI Aukusti Arvela, joka oli yhdistyksen jäsen vuodesta 1944, FM Ilpo Laiti, joka oli yhdistyksen jäsen vuodesta 1954, johtaja Juhani Nuutilainen, joka oli yhdistyksen jäsen vuodesta 1957, FM Osmo Nykänen, joka oli yhdistyksen jäsen vuodesta 1974 ja FM Aarre Stenberg, joka oli yhdistyksen jäsen vuodesta 1961.

**Elias Ekdahl** puheenjohtaja — **Sirkku Halonen** sihteeri

## KAIVOSJAOSTON TOIMINTAKERTOMUS VUODELTA 1992

### Toiminta

Kaivosjaosto on kokoontunut toimintavuoden aikana kaksi ja jaoston johtokunta viisi kertaa.

Kaivosjaoston vuosikokous pidettiin Messukeskuksessa, Helsingissä 20.3.1992 kello 13.35 alkaen. Läsnä oli 66 jäsentä. Kokouksen jälkeen kuultiin seuraavat esitelmät:

1. ETA:n vaikutuksia Suomen kaivosteollisuuteen, apul.joht. E. Ulvelin, TTK
2. Lokomosta Nordbergiin — Suomalaisen murskauslaitevalmistajan kansainvälinen tie, joht. J. Suominen, Lokomo Oy
3. Siilinjärven kaivoksen laajennus, keh.pääll. O. Paatsola, Kemira Oy.

Syyskokous pidettiin syysretken yhteydessä Sally Albatrossilla 1.9.1992. Läsnä oli 41 jäsentä. Syysretken kohteena oli Nordkalk Storugns Ab:n ja Cementan laitokset Gotlannissa. Iltajuhlasta vastasi Nordkalk Oy Ab.

Kaivosjaoston puheenjohtaja on toiminut Bergsprängningskommittén, Svenska Gruvföreningenin, BEFO:n ja NIF:n yhdysmiehenä.

Kalliomekaniikan toimikunnan johtokunnassa ovat toimineet FL Lennart Lauren ja DI Pekka Loven.

TkT Pekka Särkkä on toiminut ISRM:n yhdysmiehenä.

FL Lennart Lauren on toiminut VMY:n edustajana ISM:ssä ja pohjoismaisessa kaivosmittauskomiteassa.

### Toimihenkilöt

Toimintavuonna 1992 on jaoston puheenjohtajana toiminut DI Kimmo Kekki, varapuheenjohtajana FI Lennart Laure ja johtokunnan muina jäseninä DI Lauri Siirama, DI Mikko Räsänen, TkL Timo Soikkeli ja TkL Seija Sundholm. Sihteerinä on toiminut DI Tommy Grahn.

### Jäsenet

Jaoston jäsenmäärä oli vuoden 1992 lopussa 441 henkilöä, lisäystä edellisvuodesta 19 henkilöä. Uusia jäseniä hyväksyttiin vuoden aikana 20 kappaletta, joista nuoria jäseniä yhdeksän kappaletta.

**Kimmo Kekki** puheenjohtaja — **Tommy Grahn** sihteeri

## METALLURGIJAOSTON TOIMINTAKERTOMUS VUODELTA 1992

### Varsinainen toiminta

Metallurgijaosto on kokoontunut toimintakauden aikana vuosikokoukseen.

Vuosikokous pidettiin Vuorimiesyhdistyksen vuosikokouksen yhteydessä 20.3.1992 Helsingissä Messukeskuksessa. Kokouspaikalla rekisteröityi 268 jaoston jäsentä.

Vuosikokouksessa kuultiin seuraavat esitelmät:

- DI Seppo Isoherranen, toimitusjohtaja, Verkställande Direktör, Outokumpu Copper Oy, "Etabloituminen yhdentyvään Eurooppaan ja kansainvälistyminen – Etablering i integrerande Europa och internationalisering"
- Oik. kand. Seppo Sahlman, Putki- ja profiiliryhmän johtaja, Direktör, Rör- och profildivisionen, Rautaruukki Oy, "Rautaruukin Putki- ja profiiliryhmä jatkojalostajana Euroopassa – Rör- och profildivisionen av Rautaruukki som en vidareförädlare i Europa"
- DI Kari Autio, $TiO_2$-Tulosryhmän johtaja, Direktör, $TiO_2$-Divisionen, Kemira Oy, "Yritysostostrategian toteutus – Case Kemira Inc. USA – Genomförande av strategin för företagsförvärvande – Case Kemira Inc. USA"

Lauantain ekskursion kohteena oli Tekniikan Museo Helsingin Viikissä.

Jaoston kesäretki oli suunniteltu tehtäväksi 27.–29.8.1992 Pechenga Nickel -kombinaattiin Kuolaan. Retki jouduttiin tehtaalla sattuneen onnettomuuden johdosta peruuttamaan.

Vuonna 1992 ei järjestetty syyskokousta.

### Koulutustoiminta

Koulutustoiminta on hoidettu Metallurgian Valtakunnallisen Asiantuntijatoimikunnan (metallurgian VAT) kautta. Puheenjohtajana on toiminut TkT Veikko Heikkinen. VAT on kokoontunut toimintavuoden aikana kolme kertaa.

Varsinaiset koulutustapahtumat on perinteisesti järjestetty yhdessä yhteistyökumppanin kanssa. Tällä toimintakaudella järjestettiin INSKO:n kanssa seuraavat koulutustilaisuudet:

★ "Automaatio ja prosessin ohjaus", 13.–14.5.1992 Tampereella. Läsnä oli 20 osanottajaa.

★ "Eristäminen korkean lämpötilan prosessiteollisuudessa", 28.–29.10.1992, Vantaalla. Läsnä oli 32 osanottajaa.

Metallurgijaoston Korkeakouluyhteistyöelin kokoontui puhelinkokoukseen ja yhteiskokoukseen jaoston johtokunnan kanssa. Yhteistyöelin kokosi koulutustapahtumalistan, joka julkaistiin jaoston tiedotuslehdessä keväällä 1992. Yhteistyöelimen puheenjohtajana on toiminut professori Antti Korhonen.

### Tiedotus

Jaoston lehti "Metallurgijaosto tiedottaa" on ilmestynyt perinteistä poiketen vain kaksi kertaa. Numero 3, ns. "kesäretki-numero", jätettiin kesäretken peruuntumisen johdosta julkaisematta.

### Toimihenkilöt

Metallurgijaoston jäsenmäärä oli vuoden 1992 lopussa 1075. Vuoden 1992 aikana jaoston johtokunta puolsi uusiksi jäseniksi 21 henkilöä, joista 13 varsinaista ja 8 nuorta jäsentä (VMY:n hallituksessa hyväksyttyjä 29). Tämän lisäksi palautettiin suosittelijoille lausuntoa varten yksi jäsenanomus.

**Kalevi Nikkilä** puheenjohtaja — **Lars Helle** sihteeri

# RIKASTUS- JA PROSESSITEKNIIKKA JAOSTON TOIMINTAKERTOMUS VUODELTA 1992

## Toiminta

Rikastus ja prosessitekniikan jaoston vuosikokous pidettiin Vuorimiesyhdistyksen vuosikokouksen yhteydessä 20.3.1992 Messukeskuksessa Helsingissä. Kokouksessa valittiin johtokunnan uusiksi jäseniksi TkL Ulla-Riitta Lahtinen ja DI Seppo Lähteenmäki.

Kokouksessa oli läsnä 60 osanottajaa.

Kokouksen jälkeen kuultiin seuraavat esitelmät:
— Toimitusjohtaja, DI Seppo Kreula, Outokumpu Mintec Oy "Rikastusteknologiamme kilpailukyky"
— DI Carl-Johan Skand, Lohja Oy "Laadunvarmistusta: laatujärjestelmät mineraaliteollisuudessa"
— Toimitusjohtaja, DI Risto Heiskanen, Minera Outokumpu Chile S.A. "Lince LX-SX-EW kuparikaivos Chilessä"

## Syysseminaari

Vedenerotusseminaari pidettiin 17.—18.9.1992 Lappeenrannassa.

## Jatkokoulutuskurssi

VMY ja TKK järjestivät yhdessä jatkokoulutuskurssin: Optimaalinen piirisuunnittelu TKK:lla 31.3.—2.4.1992. Tavoitteena oli opettaa miten taulukkolaskentaa voidaan käyttää mineraalien rikastuksessa.

## Toimihenkilöt

Jaoston kokoonpano on 20.3.1992 lähtien ollut seuraava:
Jouko Kallioinen, puheenjohtaja
Ulla-Riitta Lahtinen
Seppo Lähteenmäki
Jouko Olkkonen
Jorma Reinikainen
Jukka Karhunen, sihteeri

Jaoston johtokunta kokoontui toimintavuoden aikana 7 kertaa.

## Jäsenet

Jaoston jäsenmäärä 31.12.1992 oli 290, lisäystä edelliseen vuoteen verrattuna 8 jäsentä.

**Jouko Kallioinen**
puheenjohtaja

**Jukka Karhunen**
sihteeri

# OTTEITA TUTKIMUSVALTUUSKUNNAN TOIMINTAKERTOMUKSESTA VUODELTA 1992

## Tutkimusvaltuuskunta (YVK)

Tutkimusvaltuuskunnan sääntömääräinen vuosikokous pidettiin 14.2.1992 Helsingissä. Valtuuskuntaan kuului toimintakauden aikana tutkimusjäseninä 23 yritystä, kukin yhdellä edustajalla, sekä Outokumpu Oy kahdella edustajalla. Tutkimusvaltuuskuntaan kuuluivat lisäksi VMY:n hallituksen nimittämä asiantuntijajäsen ja VMY:n neljän jaoston puheenjohtajat.

Tutkimusvaltuuskunnan puheenjohtajana toimi DI Paavo Eerola, varapuheenjohtajana DI Juha Pajari. FT Jyrki Parkkinen toimi valtuuskunnan ja sen toimikuntien sihteerinä.

Tutkimusvaltuuskunnan kokoonpano ja toimikaudet:

| Tutkimusjäsen | Varsinainen edustaja | | Varamies | |
|---|---|---|---|---|
| Vibrometric Oy | MSc Calin Cosma | -92 | DI Reijo Korhonen | -92 |
| Finnminerals Oy | DI Hannu Haveri | -92 | DI Jouko Olkkonen | -92 |
| Oy Forcit Ab | Ins Kalle Ylätalo | -94 | FM Rolf Strandberg | -92 |
| Oy Förby Ab | DI Harri Eronen | -94 | DI Jarmo Suvio | -94 |
| Kemira Oy | DI Lauri Siirama | -93 | DI Jarmo Aaltonen | -93 |
| Larox Oy | Ins Tapio Keskisaari | -93 | DI Mikko Häkämies | -93 |
| Lemminkäinen Oy | DI Bjarne Liljestrand | -93 | DI Markku Volotinen | -93 |
| Lohja Oy Ab | DI Juha Pajari | -93 | FM Heikki Latva | -93 |
| Myllykoski Oy | FM Pertti Huopaniemi | -94 | FM J-P Perttula | -94 |
| Orion-Yhtymä Oy, Normet | DI Matti Koskinen | -92 | | |
| Outokumpu Oy (Outokumpu Mining Services Oy) | DI Paavo Eerola | -93 | Ins Eero Soininen | -93 |
| Outokumpu Oy (Outokumpu Mining Services Oy) | DI Pentti Seppänen | -94 | DI Pekka Lappalainen | -94 |
| Partek Minerals Oy Ab | FM Esko Lundén | -93 | DI Kimmo Kekki | -93 |
| Rammer Oy | DI Timo Sippus | -93 | DI Matti Vestman | -93 |
| Rauma Oy | DI Veikko Linnola | -93 | DI Jouko Suominen | -93 |
| Rautaruukki Oy | DI Esko Pöyliö | -93 | FT Kyösti Heinänen | -93 |
| Roxon Oy | DI Erkki Matikainen | -93 | Ins Rauno Ihatsu | -93 |
| Suomen Malmi Oy | DI Pekka Mikkola | -94 | FM Esko With | -94 |
| Suomen Vuolukivi Oy | DI Esko Teerikorpi | -93 | | |
| Tamrock Oy | DI Rolf Ström | -93 | DI Pertti Koivunen | -93 |
| Teollisuuden Voima Oy | DI Heikki Hinkkanen | -93 | FM Timo Äikäs | -93 |
| Terraplan Oy | Ins Kalevi Hytti | -92 | | |
| YIT-Yhtymä Oy | DI Pekka Liisanantti | -92 | TkL Tuomo Tahvanainen | -92 |

VMY:n hallituksen valitsema asiantuntijajäsen: DI Urpo Salo, KTM
VMY:n jaostojen puheenjohtajat:
Geologijaosto, FL Eljas Ekdahl
Kaivosjaosto, DI Kimmo Kekki
Rikastus- ja prosessijaosto, Prof Kari Heiskanen
Metallurgijaosto, TkT Kalevi Nikkilä.

Tutkimusvaltuuskunnan toimintaan ovat tutkimusjäsenten lisäksi kertomusvuoden aikana aktiivisesti osallistuneet seuraavien laitosten tai virastojen edustajat:
— Teknillinen korkeakoulu
— Helsingin yliopisto
— Oulun yliopisto
— Geologian tutkimuskeskus
— Valtion teknillinen tutkimuskeskus
— Kauppa- ja teollisuusministeriö

## Tutkimusjohtokunta

Tutkimusjohtokunta kokoontui kertomuskauden aikana viisi kertaa: 15.1. Espoossa, 14.2. Helsingissä, 5.5. Helsingissä, 9.9. Virkkalassa ja 19.11. Espoossa.

Tutkimusjohtokunnan kokoonpano oli seuraava:
DI Paavo Eerola, Outokumpu Mining Services Oy, puheenjohtaja
DI Juha Pajari, Lohja Oy Ab, varapuheenjohtaja
DI Jarmo Aaltonen, Kemira Oy
DI Pekka Lappalainen, Outokumpu Mining Services Oy
FM Esko Lundén, Oy Partek Ab, jäsen päivämäärästä 11.12.1991
Prof Heikki Niini, TKK
DI Urpo Salo, KTM (asiantuntijajäsen)

## Tutkimustoimikunnat

— Geologinen toimikunta, pj. prof. Heikki Niini
— Kaivosteknillinen toimikunta, pj. DI Pekka Lappalainen
— Rikastusteknillinen toimikunta, pj. DI Jarmo Aaltonen.

## Tutkimukset

Johtokunta ja toimikunnat valvoivat vuoden aikana kaikkiaan kahdeksaatoista projektia, joista kaksi oli yhteispohjoismaista.

Suoraan tutkimusjohtokunnan valvonnassa oli kahdeksan projektia, joista yksi yhteispohjoismainen:
— Edunvalvonta
— Kaivosten jälkihoito
— Kaivosten ympäristöasiat
— Kiven fragmentointi
— Malmgränsbestämning med borrhålsmätningar i gruvor
— Kaivosympäristön suojelukongressi 1993
— Vuoriteollisuus 2000 teknologiaohjelma
— Analys av tremolit i dolomit

Geologisen toimikunnan valvonnassa olivat projektit:
— Lämpökuvaus geologisessa tutkimuksessa
— Teknillisen geologian terminologia
— Geologiset ympäristövaikutukset kalliotilojen louhinnassa
— Geofysiikan ja geokemian kompleksitulkinnat
— Saattoporan kultamalmin geologinen mallitus
— Malmiarvioseminaari

Kaivosteknillisen toimikunnan valvonnassa olivat projektit:
— Uuden murskaus- ja kuljetusteknologian soveltaminen avolouhintaan
— Irroitustekniikan vaikutus lopputuotteen laatuun rakennuskiviteollisuudessa

Rikastusteknillisen toimikunnan valvonnassa olivat projektit:
— Näytteenoton käsikirja
— Kuva-analyysi rikastusmineralogiassa

Tutkimusjohtokunta ja toimikunnat valmistelivat projekteja:
— EC-direktiivit
— Teollisuusmineraalit ja niiden etsintä
— Vaahdotuksen erikoismenetelmät
— Processmineralogi.

## Pohjoismainen yhteistyö

Tutkimusjohtokunta
Tutkimusjohtokunta ja eri toimikunnat ovat pitäneet yhteyttä pohjoismaisiin veljesjärjestöihin. Esko Lundén edusti tutkimusvaltuuskuntaa neuvotteluissa, joissa tutkittiin yhteispohjoismaisten EC-projektien mahdollisuuksia. 1992 valmistui hanke Malmgränsbestämning med borrhållsmätningar i gruvor (TJ/KT/GT).

Geologinen toimikunta
Geologisten toimikuntien yhteispohjoismainen kokous Nordiskt Geokommittémöte pidettiin Falunissa 14.—15.5.1992. Kokoukseen osallistui kolme edustajaa Norjasta, neljätoista Ruotsista ja neljä Suomesta. Kokouksen pääteemoina olivat ympäristökysymykset ja vuoriteollisuuden ongelmat.

Kaivosteknillinen toimikunta
Pohjoismaiset kaivosteknillisten toimikuntien Nordiskt Gruvforskningsmöte pidettiin Trondheimissa 24.—26.8.1992. Kokoukseen osallistui Ruotsista kahdeksan, Norjasta yhdeksän ja Suomesta kaksi edustajaa. Kokouksen merkittävin teema oli pohjoismaiden yhteisosallistuminen EC-projekteihin. Asiaa tutkimaan perustettiin työryhmä, johon tulivat kuulumaan Stein Krogh (SINTEF, Norja), Per-Arne Lindqvist (MITU, Ruotsi) sekä Esko Lundén (TVK/VMY, Suomi).

Rikastusteknillinen toimikunta
Pohjoismainen rikastusteknillisten toimikuntien Nordiskt Mineralteknik-Möte pidettiin 20.—21.8.1992 Outokummussa ja Siilinjärvellä. Kokoukseen osallistui Norjasta neljä, Ruotsista kolme ja Suomesta kymmenen edustajaa. Pääteemat olivat teknologiaohjelmat ja pohjoismainen EY-yhteistyö. Kutsuttuna esitelmöitsijänä johtaja Markku Koskenlinna, TEKES, selosti Suomen teknologiapolitiikkaa 90-luvulla.

## Raportit ja tiedottaminen

Tutkimusten raportointi
Vuoden 1992 aikana ja vuosien 1992/1993 vaihteessa julkaistiin tutkimusvaltuuskunnan tukemista tutkimuksista seuraavat raportit:

A98 Jukka Alli: Uuden murskaus- ja kuljetusteknologian soveltaminen avolouhintaan.
A99 Ilmo Kukkonen, Heikki Vanhala: Termisen infrakuvauksen käyttömahdollisuudet geologisiin tutkimuksiin Suomessa.
A100 Jukka Mäkelä: Geologiset ympäristövaikutukset kalliotilojen louhinnassa.
B50 Geokemian päivät Oulussa 28.—29.11.1990.
B51 Suomen kallioperän kehitys ja raaka-ainevarat. Oulu 1.—2.10.1992.
B53 Malmiarvioseminaari Otaniemessä 26.11.1992.

## Pohjoismaista saadut raportit

Stiftelsen Bergteknisk Forskning BeFo:
— Lars Olsson, Lars Rosengren, Håkan Stille: Bergklassificering med hjälp av regressionsanalys.

## Muut:

— SKN (Statens Kärnbränsle Nämnd): Geogas — a Carrier or a Tracer? Report 51., OCT 1991.
— SKN: Geogas in Crystalline Bedrock. Report 52., Oct 1991.
— Tekniska Högskolan i Luleå: Teaching and Research Activities 1991.
— SveDeFo: Verksamheten 1991.
— SINTEF: Verdiskapande forskning, Årberetning 1991.
— Svenska Gruvföreningen: Svensk Gruvrevy 1991.

TKK:n Materiaali- ja kalliotekniikan laitoksen kirjaston kanssa on sovittu, että pohjoismaiset raportit toimitetaan kirjastolle toimikunta- ja johtokuntaesittelyn jälkeen, käytännössä valtuuskunnan vuosikokouksen jälkeen vuosittain.

Tutkimusvaltuuskunnan puolesta

**Paavo Eerola** — puheenjohtaja
**Jyrki Parkkinen** — sihteeri

## UUSIA JÄSENIÄ — NYA MEDLEMMAR

Vuorimiesyhdistys-Bergsmannaföreningen r.y.:n hallitus on hyväksynyt seuraavat henkilöt yhdistyksen jäseniksi:

**Kokouksessa 29.1.1993**

**Aatos, Soile** Pirjo Hannele, FK, s. 30.12.1964, määräaikainen geologi, GTK Geokemian osasto. Os.: Hakatie 4 A 2, 54410 YLÄMAA. Jaosto: geo.
**Heinonen, Jouni** Aslak, 100 ov, s. 29.11.1967, opiskelija, Oulun yliopisto. Os.: Yliopistonkatu 28 A 101, 90570 OULU. Jaosto: geo.
**Jokinen, Jarkko** Mikael, FK, s. 14.04.1966, geofyysikko, tutkimusassistentti, GTK Kuopio. Os.: Koiravedenkatu 17 A 3, 70800 KUOPIO. Jaosto: geo.
**Juvonen, Ilkka** Antero, ekonomi, s. 14.07.1944, myyntijohtaja, Rautaruukki Oy Hämeenlinna. Os.: Rautaruukki Oy, 13300 HÄMEENLINNA. Jaosto: met.
**Kaukonen, Risto** Johan, 102.5 ov, s. 08.05.1968, opiskelija, Oulun yliopisto. Os.: Hämäläntie 8 A 2, 90800 OULU. Jaosto: geo.
**Kemppainen, Mika** Juhani, 100 ov, s. 12.10.1968, opiskelija, Oulun yliopisto. Os.: Pysäkkitie 33, 90310 OULU. Jaosto: geo.
**Kuronen, Erkki** Olavi, 100 ov, s. 16.03.1970, opiskelija, Oulun yliopisto. Os.: Toivonniementie 9 as 37, 90500 OULU. Jaosto: geo.
**Kuusinen, Markku** Juhani, pros.ins., s. 24.01.1959, prosessi-insinööri, Okmetic Oy. Os.: Törmäniityntie 15 C 35, 02710 ESPOO. Jaosto: met.
**Lampela, Outi** Kirsti Heleena, DI, s. 29.03.1949, talousjohtaja, Outokumpu Engineering Oy. Os.: Uurrekuja 36, 01650 VANTAA. Jaosto: met.
**Lappalainen, Markku**, 115 ov, s. 13.06.1968, opiskelija, Oulun yliopisto. Os.: Aleksanterinkatu 47 as 5, 90100 OULU. Jaosto: geo.
**Lassila, Kari** Tuomo, ekonomi, s. 16.08.1946, talousjohtaja, Outokumpu Oy, pääkonttori. Os.: Kuitinmäenkaari 16 B 4, 02210 ESPOO. Jaosto: met.
**Lehto, Janne** Matias, 102 ov, s. 02.08.1968, opiskelija, TKK. Os.: Avaruuskatu 3 G 129, 02310 ESPOO. Jaosto: kai.
**Montonen, Mikko** Juhani, DI, s. 20.11.1965, prosessi-insinööri, Okmetic Oy. Os.: Punavuorenkatu 9 A 26, 00120 HELSINKI. Jaosto: met.
**Pahkala, Arto** Tapio, DI, s. 14.08.1963, asiakaspalveluinsinööri, Outokumpu Polarit Oy. Os.: Honkalankatu 12, 95420 TORNIO. Jaosto: met.
**Paulasto, Mervi** Marketta, DI, s. 08.10.1966, tutkija, TKK. Os.: Eerikinkatu 29 D 76, 00180 HELSINKI. Jaosto: met.
**Peuranen, Pekka** Oskari, 160 ov, s. 30.09.1961, opiskelija, Oulun yliopisto. Os.: Toivonniemenkatu 1 B 220, 90500 OULU. Jaosto: geo.
**Pilvinen, Harri** Tapani, 140 ov, s. 04.07.1965, opiskelija, TKK. Os.: Kipparinkuja 1 G 125, 02320 ESPOO. Jaosto: met.
**Rahunen, Vesa** Jussi, DI, s. 16.01.1942, liiketoimintojen kehitysjohtaja, Outokumpu Technology Oy. Os.: Meritullinkatu 13 D 123, 00170 HELSINKI. Jaosto: met.
**Salmi, Pekka** Tapani, DI, s. 12.01.1957, tekninen asiakaspalveluinsinööri, Outokumpu Polarit Oy. Os.: Uusikatu 4 A 2, 95400 TORNIO. Jaosto: met.
**Toivanen, Markku** Reino, DI, s. 27.09.1941, toimitusjohtaja, Outokumpu Metals & Resources Oy. Os.: Miniatonkuja 1 C 18, 02360 ESPOO. Jaosto: geo kai rik met.
**Vatanen, Jukka-Pekka**, 125 ov, s. 07.09.1969, opiskelija, Oulun yliopisto. Os.: Liisantie 1 C 16, 90560 OULU. Jaosto: geo.
**Virolainen, Juha** Ilmari, DI, s. 11.09.1960, prosessi-insinööri, Okmetic Oy. Os.: Oravaistenkuja 2, 04400 JÄRVENPÄÄ. Jaosto: met.
**Vuorinen, Timo** Tapio, DI, s. 31.12.1960, projektisuunnittelija, Jaakko Pöyry Oy Vantaa. Os.: Kuusikallionkuja 4 E 41, 02210 ESPOO. Jaosto: met.

**Kokouksessa 27.5.1993**

**Airola, Raimo** Juhani, DI, s. 21.01.1943, hankinta- ja valmistuspäällikkö, Outokumpu Mintec Oy. Os.: Mankkaantie 33, 02180 ESPOO. Jaosto: rik.
**Andersin, Erik** Kristian, DI, s. 15.12.1960, tutkimusinsinööri, Outokumpu Research Oy. Os.: Aino Ackténtie 8 D 15, 00400 HELSINKI. Jaosto: met.
**Eklin, Lauri** Heikki, 130 ov, s. 11.10.1968, opiskelija, TKK. Os.: Nuottapolku 6, 00330 HELSINKI. Jaosto: met.
**Hassi, Simo**, DI, s. 03.03.1955, toimitusjohtaja, Huber Testing Oy Ab. Os.: Huber Testing Oy Ab, PL 120, 01511 VANTAA. Jaosto: met.
**Hänninen, Outi** Marjut, 165 ov, s. 14.05.1969, opiskelija, TKK. Os.: Rälssintie 16 G 84, 00720 HELSINKI. Jaosto: met.
**Julin, Yrjö** Matti Kalervo, TkL, s. 06.09.1957, valimo- ja konepajaryhmän johtaja, JOT-Yhtiöt Oy. Os.: Johan Sederholmintie 8 A 7, 00820 HELSINKI. Jaosto: met.
**Järvensivu, Mika** Markus, DI, s. 27.12.1968, tutkimusinsinööri, Outokumpu Mintec Oy. Os.: Vilpunkatu 2 E 25, 02230 ESPOO. Jaosto: rik.
**Lahtinen, Markku** Juha, TkL, s. 06.08.1958, projekti-insinööri, Outokumpu Engineering Contractors Oy. Os.: Taratie 1, 04130 SIPOO. Jaosto: met.
**Leinonen, Seppo** Tapani, LuK, s. 21.12.1965, opiskelija. Os.: Sirkunpolku 13, 87500 KAJAANI. Jaosto: geo.

**Millner, Dan** Ernst David, DI, s. 01.06.1950, myyntijohtaja, Outokumpu Engineering Services Oy. Os.: Martintie 12 F, 02270 ESPOO. Jaosto: rik.
**Mäkilä, Sari** Sinikka, 97,5 ov, s. 09.04.1966, opiskelija, TKK. Os.: Revontulentie 2 E 63, 02100 ESPOO. Jaosto: rik.
**Neuss, Ian** David, B.Sc., s. 26.06.1945, Exploration Manager/Managing Director, Outokumpu Exploration Australia Pty Ltd. Os.: Outokumpu Explor. Australia 141 Burswood Rd, VICTORIA PARK 6100 WA AUSTRALIA. Jaosto: geo.
**Nikolov, Stefan** Nikolov, DI, s. 14.06.1962, tutkimusinsinööri, Outokumpu Research Oy. Os.: Väinönraitti 3 G 51, 28330 PORI. Jaosto: met.
**Pakkanen, Jorma** Juhani, DI, s. 11.09.1944, rakenneputket-ryhmän johtaja, Rautaruukki Oy. Os.: Metsälammentie 13, 13500 HÄMEENLINNA. Jaosto: met.
**Pihlajamäki, Seppo** Juhani, ins. s. 22.08.1952, aluemyyntipäällikkö, Rammer Oy. Os.: Vierutie 14, 15560 LAHTI. Jaosto: kai.
**Syrjälä, Ulla** Anita, 130,5 ov, s. 11.12.1968, tutkimusapulainen, TKK. Os.: Hämeentie 14 B 49, 00530 HELSINKI. Jaosto: met.
**Vanhanen, Erkki** Johannes, FM, s. 07.07.1953, raaka-aine toimialapäällikkö, GTK. Os.: Keksikuja 3, 96460 ROVANIEMI. Jaosto: geo.

**Kokouksessa 2.9.1993**

**Bergström, Kaj** Rafael, DI, s. 23.11.1954, CAD-kehitysinsinööri, A Ahlström Oy Karhula. Os.: Nuijatie 11 D 51, 01650 VANTAA. Jaosto: met.
**Chernet, Tegist**, MSc, s. 27.01.1966, Research Assistant, Geological Survey of Finland, Kuopio. Os.: Päivärinteentie 31 as 1, 70300 KUOPIO. Jaosto: geo rik.
**Grönholm, Pentti** Onni Tapani, FK, s. 21.11.1964, tilapäinen geologi/tutkija, Outokumpu Finnmines Oy/Helsingin Yliopisto. Os.: Mäkitorpantie 6 B 17, 00620 HELSINKI. Jaosto: geo.
**Kajanen, Juha** Pekka, DI, s. 19.09.1965, tutkija, TKK Kalliotekniikan laboratorio. Os.: Haavikkopolku 1 K 66, 00630 HELSINKI. Jaosto: geo kai.
**Karvinen, William (Bill)**, PhD, s. 01.04.1946, Consulting Geologist, W.O. Karvinen & Ass. Ltd. Os.: RR 3, ODESSA Ont. CANADA K8H 2HO. Jaosto: geo.
**Kaskiala, Markku** Juhani, DI, s. 12.03.1951, laboratorioinsinööri, TKK Materiaalien valmistustekniikka. Os.: Topeliuksenkatu 7 B 31, 00250 HELSINKI. Jaosto: met.
**Konttinen, Jukka** Pekka, DI, s. 29.04.1965, käyttöinsinööri, jatkuvalu, Rautaruukki Oy Raahe. Os.: Ruskontie 6 A, 92120 RAAHE. Jaosto: met.
**Kupari, Pentti** Antero, DI, s. 21.03.1961, tutkimusinsinööri, Outokumpu Polarit Oy. 95300 TERVOLA. Jaosto: met.
**Lehtonen, Jyri** Antti, DI, s. 01.12.1956, toimitusjohtaja, JOT-yhtiöt Oy Helsinki. Os.: Vanhakelkkamäki 20, 00570 HELSINKI. Jaosto: met.
**Liikanen, Jaakko** Seppo Kalervo, FK, s. 14.02.1952, geologi, ESACONS Oy Kuusankoski. Os.: Jyrääntie 4, 45720 KUUSANKOSKI. Jaosto: geo.
**Neuvo, Jussi** Mikael, DI. s. , toimitusjohtaja, Osuuskunta Metex. Os.: Dosentintie 1 B, 02700 KAUNIAINEN. Jaosto: met.
**Rissanen, Juha** Pekka, FM, s. 08.07.1960, geologi, Malmikaivos Oy Luikonlahti. Os.: Uunonpolku 12 B 13, 73600 KAAVI. Jaosto: geo.
**Sassi, Martti** Olavi, DI, s. 20.12.1964, tutkimusinsinööri, Outokumpu Polarit Oy. Os.: Kauppakatu 40 as 6, 95400 TORNIO. Jaosto: met.
**Wiik, Bengt** Torvald, DI, s. 25.09.1963, t.f. assistent, TH/Mak. Os.: Fredriksgatan 24 D 22, 00120 HELSINKI. Jaosto: met.

## UUTTA JÄSENISTÄ — NYTT OM MEDLEMMARNA

**Koivisto, Harri,** DI, käyttöpäällikkö, Partek Minerals Oy Ab. Os.: Mattilantie 59, 53650 LAPPEENRANTA.
**Paulin, Pertti,** DI, sisäinen tarkastaja, Metra Oy Ab. Os.: Laukkamäentie 21, 08500 LOHJA as..
**Sulanto Jukka,** toimitusjohtaja, Outokumpu Engineering Contractors Oy, Espoo.

## SUORITETTUJA TUTKINTOJA — AVLAGDA EXAMINA

## OULUN YLIOPISTO

### Geofysiikan laitos

Filosofian maisterit:

**Hiltula, Esa:** "Geomagneettinen aktiivisuus ja sen jaksollisuus".
**Niskanen, Matti:** "Geofysikaalisia tutkimuksia grafiittiesiintymän paikantamiseksi Keski-Pohjanmaan alueella".
**Salmirinne, Heikki:** "Johdevyökykkeiden kartoitus aerogeofysikaalisilla menetelmillä Keski-Pohjanmaan alueella".

### Prosessitekniikan osasto

Diplomi-insinööri:

**Ollila, Seppo:** "Palamisilmiöt masuunin hormeilla".

## TEKNILLINEN KORKEAKOULU, OTANIEMI

### Materiaali ja kalliotekniikan laitos

Tekniikan tohtorit:

Tekniikan lisensiaatti **Ari Tapani Jokilaakson** väitöskirja "Removal of antimony and arsenic from impure copper concentrates under simulated flash smelting reaction shaft conditions" tarkastettiin 9.10.1992 Teknillisen korkeakoulun Materiaali- ja kalliotekniikan laitoksella Otaniemessä. Virallisena vastaväittäjänä toimi professori Joachim Krüger, Institut für Metallhüttenwesen und Elektrometallurgie der RWTH Aachen, Saksa. Valvojana toimi professori Kaj Lilius, Teknillinen korkeakoulu.

Väitöskirjassa on tutkittu epäpuhtaiden kuparirikasteiden sisältämien antimonin ja arseenin hallittua poistamista Outokumpu Oy:n kehittämässä kuparinvalmistusprosessissa (liekkisulatusprosessi). Tutkimukset on tehty laboratoriouunissa, jossa on voitu keskittyä yksittäisten rikastehiukkasten ja kuuman kaasun välisiin reaktioihin. Palavat hiukkaset on sammutettu veteen, jolloin niiden reaktiot pysähtyivät tarkasti määrätyn ajan kuluttua. Kaasun happipitoisuutta ja lämpötilaa vaihtelemalla saatiin kartoitettua olosuhteet, joissa ko. epäpuhtausaineet poistuvat haihtumalla kaasuun. Parhaiten antimoni ja arseeni poistuivat, kun kaasun lämpötila oli korkein mahdollinen ja happipitoisuus oli 1—2 til.-%.

Tekniikan lisensiaatti **Jyrki Matti Miettisen** väitöskirja "Mathematical simulation of interdentritic solidification of low-alloyed and stainless steels" tarkastettiin 12.12.1992 Teknillisen korkeakoulun Materiaali- ja kalliotekniikan laitoksella Otaniemessä. Virallisena vastaväittäjänä toimi apulaisprofessori Jorma Kivilahti ja valvojana professori Lauri Holappa, Teknillinen korkeakoulu.

Työssä kehitettiin termodynaamiskineettinen malli, jolla voidaan simuloida matalaseosteisten ja ruostumattomien terästen interdendriittistä jähmettymistä. Malli laskee stabiilien seosfaasien osuudet ja koostumukset sekä seosaineiden mikrosuotautumat lämpötilan funktiona jähmettymisen edetessä. Näiden tietojen avulla voidaan etsiä syitä tiettyjen terästen murtumisaltiuteen. Mallia voidaan soveltaa erilaisille valuprosesseille (valannevalu, jatkuvavalu, nauhavalu, jne.) liittämällä se asianmukaiseen makroskooppista lämmönsiirtymistä simuloivaan matemaattiseen malliin.

Tekniikan lisensiaatit

**Karlemo, Ben:** "Titaanidioksidin valmistus RF-plasmalla".

**Korhonen, Juha Ville:** "Magneettisten karttojen geologisesta hyödyntämisestä".

**Korpiola, Kari:** "Induktiivisen plasmalaitteiston käyttöönotto ja kehitystyö".

**Kukkonen, Jari-Pekka Valo:** "Sähkökemialliset tutkimusmenetelmät $Al_2O_3$ ja $Al_2O_3$-$TiO_2$ pinnoitettujen terästen korroosiotutkimuksessa".

**Laine, Tenho:** "Kallioväestönsuojien rakennesuunnittelukäytäntö Suomessa".

**Larkiola, Jari:** "Rullamuovauksen mallintaminen".

**Niemelä, Oili:** "Näytteenotto jauheista".

**Nikolov, Stefan:** "Eräiden epäpuhtauksien eliminoiminen rikkaasta kuparikivestä ja raakakuparista emäksisiä kuonia käyttäen".

**Partinen, Jarkko:** "Sähkömagneettinen sekoitus teräksen jakuvavalussa; teoria, matemaattinen ja fysikaalinen mallintaminen".

**Sundström, Salla:** "3D-ROCK mallinnusjärjestelmä kallioperän rakennetutkimuksiin. Osa I. Tutkimustulosten käsittely ja tulkinta".

**Yang, Yongxiang:** "Thermal processing of metal powders in a radio frequency plasma".

**Zeng, Kejun:** "A thermodynamic evaluation of the Ni-Nb and Cr-Zr binary systems".

Diplomi-insinöörit:

**Ahokainen, Tapio:** "Liekkisulatusuunin kolmiulotteisen laboratoriomallin numeerinen simuloiminen".
**Hukkanen, Jopi:** "Eräiden ohutkalvopinnoitteiden vaikutus rahanleimaustyökalujen kestoikään".
**Inkinen, Jukka-Pekka Ilmari:** "Halidi-ionien vaikutus ruostumattoman teräksen pistekorroosioon".
**Isomäki, Iikka:** "Raudan ja piinitridikeramiikan kemiallinen vuorovaikutus".
**Jokinen, Kalle:** "Game gheoretic approach to union power and planning horizon: Application to Finnish data".
**Jääskeläinen, Kari:** "Pellettisintrausmenetelmän soveltuvuus Rautaruukki Oy:n sintrauskäytäntöön".
**Kankare, Aimo:** "Tuotannon ohjattavuuden kehittäminen alumiinituotteita valmistavassa yrityksessä".
**Kaukojärvi, Pasi:** "Kromisilisidi pohjaisten ohutkalvovastusmateriaalien valmistus ja karakterisointi".
**Kuntsi, Timo:** "Johdepolymeeriseosten optimointi".
**Laine, Jukka:** "Dynaamisen mallin kehittäminen teräksen jatkuvavalun sekundäärijäähdytyksen ohjaukseen".
**Laitinen, Kai:** "Metallien kuumennus- ja lämpökäsittelyuunien kerramiset kuitueristeet".
**Lehto, Harri Juhani:** "Syötteen raekoon ja pH:n vaikutus talkin vaahdottuvuuteen".
**Mononen, Sakari:** "Rauta- ja alumiiniköyhien kivimateriaalien tekninen saatavuus Suomessa".
**Myllykoski, Pirkka:** "Kuumanauhan Crownin madaltamisen vaikutukset kylmävalssatun nauhan poikittaiseen paksuusprofiiliin ja tasomaisuuteen".
**Peltonen, Kimmo:** "Suomen kallioperän malmipotentiaalin arviointi".
**Pitkänen, Petri:** "Kemin maanalainen kaivos".
**Rastas, Matti:** "Kaapelilangan suoraveto".
**Ruostetoja, Petri:** "Kalliomurskeen rakeisuus".
**Sjöblom, Johanna Tiina:** "Vesiohenteisten pohjamaalien käyttö laivan ulkopinnoissa".
**Somervuori, Mervi Elisabet:** "Materiaali- ja pinnoitevalinta fluorivety-ympäristössä".
**Suomi, Marja-Leena:** "Raakaraudan piipitoisuuden ennustusmalli".
**Tolppanen, Pasi Juhani:** "Merenalaisen liikennetunnelin suunnittelu".
**Tuononen, Kari:** "Autogeenijauhatuksen testausmenetelmät".
**Tuukkanen, Matti:** "Kuulalaakeriteräksen suotaumarakenteen tutkiminen".
**Vehviläinen, Jouni:** "Rautarikkaan metallikuparifaasin esiintyminen kuparisulaton kuonissa".
**Vuorinen, Tuija-Liisa:** "Seostuksen ja pinnoituksen vaikutus lyijyanodilla tapahtuvaan hapenkehitysreaktioon".
**Zhu, Lin:** "Effect of gelatine additives on electrodeposition of copper".

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## OIKAISU

**Vuoriteollisuus-Bergshanteringen -lehteen N:o 1, 1993.**

Vuorimiesyhdistys-Bergsmannaföreningen 1943—1993.
Valitan, että ainakin seuraavat, pelkästään omasta huolimattomuudestani aiheutuneet virheet ovat edellä mainitussa kirjoituksessa.
Sivu 20: Myös Imatran kuparitehtaan 9 MW:n (eikä 2,4:n).
Sivu 33: Outokummussa Kerettiin... syksyllä 1954 (eikä 1955).
Sivu 46: lisättävä: 1984 TkL Heikki Aulanko, 40-vuotishistoriikki.

**Toimi Lukkarinen**

# Vuorimiesyhdistys palkitsi ansioituneita vuorimiehiä

Vuorimiesyhdistys-Bergsmannaföreningen r.y. päätti 50-vuotisjuhlakokouksensa yhteydessä palkita Vuorimiesyhdistyksessä ja vuoriteollisuudessa ansiokkaasti toimineita vuorimiehiä yhdistyksen Eero Mäkinen ja Berndt Grönblom -mitalilla.

Vuorineuvos Eero Mäkisen nimeä kantavan ansiomitalin saivat professorit Toimi Lukkarinen ja Heikki Paarma sekä diplomi-insinööri Urpo J. Salo.

Grönblom-mitali ojennettiin tekniikan lisensiaatti Olavi Siltarille sekä diplomi-insinööreille Esko I. Laitinen ja Reino Mäkelä.

Mitalistit kuvassa vasemmalta Prof. Lukkarinen, Prof. Paarma, DI Salo, DI Laitinen, DI Mäkelä ja TkL. Siltari.


# Vuoriteollisuus 2000

## Teknologiaohjelma

Vuorimiesyhdistys asetti keväällä 1992 projektin selvittämään mineraalisia raaka-aineita hyödyntävän teollisuuden sekä sen liitännäistoimintojen merkitystä ja tulevaisuuden näkymiä sekä kokoamaan ohjelman alan kehitystyölle. Tässä selvityksessä vuoriteollisuudella tarkoitetaan lähinnä perinteisten metallimalmien sekä ns. teollisuusmineraalien etsintää, louhintaa ja rikastamista; metallurginen teollisuus on jätetty ulkopuolelle.

Raportin alkuosassa tarkastellaan Suomen vuoriteollisuuden historiallista taustaa, nykyistä tasoa, kansantaloudellista merkitystä ja tulevaisuuden näkymiä. Pääosa arvioinneista ja visioista on peräisin teollisuuden johdon haastatteluista. Raportin toinen osa koostuu teknologiaohjelmasta. Se perustuu yhdistyksen asettamien työryhmien ideointiin ja jakautuu geologisiin, kaivosteknisiin, rikastusteknisiin ja ympäristönsuojelun aliohjelmiin.

Maailmanlaajuisesti ajatellen vuoriteollisuus on kehittymässä ja laajenemassa väkiluvun ja raaka-ainetarpeen kasvaessa. Jo nykyisellään se tukeutuu ratkaisevasti korkeaan teknologiaan ja tutkimukseen. Runsaan liitännäisteollisuutensa kanssa se on integroitunut välttämättömäksi osaksi nykyaikaista yhteiskuntaa.

Suomen vuoriteollisuuden ja sen liitännäisteollisuuden suorituskyky ja tuotannon arvo ovat maamme väkilukuun nähden maailman huippuluokkaa. Tämän tason säilyttäminen riippuu osaksi kotimaamme raaka-ainevaroista, osaksi yhtiöidemme kansainvälisestä menestymisestä. Rakennuskiven, kiviaineksen ja teollisuusmineraalien raaka-ainevarat ovat hyvät. Sen sijaan metallisten varojen kotimainen ehtyminen on haaste lähivuosien kehitykselle. Menestyminen edellyttää panostusta jatkuvaan koulutukseen ja tutkimukseen — ja tässä tarvitaan myös yhteiskunnan tukea.

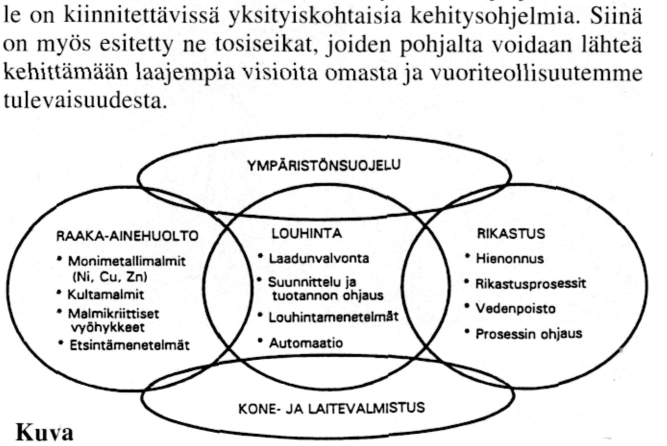
Raportin mukaan työnjako lähitulevaisuuden kehitystoiminnassa olisi seuraava:

— Malminetsinnän kehittämisestä, johon edelleen on voimakkaasti panostettava, huolehtii Geologian tutkimuskeskus.

— Kaivos- ja mineraaliteknologiassa käynnistetään suurehkoja kehitysohjelmia yritysten ja korkeakoulujen tutkimusorganisaatioiden toimesta. Rahoituksessa TEKESin osuus on tärkeä. Monikansallisiin ohjelmiin on pyrittävä mukaan. Esimerkiksi ympäristönsuojelun osalta tavoitteeksi on pitkällä tähtäimellä asetettava nk. jätteetön kaivos: kaivoksen jäännöstuotteet sijoitetaan mahdollisimman pitkälle jo tuotannon aikana louhinnan yhteydessä syntyneisiin tiloihin.

— VMY:n tutkimusvaltuuskunnan toimintaa on tarpeen jatkaa mutta aikaisempaa pienemmällä volyymilla. Pääpaino on edunvalvonnassa, informaation välittämisessä ja pohjoismaisten yhteyksien ylläpitämisessä.

Raporttiin tukeutuen on hyvä asettaa tavoitteita vuoriteollisuuden kehitykselle. Siinä on annettu yleisraameja, joiden sisälle on kiinnitettävissä yksityiskohtaisia kehitysohjelmia. Siinä on myös esitetty ne tosiseikat, joiden pohjalta voidaan lähteä kehittämään laajempia visioita omasta ja vuoriteollisuutemme tulevaisuudesta.




**Kuva**

Kaivosteollisuus on toiminnallisesti jaettu kolmeen "lenkkiin": raaka-ainehuoltoon, louhintaan ja rikastukseen. Kullakin on oma painopistealueensa teknologian kehittämisen kannalta. Ympäristönsuojelu ja siihen liittyvä teknologia koskettaa kaikkia toimintolenkkejä, samoin kone- ja laitevalmistus.

# The Finnish Association of Mining and Metallurgical Engineers 50 years old

The 50th Anniversary meeting of the Finnish Association of Mining and Metallurgical Engineers took place on Friday 19th and Saturday 20th of March at the brand new Marina Convention Centre in the heart of the City of Helsinki. More than 800 members and guests of the society had been gathered together to witness this historical milestone (Fig. 1).

The celebration was opened by the Society's Chairman, professor Raimo Matikainen (Fig. 2) who in his speech summarised the development of the Society from its start to present organisation with more than two thousand members. The States address to the celebrating society was given by Mr. Pekka Tuomisto, the Minister of Commerce and Industry (Fig. 3). The main address was presented by professor Markku Mannerkoski, the Director General of the Technical Research Centre of Finland (Fig. 4).

After the music played by Polytech Symphony Orchestra (Fig. 5) the audience enjoyed the excellent plenary speeches given by Sir Arvi Parbo, Western Mining Corporation (Fig. 6) and Mr Lenhard Holschuh, Secretary General of IISI (Fig. 7).

The Friday's program was continued in the afternoon with two sessions covering special topics of mining and base metal industry. The guest speakers in the Base Metal Session were Prof. Dr.-Ing. Ulrich Seiffert, Volkswagen AG, Dr. Paul E. Nilles, CRM and Prof. Nickolas Themelis, Columbia University, NY.

The celebration was continued at Marina in the evening when attendants and their wives collected to Anniversary banquet (Figs. 8, 9, 10 and 11).

Saturday afternoon was the occasion of the Society's traditional lunch which took place in a near-by restaurant, Wanha-Satama. Once again you could feel the old Finnish "Mining and Metallurgy" spirit accompanied by the Polytech Brass Band, Humpsvakar.

H. Laapas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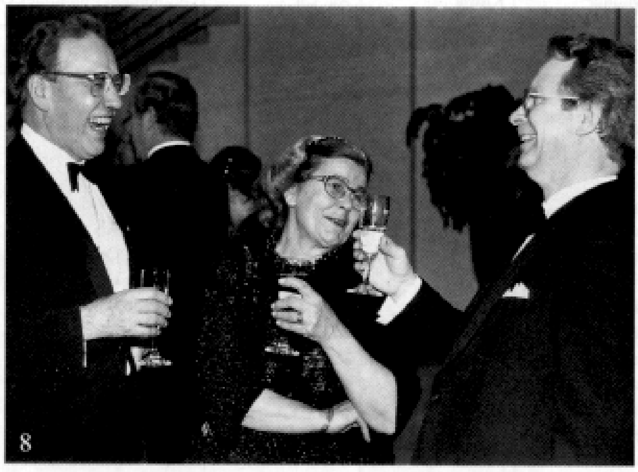
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# Tilastotietoja vuoriteollisuudesta v. 1992

## Ylitarkastaja Urpo J. Salo

| Kaivos | Kunta | Tärkeimmät arvoaineet | Haltija | Yhteensä nostettu | Malmia tai hyötykiveä | Kaivostyöntekijöitä keskimäärin | | | Kaivoksessa suoritettuja |
|---|---|---|---|---|---|---|---|---|---|
| | | | tn | tn | | avolouhos | maan alta | yht. | työtunteja |
| **Malmikaivokset** | | | | | | | | | |
| 1. Kemi | Keminmaa | Cr | Outokumpu Chrome Oy | 4 578 096 | 937 396 | 60 | — | 60 | 104 504 |
| 2. Pyhäsalmi | Pyhäjärvi | Cu, Zn, S | Outokumpu Finnmines Oy | 1 420 572 | 1 046 793 | 2 | 102 | 104 | 175 612 |
| 3. Enonkoski | Enonkoski, Savonlinna | Ni, Su | Outokumpu Finnmines Oy | 889 213 | 838 134 | 1 | 50 | 51 | 82 487 |
| 4. Hitura | Nivala | Ni, Cu | Outokumpu Finnmines Oy | 656 503 | 495 214 | 3 | 66 | 69 | 108 800 |
| 5. Vammala | Vammala | Ni, Cu | Outokumpu Finnmines Oy | 639 593 | 595 183 | — | 67 | 67 | 109 554 |
| 6. Vihanti[1)] | Vihanti | Zn, Cu, Pb | Outokumpu Finnmines Oy | 396 189 | 393 161 | — | 25 | 25 | 41 330 |
| 7. Saattopora | Kittilä | Au | Outokumpu Finnmines Oy | 308 769 | 297 533 | 6 | 15 | 21 | 34 772 |
| 8. Hälvälä[1)] | Kerimäki | Ni | Outokumpu Finnmines Oy | 80 012 | 78 800 | — | 4 | 4 | 3 610 |
| 9. Juomasuo[2)] | Kuusamo | Au | Outokumpu Finnmines Oy | 60 235 | 17 635 | 25 | — | 25 | 12 000 |
| 10. Telkkälä[1)] | Taipalsaari | Ni | Outokumpu Finnmines Oy | 37 849 | 34 739 | — | 7 | 7 | 5 446 |
| 11. Pahtavuoma[2)] | Kittilä | Au, Cu | Outokumpu Finnmines Oy | 28 501 | — | | | | 800 |
| Malmikaivokset 11 kpl | | | Yhteensä | 9 095 532 | 4 734 588 | 97 | 336 | 433 | 679 915 |
| **Kalkkikaivokset** | | | | | | | | | |
| 1. Parainen | Parainen | Klk | Oy Partek Ab | 1 568 428 | 1 391 793 | 23 | 2 | 25 | 42 687 |
| 2. Ihalainen | Lappeenranta | Klk, Wol | Oy Partek Ab | 1 467 360 | 1 035 810 | 20 | — | 20 | 34 500 |
| 3. Tytyri | Lohjajärvi | Klk | Lohja Oy Ab | 551 011 | 551 011 | — | 40 | 40 | 64 298 |
| 4. Ruokojärvi | Kerimäki | Klk, Dol | Louhen Kalkki | 339 940 | 326 364 | — | 15 | 15 | 25 153 |
| 5. Mustio | Karjaa | Klk | Lohja Oy Ab | 322 866 | 222 018 | 6 | — | 6 | 11 494 |
| 6. Ryytimaa | Vimpeli | Dol | Nordkalk Oy Ab | 191 778 | 145 109 | 4 | — | 4 | 6 796 |
| 7. Sipoo | Sipoo | Klk, Dol | Nordkalk Oy Ab | 178 573 | 178 573 | — | 16 | 16 | 24 640 |
| 8. Vampula | Vampula | Dol | Nordkalk Oy Ab | 161 546 | 114 887 | 6 | — | 6 | 10 515 |
| 9. Förby | Särkisalo | Klk | K. Forsström Ab | 160 076 | 153 863 | — | 15 | 15 | 22 578 |
| 10. Siikainen | Siikainen | Dol | Nordkalk Oy Ab | 157 862 | 154 415 | 6 | — | 6 | 10 048 |
| 11. Siivakkala | Vampula | Dol | Nordkalk Oy Ab | 76 769 | 21 635 | 1 | — | 1 | 2 150 |
| 12. Kalkkimaa | Tornio | Dol, Kv | Saxo Oy | 76 007 | 76 007 | 1 | — | 1 | 2 000 |
| 13. Vesterbacka | Vimpeli | Dol | Nordkalk Oy Ab | 28 424 | 9 367 | — | — | — | 592 |
| 14. Ahola | Varmo | Dol | Louhen Kalkki Oy | 20 937 | 20 937 | — | — | — | 480 |
| 15. Paltamo | Paltamo | Dol | Juuan Dolomiittikalkki Oy | 10 000 | 10 000 | 1 | — | 1 | 1 100 |
| 16. Juuka | Juuka | Dol | Juuan Dolomiittikalkki Oy | 8 000 | 8 000 | 1 | — | 1 | 900 |
| Kalkkikaivokset 16 kpl | | | Yhteensä | 5 319 577 | 4 419 789 | 68 | 88 | 157 | 259 931 |
| **Mineraalikaivokset** | | | | | | | | | |
| 1. Siilinjärvi | Siilinjärvi | P, Klk | Kemira Oy | 9 091 069 | 6 832 805 | 82 | — | 82 | 145 474 |
| 2. Lahnaslampi | Sotkamo | Tlk, Ni | Finnminerals Oy | 809 978 | 370 567 | 10 | — | 10 | 16 720 |
| 3. Horsmanaho | Polvijärvi | Tlk, Ni | Finnminerals Oy | 458 431 | 307 987 | 4 | — | 4 | 8 010 |
| 4. Lipasvaara | Polvijärvi | Tlk, Ni | Finnminerals Oy | 320 327 | 115 800 | 8 | — | 8 | 15 647 |
| 5. Tulikivi | Juuka | Vuolukivi | Suomen Vuolukivi Oy | 177 053 | 47 253 | 24 | — | 24 | 33 000 |
| 6. Kemiö | Kemiö | Ms, Kv | Lohja Oy Ab | 149 950 | 116 912 | 4 | — | 4 | 6 460 |
| 7. Kinahmi | Nilsiä | Kv | Lohja Oy Ab | 146 729 | 143 619 | 2 | — | 2 | 3 300 |
| 8. Uutela[2)] | Sotkamo | Tlk, Ni | Oy Metra Ab | 59 894 | 40 894 | 10 | — | 10 | 1 400 |
| 9. Nunnanlahti | Juuka | Vuolukivi | Nunnanlahden Uuni Oy | 54 770 | 19 030 | 9 | — | 9 | 9 080 |
| 10. Vartsila | Nilsiä | Kv | Lohja Oy Ab | 13 000 | 13 000 | — | — | — | 120 |
| Mineraalikaivokset 10 kpl | | | Yhteensä | 11 281 201 | 8 007 867 | | | 153 | 239 211 |
| **Muut kaivokset: Vuorivillan ja sementinvalmistuksen kiviaineksia** | | | | | | | | | |
| 1. Ybbernäs | Parainen | Al, Fe, Mg | Paroc Oy Ab | 121 299 | — | | | | 5 700 |
| 2. Näträmälä | Imatra | Al, Fe, Mg | Paroc Oy Ab | 51 147 | 51 147 | | | | 326 |
| 3. Mustamäki | Lemi | Al, Fe | Oy Partek Ab | 19 240 | 19 240 | | | | 170 |
| 4. Kuurmanpohja | Joutseno | Al, Fe | Paroc Oy Ab | 11 353 | 11 353 | | | | 148 |
| 5. Sallittu | Suomusjärvi | Al, Fe, Mg | Paroc Oy Ab | 10 428 | — | | | | 600 |
| 6. Kärnä | Savitaipale | Al, Fe | Paroc Oy Ab | 5 311 | 5 311 | | | | 210 |
| 7. Metsäsianniemi | Kiiminki | Al, Fe | Paroc Oy Ab | — | 33 136 | | | | 4 000 |
| Muut kaivokset 7 kpl | | | Yhteensä | 218 778 | 120 187 | | | 7 | 11 154 |
| Kaikki kaivokset 44 kpl | | | Yhteensä | 25 915 088 | 17 282 431 | | | 750 | 1 190 211 |

1) toiminta päättyi
2) koelouhinta

## Rikasteiden, metallien, mineraalien ja sementin tuotanto

| | 1990 | 1991 | 1992 |
|---|---|---|---|
| **Rikasteet** tonnia | | | |
| Rikkirikaste | 671 661 | 724 114 | 652 907 |
| Kromirikaste, palarikaste ja valuhiekka | 489 265 | 458 018 | 499 305 |
| Fe-pasute, Siilinjärvi | | | |
| ei käyttöä, varastoitu | 233 000 | 203 000 | 225 000 |
| Nikkelirikaste | 135 397 | 121 259 | 135 200 |
| Sinkkirikaste | 99 084 | 107 519 | 59 545 |
| Kuparirikaste | 52 449 | 43 883 | 37 397 |
| Lyijyrikaste | 4 104 | 2 938 | 908 |
| **Metallit ja metallurgisia tuotteita** tonnia | | | |
| Raakateräs | 2 860 500 | 2 890 000 | 3 076 824 |
| Raakarauta | 2 283 000 | 2 331 500 | 2 451 518 |
| Jaloteräs (aihiot) | 226 017 | 258 200 | 321 738 |
| Ferrokromi | 156 518 | 190 000 | 187 130 |
| Sinkki | 174 923 | 170 389 | 170 523 |
| Katodikupari | 65 103 | 64 433 | 70 948 |
| Katodinikkeli | 16 882 | 13 847 | 14 781 |
| Kadmium | 569 | 592 | 590 |
| Koboltti | 333 | 266 | 233 |
| Elohopea/kg | 140 972 | 74 000 | 85 000 |
| Hopea/kg | 28 508 | 30 322 | 27 168 |
| Seleeni/kg | 31 160 | 35 210 | 30 040 |
| Kulta/kg | 2 813 | 2 240 | 1 600 |
| **Mineraalit** tonnia | | | |
| Kalkkikivi yhteensä | 4 753 600 | 3 864 300 | 3 191 100 |
| Kalkkikiven käyttö | | | |
| — Sementin valmistus | 2 397 000 | 1 714 000 | 1 554 200 |
| — Maanparannuskalkki | 1 269 000 | 1 119 800 | 796 300 |
| — Kalkinpoltto | 439 000 | 396 600 | 363 600 |
| — Rouheet, tekn.jauheet ym. | 648 600 | 633 900 | 477 000 |
| Apatiitti | 546 134 | 472 459 | 554 722 |
| Talkki | 385 207 | 360 790 | 370 873 |
| Kvartsi | 276 373 | 200 987 | 169 071 |
| Vuorivillakivi | 153 000 | 124 400 | 181 500 |
| Maasälpä | 52 630 | 53 337 | 47 470 |
| Vuolukivituotteita | 33 570 | 30 583 | 31 932 |
| Wollastoniitti | 29 570 | 27 844 | 27 842 |
| Kiillerikaste | — | 4 693 | 5 134 |
| **Sementti** tonnia | 1 666 600 | 1 324 000 | 1 128 600 |

VUORITEOLLISUUS
BERGSHANTERINGEN

*toivottaa kaikille*
*lukijoilleen ja*
*ilmoittajilleen*
*Hyvää Joulua ja*
*Onnellista Uutta Vuotta*

VUORITEOLLISUUS
BERGSHANTERINGEN

*till önskar alla sina*
*läsare och*
*annonsörer*
*God Jul och*
*Gott Nytt År*


SUOMI-SALAMA 1992
VUOSIKERTOMUS 1992
OY KYRO AB

# PALVELUHAKEMISTO

## GEOALAN PALVELUJA



## PUMPPUJA



## KALLIOPORAT



## SUODATINKANKAITA



## LOUHINTAA JA KIVENJALOSTUSTA



## TERÄKSEN VALMISTUSTA JA JATKOJALOSTUSTA



## LÄMPÖKÄSITTELYTEKNIIKKAA



## TERÄSTÄ



## MITTALAITTEITA



## TUTKIMUSPALVELUT



## MURSKAUSLAITOKSIA



## TUTKIMUSPALVELUT



## TUTKIMUSURAKOINTIA



## VENTTIILEITÄ, LÄMMÖNSIIRTIMIÄ

# Vuorimiesyhdistys — Bergsmannaförening ry:n tutkimusselosteet, kirjat ja julkaisut

**Tutkimusselosteet: sarja A**

| | | hinta |
|---|---|---|
| A 9 | "Rikastamoiden jätealueiden järjestely Suomen eri kaivoksilla" | 20,— |
| A 10 | "Kuilurakenteet | 20,— |
| A 20 | "Rikastamoiden instrumentointi" | 20,— |
| A 22 | "Tulenkestävät keraamiset materiaalit" | 20,— |
| A 24 | "Kaivosten ja avolouhosten geologinen kartoitus | 20,— |
| A 25 | "Geofysikaaliset kenttätyöt I — Painovoimamittaukset" | 20,— |
| A 27 | "Kallion rakenteellisten ominaisuuksien vaikutus louhittavuuteen" | 45,— |
| A 32 | "Seulonta" | 40,— |
| A 34 | "Geologisten joukkonäytteiden analysointi" | 50,— |
| A 36b | "Pakokaasukomitea — uusimpien julkaisujen sisältämät tutkimustulokset dieselmoottorien saastetuoton vähentämiseksi" | 50,— |
| A 39 | "ATK-menetelmien käyttö kallioperäkartoituksissa" | 25,— |
| A 42 | "Kaivosten työympäristö" | 50,— |
| A 47 | "Murskeen varastointi talviolosuhteissa" | 40,— |
| A 50 | "Kaukokartoitus malminetsinnässä" | 100,— |
| A 52 | "Suunnattu kairaus" | 50,— |
| A 53 | "Kivilajien kairattavuusluokitus" | 50,— |
| A 54 | "Nykyaikaiset murskauspiirit" | 50,— |
| A 55 | "Murskaus- ja rikastusprosessien asettamat tekniset olosuhdevaatimukset Suomessa" | 50,— |
| A 56 | "Pölyntorjunta kaivoksissa" | 50,— |
| A 57 | "Palontorjunta kaivoksissa" | 50,— |
| A 58 | "Paikan ja suunnan määritys geofysikaalisissa tutkimuksissa" | 50,— |
| A 59 | "Utveckling av seismiska metoder för geologiska och bergmekaniska undersökningar" | 50,— |
| A 60 | "Holvautuminen purkumenetelmät" | 50,— |
| A 61/I | "Rakeisen materiaalin kosteuden mittaus" | 50,— |
| A 62 | "Luettelo Suomessa olevista ja tänne helposti saatavista elementtiohjelmistoista" | 30,— |
| A 63 | "Avolouhoksen seinämän kaltevuuden optimointi" | 50,— |
| A 64 | "Suomessa tehdyt kallion jännitystilan mittaukset" | 50,— |
| A 65 | "Kiintoaineen ja veden erotus" | 50,— |
| A 66 | "Pohjavesikysymys kalliotiloissa" | 50,— |
| A 67 | "Crosshole seismic investigation" | 70,— |
| A 68 | "Automation of a drying process" | 70,— |
| A 69 | "Rakeisen materiaalin jatkuvatoiminen kosteuden mittaus" | 50,— |
| A 70 | "Happamien ja intermediaaristen magmakivien kivilajimääritys pääalkuainekoostumuksen perusteella" | 50,— |
| A 71 | "Kallion tarkkailumittaukset" | 50,— |
| A 72 | "Elementtimenetelmien käyttö kaivostilojen lujuuslaskennassa" | 50,— |
| A 73 | "Crosshole seismic method" | 50,— |
| A 74 | "Pölynerotus ja ilmansuojelu" | 70,— |
| A 75 | "Heikkousvyöhykkeiden geofysikaaliset tutkimusmenetelmät" | 90,— |
| A 76 | "Teollisuusmineraaliesiintymien raakku- ja malmityyppikartoitus geofysikaalisten menetelmien avulla" | 50,— |
| A 77 | "Kaivosten jätevedet, kiinteät jätteet ja ympäristönsuojelu" | 50,— |
| A 78 | "Suomen kaivokset ja ympäristösuojelu" | 50,— |
| A 79 | "Kaivosten kiinteiden jätteiden ja jätevesien käsittely — Ohjeita ja suosituksia" | 50,— |
| A 80 | "Hienojen raeluokkien rikastus" | 100,— |
| A 81 | "Measurement of Rock Stress in Deep Boreholes" | 50,— |
| A 82 | "Avolouhosseinämien puhdistus" | 70,— |
| A 83 | "Economical Blasting in Open Pits" | 50,— |
| A 84 | "Näytteenotto ja havainnonteko kaivosteknisten kallio-ominaisuuksien selvittelyssä" | 50,— |
| A 85 | "Mineralisaatioiden luokittelu taajuusalueen spektri-IP-mittauksia käyttämällä" | 100,— |
| A 86 | "Kalliokaivojen paikantaminen" | 30,— |
| A 87 | "Syväsähköiset malminetsintämenetelmät" | 100,— |
| A 88 | "Suomen nikkelimalmien petrofysikaaliset ominaisuudet." | 150,— |
| A 89/I | "Näytteenotto jauheista" | 70,— |
| A 89/II | "Näytteenotto jauheista" | 70,— |
| A 91 | "Panostuksen mekanisointi ja automatisointi" | 70,— |
| A 92 | "Painevalssimurskain — kirjallisuusselvitys" | 70,— |
| A 93 | "Kallioperän atmogeokemiallinen tutkimus Testiprojekti 1989-90" | 80,— |
| A 94 | "Geological waste rock dilution" | 100,— |
| A 95 | "Mineraalipölyt" | 80,— |
| A 96 | "Pohjoismainen datamalliprojekti" | 80,— |
| A 97 | "Malmiarvion laatiminen" | 100,— |
| A 98 | "Uuden murskaus- ja kuljetusteknologian soveltaminen avolouhintaan." | 100,— |
| A 99 | "Termisen infrapunakuvauksen käyttömahdollisuudet geologisiin tutkimuksiin Suomessa" | 100,— |
| A 100 | "Geologiset ympäristövaikutukset kalliotilojen louhinnassa" | 80,— |
| A 101 | "Vuoriteollisuus 2000 — teknologiaohjelma" | 50,— |
| A 102 | "Geokemian ja geofysiikan kompleksitulkinnat" | 120,— |
| A 103 | "Kuva-analyysi rikastumismineralogiassa" | in print |

**Koulutus- ja seminaarimonisteet, kalliomekaniikan päivien esitelmämonisteet sekä muut julkaisut: sarja B**

| | | |
|---|---|---|
| B | "Kalliomekaniikan päivät 1967-78, 1983-84 à | 50,— |
| B 12 | "Kalliomekaniikan sanastoa" | 10,— |
| B 14 | "Kaivossanasto" | 8,— |
| B 16 | INSKO 106-73 "Terästen lämpökäsittelyn erikoiskysymyksiä" | 45,— |
| B 17 | INSKO 49-74 "Skänkmetallurgi-Senkkametallurgin" | 45,— |
| B 18 | INSKO 90-74 "Investoinnit ja käyttölaskenta metallurgisen teollisuuden toiminnan ohjauksessa" | 45,— |
| B 19 | INSKO 45-75 "Materiaalitoimitusten laadunvalvontakysymyksiä metalliteollisuudessa" | 45,— |
| B 23 | "Laatokan-Perämeren malmivyöhyke" | 40,— |
| B 25 | "Raakkulaimennus ja sen taloudellinen merkitys kaivostoiminnassa" | 50,— |
| B 27 | "Uraaniraaka-ainesymposiumi" | 50,— |
| B 29 | "Kaivos- ja louhintatekniikan käsikirja" | loppuunmyyty |
| B 30 | "Teollisuusmineraaliseminaari" | 50,— |
| B 32 | "Valtakunnallisen geologisen tietojenkäsittelyn kehittämisseminaari" | 50,— |
| B 37 | "Kaivoskohteiden urakkasopimusjärjestelmä" | 50,— |
| B 38 | "Tuotantomineralogian seminaari 16.1.1986" | 60,— |
| B 39 | "Maanalaisen louhintatyömaan sähköistys ja automaatio" | 100,— |
| B 40 | "Vuorimiesyhdistyksen tutkimusselosteen kirjoitusohjeet" | — |
| B 41 | "Mineraalitekniikan tutkimuksen valtakunnallinen kehittämisohjelma 1988" | 50,— |
| B 42 | "Malminetsinnän tehtävä ja tarkoituksenmukainen organisointi Suomessa yhteiskunnan ja vuoriteollisuuden kannalta" | 30,— |
| B 43 | "Mineraalisten raaka-aineiden tarve ja saatavuus Suomessa" | loppuunmyyty |
| B 44 | "Kalliotekniikan tutkimus- ja kehitysohjelma" | 50,— |
| B 45 | "Kairaus -89 koulutuspäivät" | loppuunmyyty |
| B 46 | "Kalliomekaniikan päivä 89" | 80,— |
| B 47 | "Suomalainen kivi — rakennuskivipäivät Oulussa 26.–27.4.90" | loppuunmyyty |
| B 48 | "Kalliomekaniikan päivä 1990" | 120,— |
| B 49 | "Tuotantomineralogian seminaari 1990" | 100,— |
| B 50 | "Geokemian päivät Oulussa 28.–29.11.90" | loppuunmyyty |
| B 51 | "Suomen kallioperän kehitys ja raaka-ainevarat" Oulu 1.–2.10.1992 | 100,— |
| B 52 | "Fragmentointiseminaari 7.—8.11.90" | 50,— |
| B 53 | "Malmiarvioseminaari 26.11.92" | 100,— |
| B 54 | "Itä-Suomen kultaesiintymät, Ekskursio-opas 28.—29.9.93" | 80,— |

**Vuoriteollisuus — Bergshanteringen-lehden vanhempia numeroita myytävänä vuosikertojen täydennykseksi jäsenille hintaan 2,50/numero.**

**Julkaisuja ja lehtiä voi tilata yhdistyksen rahastonhoitajalta kirjallisesti osoitteella:**

**Vuorimiesyhdistys — Bergsmannaföreningen r.y.**
**c/o Outokumpu Oy/M. Parkkinen**
**PL 280, 02101 ESPOO**
**tai telefax 90-4213888**

LuK Marjatta Parkkinen hoitaa Vuorimiesyhdistyksen jäsenrekisteriä. Mikäli osoite, tehtävät tai vakanssi on muuttunut, pyydämme lähettämään muutosilmoituksen kirjallisena siinä muodossa, jossa haluatte sen "Uutta jäsenistä" palstalle.

Os.: Vuorimiesyhdistys-Bergsmannaföreningen r.y.
c/o Outokumpu Oy/M. Parkkinen
PL 280, 02101 ESPOO
tai telefax 90-4213888

NatK Marjatta Parkkinen sköter om Bergmannaföreningens medlemsregister. Om er adress, arbetsuppgifter eller tjänst har ändrats, anhåller vi om skriftlig ändringsanmälan, till "Nytt om medlemmarna" spalten.

Adr.: Vuorimiesyhdistys-Bergsmannaföreningen r.y.
c/o Outokumpu Oy/M. Parkkinen
PB 280, 02101 ESBO
eller telefax 90–4213888

## OHJEITA KIRJOITTAJILLE

Lehden painatuskustannusten pienentämiseksi ja ulkoasun yhtenäistämiseksi kirjoittajia pyydetään noudattamaan seuraavia ohjeita:

**Käsikirjoitukset** on kirjoitettava koneella yhdelle puolelle arkkia 2-välillä. Otamme myös pc-diskettinä kirjoituksenne. Silloin pyydämme liittämään mukaan yhden paperikopion. On pyrittävä lyhyeen ja ytimekkääseen esitystapaan. Artikkelien **suositeltava enimmäispituus kuvineen, taulukkoineen ja kirjallisuusviitteineen** on 4 painosivua. Toimituksen mielestä lyhennettäviksi mahdolliset käsikirjoitukset palautetaan kirjoittajille korjausta varten. 3 konekirjoitusarkkia = noin 1 sivu.

**Pääotsikot ja alaotsikot** erotetaan toisistaan selkeästi.

**Kuvat ja taulukot** numeroidaan jatkuvasti ja niiden tekstit sekä näiden **englanninkieliset käännökset** kirjoitetaan erilliselle arkille. Kuvien olisi mahduttava yhden palstan leveydelle **(85 mm)**, mutta ne on piirrettävä vähintään kaksinkertaiseen kokoon ottaen viivapaksuuksia ja kirjainkokoja valittaessa huomioon pienennyksen vaikutus. Kuvia ei varusteta kehysviivoin. Kuvien paikat on merkittävä käsikirjoitukseen. Kuvien ja piirustusten tulisi mieluimmin olla mustavalkoisia.

**Kaavat ja yhtälöt** on kirjoitettava selvästi ja yksinkertaiseen muotoon, mahdollisuuksien mukaan välttäen ala- ja yläindeksien, erikokoisten merkkien ja vieraiden kirjainten käyttöä. On käytettävä SI-yksiköitä.

**Kirjallisuusviitteet** numeroidaan jatkuvasti / / sulkuihin tekstissä ja esitetään lopussa seuraavassa muodossa:

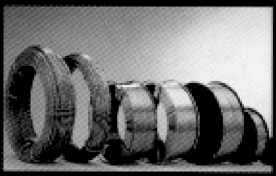
1. *Järvinen, A.*, Vuoriteollisuus — Bergshanteringen, 34 (1976) 35—39.
2. *Kirchberg, H.*, Aufbereitung bergbaulischer Rohstoffe, Bd 1. Verlag Gronau, Jena 1953.

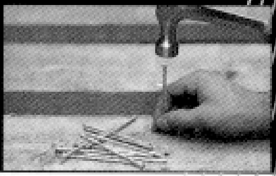
Jokaiselle artikkelille on ilmoitettava **englanninkielinen otsikko** sekä laadittava kielellisesti tarkistettu englanninkielinen yhteenveto — **summary** — pituudeltaan enintään noin 20 konekirjoitusriviä.

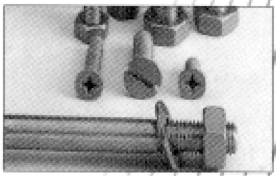
Palauttakaa **aina** käsikirjoitus yhdessä korjatun oikovedoksen kanssa takaisin toimitukseen.

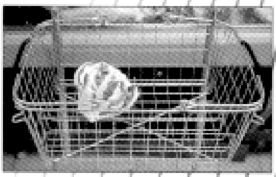
Keväällä ilmestyvään lehteen tarkoitetut artikkelit on lähetettävä toimitukselle **13.3.** mennessä, syysnumeroon tarkoitetut **14.10.** mennessä.

**Eripainoksia** toimitetaan kirjoittajan laskuun eri sopimuksella. Eripainoksien minimimäärä on **100 kpl**.



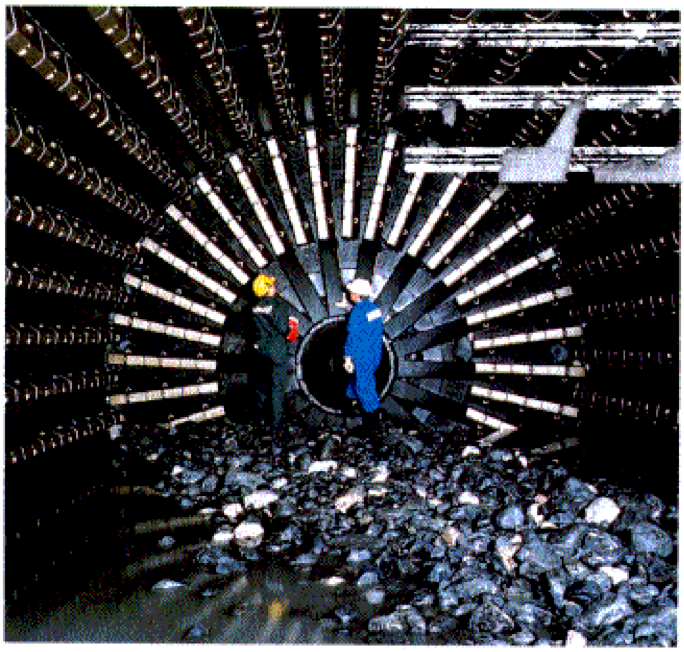






JOUKKOKIRJE

SVEDALA



Grinding

Wear resistance

Materials handling

Screening

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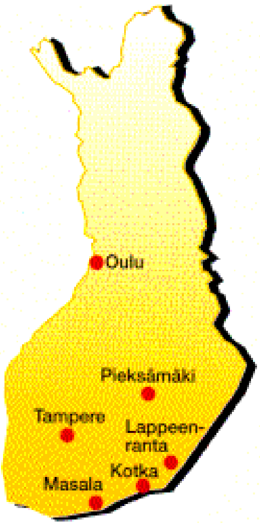
Trellex specializes in cost-effective products for the civil engineering, mineral processing and materials handling industries. With more than 25 years' experience of real-world applications, Trellex applies state-of-the-art polymer technology to develop, manufacture nad market products that meet the industry's needs for higher performance, longer service life and greater profitability.




Continuous support, fast deliveries and up-front service are the hallmarks of Trellex' long-term commitment to the mining and mineral-processing industry.

Based on the state-of-the-art technology and applications expertise, Trellex products are used for:

• Wear resistance • Dust and noise control • Screening • Grinding • Materials Handling • Fendering

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