MINING, MINING WASTE AND RELATED ENVIRONMENTAL ISSUES: PROBLEMS AND SOLUTIONS IN CENTRAL AND EASTERN EUROPEAN CANDIDATE COUNTRIES

A report of JRC Enlargement Project

PECOMINES

Inventory, Regulations and Environmental Impact of Toxic Mining Wastes
in Pre-accession Countries

G. Jordan and M. D'Alessandro Editors

EUROPEAN COMMISSION
DIRECTORATE-GENERAL
Joint Research Centre

2004

EUR 20868 EN

The mission of the JRC is to provide customer-driven scientific and technical support for the conception, development, implementation and monitoring of EU policies. As a service of the European Commission, the JRC functions as a reference centre of science and technology for the Union. Close to the policy-making process, it serves the common interest of the Member States, while being independent of special interests, whether private or national.

EUROPEAN COMMISSION
DIRECTORATE-GENERAL
Joint Research Centre

LB-NA-20868-EN-C

ISBN 92-894-4935-7
9 799289 449358

Publications Office
Publications.eu.int

Mining, mining waste and related environmental issues: problems and solutions in Central and Eastern European Candidate Countries

Editors:
Gyozo Jordan and Marco D'Alessandro

Technical Editor:
Marco D'Alessandro

Project Manager:
Giovanni Bidoglio

Project Members:
Marco D'Alessandro, Tamas Hamor, Gyozo Jordan, Marc Van Liedekerke, Panos Panagos, Erik Puura, Stefan Sommer and Anca-Marina Vijdea

In bibliographies, this report should be referred to as:
G. Jordan and M. D'Alessandro (eds) 2004: Mining, mining waste and related environmental issues: problems and solutions in Central and Eastern European Candidate Countries – Joint Research Centre of the European Commission, Ispra, EUR 20868 EN, ISBN 92-894-4935-7, ***208*** *p.*

Legal Notice

A great deal of additional information on the
European Union is available on the Internet:
It can be accessed through the Europea server
(http://europa.eu.int)

Luxerbourg: Office for Official Publications of the European Communities
ISBN 92-894-4935-7

Printed in Italy by
Grafiche Ponticelli - Castrocielo (Fr)

Preface

Mining for resources to satisfy energy and raw material requirements can seriously alter the composition of the landscape, disrupting land use and drainage patterns, contaminating soil and water resources, and affecting habitats for wildlife, often with trans-boundary effects. Recent events have brought back to the attention of the media, public and decision-makers the problem of potential emissions from thousands of mining sites in Europe, highlighting the priority of prevention as opposed to aftercare. In this context, the European Commission has taken the initiative for the preparation of a proposal for a Directive on the management of waste resulting from prospecting, extraction, treatment, and storage of minerals.

The understanding of the full range of pressures from mining sites can be first achieved through the compilation of inventories for closed and abandoned mines and quarries. Screening and ranking should be then based on impact assessment and prevention of water and soil pollution.

On European level, there is a substantial gap in information on the location and management of mining and quarry wastes. The relative share of mine and quarry waste in the total solid waste generated is known to be much higher in Candidate Countries than in the EU Member States. Involvement of these countries in the development and implementation of new EU legislation is therefore very important. Country reports in this book demonstrate that relevant mining and environmental information is not lacking, but it is often scattered among different institutions and available in different formats not easily comparable.

This publication is a result of the PECOMINES project, which contributes to the Enlargement Action launched by the JRC to support the implementation of the acquis communautaire through focused research initiatives. Country reports have been contributed by national experts of the PECOMINES Steering Committee. Country reports are an important tool of the PECOMINES mine waste inventory methodology: they provide a means of including expert knowledge in the inventory both at the national and site scales.

The ten contributions together with the introduction and concluding chapters in this book give the reader an overview of the status of mining, mining waste and related environmental problems and solutions in Central and Eastern European Candidate Countries.

Giovanni Bidoglio
Head of the Soil and Waste Unit
Joint Research Centre

Table of Contents

About This Book

In order to provide an efficient way for communicating mining waste related problems on the European scale and to facilitate the review of current situation, the PECOMINES project publishes the present volume on the status of mining, mining waste and related environmental problems and solutions in Central and Eastern European Candidate Countries. Each country represented by PECOMINES Steering Committee (SC) members contributed a chapter to the volume published by the Soil and Waste Unit, IES of the Directorate General Joint Research Centre, European Commission. The objectives are (1) to obtain a country summary on total mining waste streams and associated environmental problems at the national level, and (2) to develop detailed descriptions of a few selected ‘hot spots’ that are mining sites or areas having significant proven or potential environmental impacts of major concern in the country.

Section 1 Introduction: ‘Mining and Mining Waste: Pressures, Impacts and Responses in the European Union and Candidate Countries’ provides an overview of the key environmental issues associated with mining and mine waste management. The chapter follows the Proposal for the Mine Waste Directive and discusses its three main points of reasoning for new legislation: scale of the problem, problems of accidents and problems of abandoned mines. A description of the most important ways of addressing related problems, such as impacts, remediation and long-term monitoring follows. Response to these problems by European legislation and the industry is then discussed, and finally the PECOMINES integrated research approach is presented briefly. The last section describes the inventory approach of the PECOMINES project because the present volume is an integral part of the inventory strategy and results of the project. Throughout the presentation emphasis is put on illustrative examples from the Candidate Countries in the context of discussed topics. The objectives of the chapter are (1) to raise some new points and highlight some special aspects of mining not commonly presented elsewhere, and (2) to set the scope and framework for the presentation of Candidate Country Country Reports on mining and mining waste in Section 2.

Section 2 contains the Country Reports. Each country chapter starts with a report on mining waste situation at the national level followed by the detailed characterisation of a few selected ‘hot spots’ for the contributing Candidate Countries: ***Bulgaria, Czech Republic, Estonia, Hungary, Latvia, Lithuania, Poland, Romania, Slovakia and Slovenia.***

Each country report begins with summary data and statistics for the country on the mining waste and description of related environmental and socio-economic problems at the national level. This is followed by scope of the problem describing the environmental and socio-economic scale of the problem and giving priority in relation to other environmental problems. Next, a list and brief description of national databases on mining, mining waste and relevant environmental information is provided. Finally, investigation methods for (1) the inventory of mining sites and for (2) the assessment of active and abandoned mining sites and related environmental problems are presented.

In the second part of a country chapter illustrative cases of selected ‘hot spots’ are provided. This enables the demonstration of investigation methods and the presentation of the scale of problems in terms of waste quantities, socio-economic aspects, spatial extent, potential risks and financial needs for environmental management. These detailed case studies should be useful for the non-expert of mining to see closely and to understand 'on-hand' the problems of mining. For each site mining history and investigation methods including past and present investigation efforts, data and databases and monitoring efforts are described. This is followed by description of the hazard source, as well as the conditions of the receiving environment and the impacts on hydrosphere, soil, ecosystems and atmosphere. Regional socio-economic impacts are also described for the selected sites, and an outlook for future tasks and needs for mitigation of mining waste environmental risk and impact is provided.

Finally, each chapter is concluded for on-going major efforts and plans at the national level, and future tasks and needs for mitigation of mining waste environmental risk and impact in the country. 'References and important sources of information' are intended to list documents and web sites that provide further important information not detailed in the text. Abundant charts, tables, maps and photos make each report and the whole volume easy to read.

Section 3 Summary: 'Mining and Mining Waste: Problems and Solutions in the Central and Eastern European Candidate Countries' presents conclusions drawn from the country reports and the PECOMINES project. Experiences of the recently closed historic mining in the Candidate Countries summarised in this volume provided an excellent ground for identifying some of the most important characteristics specific to mining. This is briefly presented in section 'Problems: why mining?' The following section 'Solutions: research and methodological development' briefly reviews major national and international efforts and their results and presents a summary of the main environmental research methods that have been applied and tested for assessment of mining for environmental decision support. This section provides a state-of-the-art review of current efforts, methods and results that can be used to identify major trends and to develop the necessary tools for supporting new European legislation. This methodological framework helps the reader to put in context the final section of the chapter 'Solutions: experiences in Eastern European Candidate Countries' that tries to summarise efforts and results in these countries for answering mine waste problems using selected illustrative examples. References are intended only to provide some key links to further detailed information.

For receiving the mine waste inventory information, a crucial role was given to the Steering Committee of the project - 18 experts from 10 Candidate Countries, who assisted in finding and interpreting appropriate information sources. The present volume consists of country reports on mining and mining waste contributed by SC members.

The final format of the volume was agreed on the 3rd PECOMINES Steering Committee Meeting held in Ispra in January, 2003. The ten contributions together with the introduction and summary in this volume is intended to provide an overview of the status of mining, mining waste and related environmental issues, problems and solutions in Central and Eastern European Candidate Countries for the mining and environmental professionals and non-expert policy and decision makers.

The Editors
Gyozo Jordan
Marco D'Alessandro

Ispra, 14 September, 2003

Mining, Mining Waste and Related Environmental Issues in Hungary

Béla Fodor[1]
György Tóth[2]
Anikó Somody[3]
Géza Szebényi[1]

[1] *Hungarian Geological Survey, Budapest, HUNGARY*
[2] *Geological Institute of Hungary (MÁFI), Budapest, HUNGARY*
[3] *Mecsekérc Rt., Pécs, HUNGARY*

Introduction

Transition to market economy during the last decade had a huge impact on mining including environmental and socio-economic problems in Hungary. Liberalisation of mining and mineral prospecting resulted in increased activity of mining industry. At the same time, however, several (mostly underground) mines that proved uneconomic have been closed. The mining sector has undergone a traditional privatisation procedure. As a result, a mixed structure now exists, in which the important or strategic commodities, such as oil and gas are managed by the state in most of the cases. Blue-chip commodities have been purchased by foreign investors while local operations are run by small enterprises.

The most important mining laws and regulations are the following:

- The Concession Act (Act XVI/1991);
- The Company Act (Act VI/1988);
- The Foreign Investment Act (Act XXIV/1988);
- The Mining Act (Act XLVIII/1993).

The Mining Act covers major environmental problems related to mining. Supervised by the Regional Mine Authorities, these include protection of air quality, natural waters and fertile lands. Practically every mining operator is required to carry out environmental impact studies as described in the 86/1993 Governmental Decree.

Hungary's mineral row material reserves and supplies show a fairly average picture. The reserves of the industrial minerals and construction materials satisfy the requirements for a long time, but considerable oil, natural gas and metallic commodities import is necessary (e.g. 75% of natural gas and approximately 77% of oil of the total consumption was derived from import in 2002). At present, the Hungarian mining industry produces hydrocarbons, coals, bauxite, manganese ore, industrial minerals and construction materials. Locations of mining activities are quite evenly distributed in the country (***Figure 1***). The number of operating, abandoned and suspended mines and the mineral deposits without mine opening are shown in ***Table 1***. ***Table 2*** contains only those abandoned and suspended mines that have registered mineral resources in the National Mineral Inventory at present. In the course of many centuries-old history of Hungarian mining, about 5,000-6,000 mining objects have been operated. The largest parts of these ones are unknown at present, therefore ***Table 2*** does not contain these old mines.

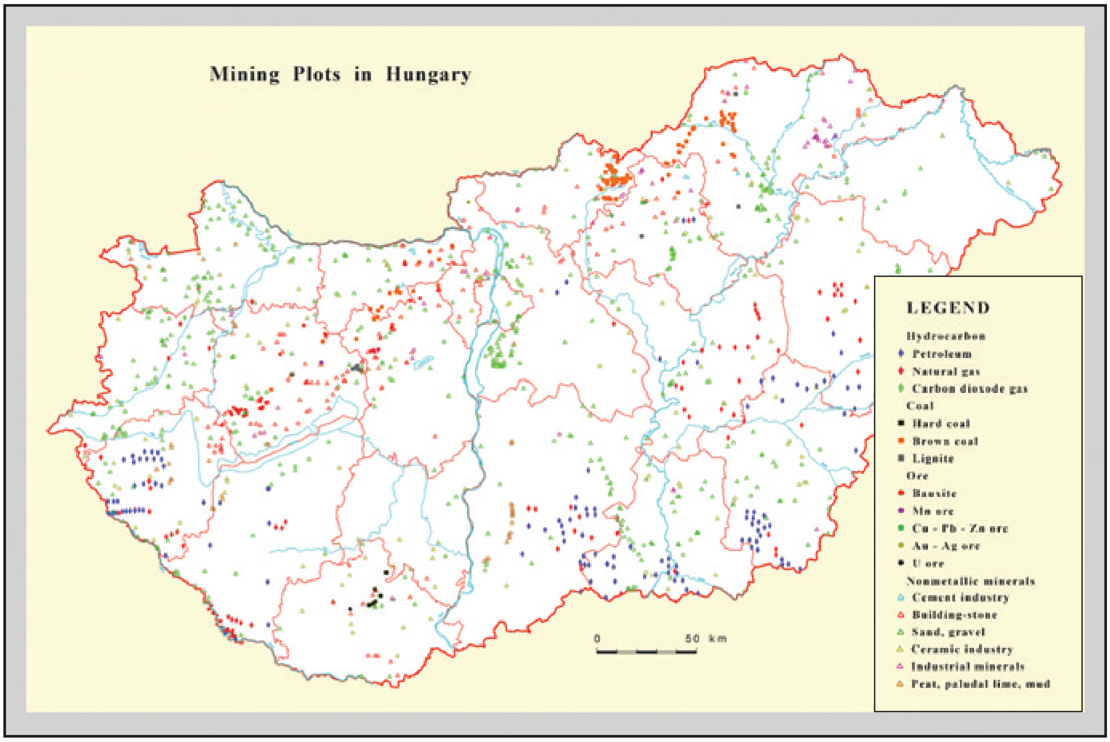

Figure 1. *Locations of active mines in Hungary (2001).*

Table 1. Mineral production in Hungary (2001).

Commodity	**Production**
(in million tons)	
Petroleum	1.06
Natural gas (1,000 m^3 gas=1 ton)	3.29
Carbon dioxide	0.10
Black coal	0.64
Brown coal	5.39
Lignite	8.04
Bauxite	1.00
Manganese ore	0.04
Industrial minerals	3.18
Cement minerals	6.07
Building & decoration stones	8.64
Sand & gravel	32.24
Ceramic minerals	9.72
Peat, lime mud	0.13
Total	**79.54**

Table 2. Number of operating, abandoned and suspended mines and mineral deposits without mine opening in Hungary (2001).

RAW MATERIAL	NUMBER OF OPERATING MINES (Mining Plots)	NUMBER OF ABANDONED AND SUSPENDED MINES	NUMBER OF DEPOSITS WITHOUT MINE OPENING
Coal	24	91	126
Hydrocarbons	122	33	61
Bauxite	8	38	217
Ores	1	24	8
Industrial Minerals	65	35	102
Other Nonmetallic Commodities	840	494	741
TOTAL:	**1060**	**715**	**1255**

Mining and Mining Waste

As a consequence of former mining activities, more than one thousand Mt mining and processing waste were generated. The area of mining waste dumps covers approximately 1% of the total productive land area. The yearly mining waste output is more than 10 Mt, the utilized volume is about 0.7-1.0 Mt/y at present.

The number of mining and processing waste dumps (including tailings ponds) can be estimated about 6,000-7,000. The last country-wide survey (1987-1991) identified and registered 3,540 mining waste dumps and tailings ponds. Detailed survey has been made for 1,220 dumps of these, including the following parameters: mining site name, administration unit, coordinates, material(s) of the waste dump, area, volume, actual or proposed way of the utilization and references to the available chemical, geological and technological studies and reports. More recent survey of waste dumps has not been made and yearly material balance-based inventory has not been carried out since 1991. The largest part of the mining waste dumps and tailings ponds are or may become secondary mineral commodities but some of these contain hazardous toxic components. These mining waste dumps contain overburden rocks, separable barren materials associated with the mineral deposit and row material of low grade.

According to the national survey, processing waste dumps and tailings in Hungary include (1) red mud near aluminium plants, (2) flying and bottom ash of electric power plants, (3) clinker, (4) slag from smelters, (5) slurry ponds near (closed) uranium ore dressing plant and (6) slurry ponds near a (closed) Cu-Pb-Zn ore dressing plant.

Mining waste dumps and tailings ponds are known to cause significant environmental problems but dedicated programmes for the reclamation and mitigation of environmental impacts are ongoing. Two of the above environmental problems have priority in relation to the mining waste at the national level: tailings ponds and waste dumps of closed uranium and base metal ore mines. Both of these are under reclamation at present.

Databases

1. **National Mineral Resource/Reserve Inventory** and regular annual balance is made by the Hungarian Geological Survey. The Inventory contains data of more than 3,000 known deposits. This gives approximately 34,000 database records processed for the yearly report.

2. **Map Series of Mineral Deposits and Mining Plots** (1:500,000) made by the Hungarian Geological Survey. The map series was made by type of mineral resource groups (fossil fuels, ores, industrial minerals, other nonmetallic minerals) and status of mine (operating, suspended, abandoned mines and deposits without mine opening).

3. **Mining Waste Database,** described above, is stored at the Hungarian Geological Survey in printed papers, of which 260 mining waste sites and 8 ‘hot spots’ are in the digital database.

4. **Dangerous Waste Material Sites Database** at the Ministry for Environmental Protection and Water Affairs contains detailed information on the mining waste dumps and tailings ponds, too.

5. **National Landscape Wounds and Quarries Database** at the Ministry for Environmental Protection and Water Affairs contains detailed survey information for 15,008 sites, of which 5,300 has been field investigated. The database contains more than 70 parameters for each site. Topographic data and landuse information are also parts of the GIS database.

Investigation methods

The data collection from of the former survey (1991) is shown in the previous section. Last year the Hungarian Geological Survey analysed 260 mining waste sites (total waste quantity is 310 Mt), which are only a little part of the total mining waste dumps. The database of the mining waste sites contains among others: identification data, coordinates, description of contamination source, sensitivity to the contamination of the surroundings, area of contamination source, material and origin of the mining waste dump and tailings pond, volume of mining waste, place of storage and its documents, protective and monitoring system of contamination, burden on the environment (soil, underground water, streams, air, population, flora and fauna, man-made environment), socio-economic impacts, available studies of the contamination source.

The ‘National Landscape Wounds and Quarry Database’ is a result of a project between 1992-1996. For the inventory of artificial holes in the surface (‘landscape wounds’) 1:25,000 topographic maps were used because preliminary investigation showed that remotely sensed images were not efficient in finding small holes and holes covered by vegetation (that includes most of the holes). Also, for quarries that turned into ponds could not be distinguished from natural lakes using remote sensing. The more than 70 parameters obtained during field investigations include location, accessibility, size of hole, size and composition of waste rock dump and tailingss, size of pond, buildings on site, environmental data including protected areas, location in administrative units and status of remediation. According to the survey, there are 600 quarries located in protected areas. Based on the results of the survey the Ministry of Environment started a programme for the recultivation of sites based on environmental priorities (***Figure 2***). Each year a tender is issued for the recultivation and sustainable use of quarries and quarry ponds such as recreation ponds, openair theatres, geological openair exhibitions, landfill locations, remediaton, etc.

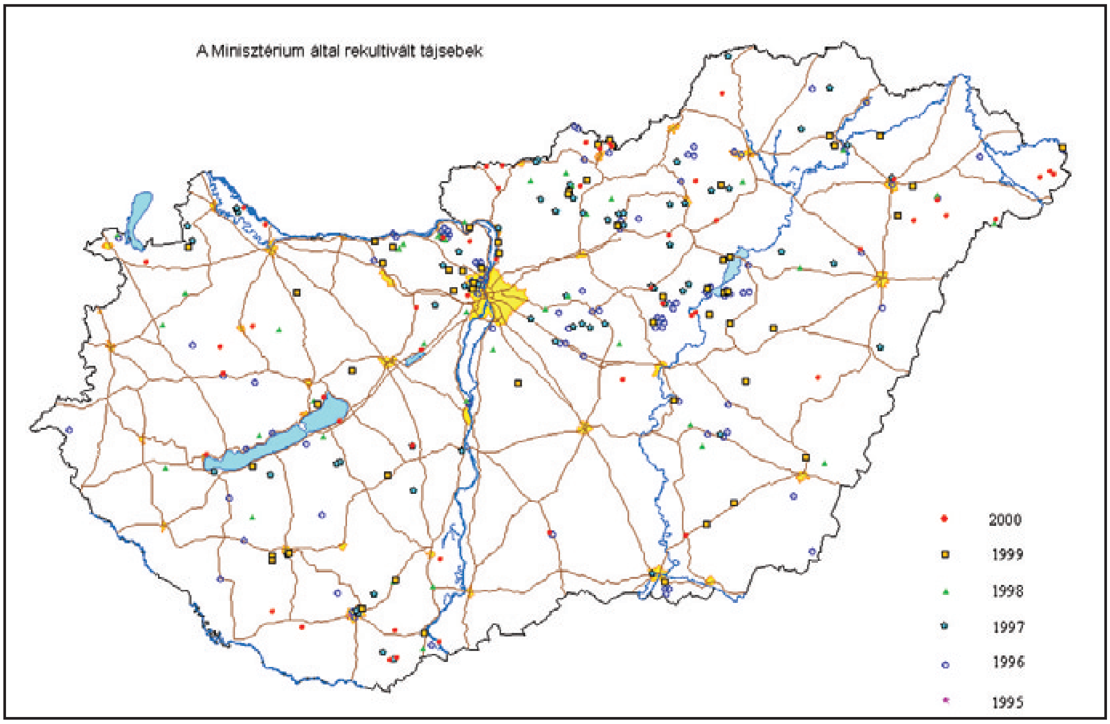

Figure 2. *Quarries recultivated by the Ministry of Environment.*

Case studies – characterization of selected “hot spots”

Site 1. Recsk-Lahoca ore mines

Mining and mining waste

Historic mining of the Lahoca Upper Eocene hydrothermal deposit started at the Recsk copper mines in 1852 and it was closed in 1979. During this period Cu, As and Ag ore hosted in biotite-amphibole andesite and polycyclic breccia was exploited in underground mines producing a total estimated exploited quantity of 3 Mt ore. 2 Mt of waste rock was produced, of which 0.5 Mt was disposed on site as waste and 1.5 Mt used for backfilling in the mine. An about 500,000 m^3 tailings were disposed on site. The chemical characteristics of the solid tailings are Au=0.8-1.0 ppm, Cu=0.05-0.2%, Fe=1-3%, with traces of As, Sb, Cd, Zn, Pb.

Mining started in the nearby Recsk Deep Complex in 1970 and operation came to an end in 1996. The Upper Eocene porphyry copper, skarn copper-zink, metasomatic polymetallic deposits were mined for Cu, (Mo), Zn, (Pb) and Fe ore. Due to market price changes the mine was temporarily suspended in the development stage in the early 90s. 0.8 Mt waste rock was produced for the 70,000 tons exploited ore quantity. Of the total waste, 0.7 Mt was disposed on site as waste, 50,000 t used for construction and 50,000 t transported out of the site.

Environmental impacts

The Lahoca shallow mine shafts and adits together with associated waste rock dumps emit acid mine drainage and solid material of waste and tailings due to erosion (***Figure 3***).

Figure 3. *Erosion on waste rock dumps at the Lahoca mines in Recsk, Hungary (photo: T. Kemper).*

Quantities and composition of the emissions observed in groundwater are typically pH 1.9-3, containing 984-5,760 mg/l SO_4, Fe solvent 56-866 mg/l, Zn 1-7 mg/l, Cu 0.1-74 mg/l, Ni 0.01-1.25 mg/l; Cd 9-33 g/l, As 37-443 µg/l and Fe oxy-hydroxides. The main environmental impacts of acid mine leachate include destruction of vegetation and landscape, high intensity corrosion of linear object of infrastructure and acidification of soils and groundwater with heavy metal pollution of Cu, As, Cd, Co, Zn and Fe.

Recsk Deep Complex produces limited acidification due to the high buffer capacity of the host Triassic carbonates. Na, Cl and SO_4 emissions from mine water are however significant. CO_2 and H_2S gas emission from boreholes is also of environmental concern. Quantities and composition of the mine water emission is characterised by 10 g/l dissolved salt content (including 3 g/l Na and Cl, 1.3 g/l SO_4 and 20 µg/l As), CO_2 and traces of H_2S and CH_4, at a 1.5-2 m^3/min pumping rate (pumping stopped in 1996). Wastes produced are not dangerous due to specific geological conditions and careful waste dump remediation. The estimated area of landscape destruction is 100,000 m^2, including 5 km^2 complete ecosystem destruction and 4 km^2 surface water impact with NaCl and SO_4.

Site 2. Gyongyosoroszi Polymetallic Pb, Zn ore mines

Mining and mining waste

Historic underground mining of the Gyongyosoroszi Middle Miocene polymetallic hydrothermal vein deposits commenced in 1400, and modern mining started in 1925. Mining operation ceased in 1986. During this period Pb, Zn, Au, Ag and Cu ore hosted in pyroxene andesites was exploited producing a total estimated exploited quantity of 3.7 Mt ore. 1.42 Mt of waste rock was produced, of which 0.14 Mt was disposed on site as waste, 0.36 Mt used for backfilling in the mine, and 0.92 Mt was transported out from the site. An about 1.17 Mm^3 tailings were disposed on site. Chemical treatment used xantathes. The chemical characteristics of the solid tailings are acidic with significant heavy metal pollution.

Figure 4. *Oxidized heavy metal-bearing tailings deposited on the floodplains below the Gyongyosoroszi tailings dump (photo: S. Sommer).*

Environmental impacts

Besides natural surface anomalies, the main sources of metal pollution are waste dumps, flotation tailings, different water reservoirs and mine water. Technological neglect and breakdowns, the open storage of the concentrates, erosion by rain, wind, and surface run-off, etc., all contributed to the spread of contamination (***Figure 4***). The dams containing the flotation waste burst many times and more than 100,000 t mud with 5% sulfide mineral content entered the valley and stream. The total tailings loss amounts to approximately 800 t galena(PbS)-sphalerite(ZnS) concentrates. The maximum heavy metal concentrations are found in the 'yellow sand' (oxidised tailings) deposited on the narrow flood plain of the stream (***Figure 4***). Escaped tailings mud was carried by stream water and more than 100,000 m^3 of contaminated mud was deposited in downstream industrial and agricultural water reservoirs.

Site 3. Mecsek Uranium Mines

Mining and mining waste

In compliance with the geo-chemical characteristics of uranium and the changing redox conditions in the „productive formation" (alongside the redox front) there are oxidised (red) and reduced (grey) ore types. Besides these two redox types there are altogether another 6 morphological types of mineralisation. The main ore minerals are uranium oxides, which belong to the uraninite-pitch blende-uranium series. The thickness of the productive formation is in the 5-120 m range. The ore bodies are found in sandstone in different layers and at several levels. Their size also varies i.e. they can be some meters or some tens of meters large (sometimes can even reach a few hundreds of meters) and their slips and slants can also be significantly different. Their average thickness is about 1 m and the range of difference alters between 0.3-0.5 m. The average quality of the locality can be described as 0.13 U%, but the range within which it can change is 0.03–3.0%. The quality range of the individual ore bodies is 0.06–0.35 U%. The size of the squats depends on the sizes of the micromorphogenetic elements and that of the related elements, but generally the size can be described as extremely diversified.

There were three areas suitable for industrial development designated by the end of 1955. Regular industrial exploration activity started at the first two sites (no. I and II mine camps) in 1956 and production started in 1957 and 1958 at Kovagoszolos I and Bakonya II mine camps, respectively. As a result of further research the production of mine camp III started in 1959. No. IV and V mine camps started in 1971 and 1983, respectively. There was some search in the "prospective" VI mine camp area, too, but owing to the economic changes that have occured since then there has been no development or production started. There was 175,300 m^3 rock stripped during this work. The total length of the vertical shafts open to the ground level is 6,300 m. The total length of the blind shafts amounts to 3,300 m (***Figure 5***), and the quantity of stripped rock was 61,130 m^3, which was taken

Figure 5.
Underground workings at the Mecsek Uranium Mines.

up to the refuse dumps. About 50% of the ore stock has been extracted. In the course of extraction there was about 18 Mm^3 rock (46 Mt) and 10 Mm^3 ore (25,4 Mt) stripped and taken up to the surface. The produced ore contained 810 t metal, which yielded 20,8 thousand kg uranium in metal form. Within the framework of the operations there were social and other service facilities built, energy and telecommunication providing systems which constituted integral parts of the mine plant, but belonged to an independent operational and plant control system.

The rock suitable for uranium recovering was crushed below 30 mm then it was placed in form of 10–13 m high prisms into adequately built basins insulated by plastic liner for heap leaching (***Figure 6***). For uranium dissolution sodium carbonate solution was leached through the rock and uranium was removed from the accumulated liquid. This procedure was carried out on two sites involving 2,2 Mt and 5 Mt of rock, respectively. Altogether approximately 500 t uranium was recovered in the two heaps.

The total quantity of waste rock produced amounts to 34.2 Mt, of which 33.9 Mt was disposed on site as waste and 0.3 Mt was used for backfilling in the mine. Chemical treatment used H_2SO_4, HCl, MnO and ion exchange resins, and processing altogether resulted in 16.2 Mm^3 neutral solid tailings.

Environmental impacts

Mining activity has caused radical changes in several hydrogeological parameters. There is still water removal going on to protect quality of the Tortyogo stream (in 1995 it amounted to 2,400 m^3/day) and the removed water is returned after due purification. Mining activity caused significant changes in the quality of the water as well. Deep mine water and the water pumped out as industrial water has 500-1000 mg/l dissolved material content. These waters are generally calcium-magnesium-hydro-carbonate type, but sometimes increased sodium and sulphate contents can also be experienced. The dissolved uranium content of the mine water is 500-2800 mg/l i.e. it may exceed the permitted values. The water seeping through the refuse dumps and escaping from the percolation basins has a harmful effect on the quality of the underground waters. These problems have been partly eliminated already. The quality of karst water is not affected directly by the mining activity. Pannonian sedimentary strata waters can be adversely affected by the solutions escaping from percolation or by the solutions that flow through the basin area and seep in.

From the middle of 1950's in the course of exploitation a cavity system of about 18 Mm^3 was formed in the ground. Today, the vast amount of rock material excavated from it can be found in waste rock-piles and tailings ponds and they pollute the environment in various ways. Though elimination of the biggest danger has been done also in the previous decades, the full and systematic remediation of environmental damage was started a few years ago only.

During its activity the Mecsek Ore Mining Company deposited about 18,5 Mt caked waste-rock on an area of 45 ha. One part of it originates from shaft sinking and as a natural material it does not cause considerable pollution. The other part is the so-called mine waste-rock which, because of its low uranium content, did not get into the system of ore processing technology. Parameters of waste-rock piles are the following:

- U-content: ~ 20–70 g/t;
- RA 226 content: ~ 0.3–1.6 Bq/g;
- Rn 222 exhalation: ~ 0.1–0. 5 $Bq/m^2/s$;
- Gamma dose intensity: ~ 400–2000 nGy/h.

During remediation of waste-rock piles the radiological parameters adequate to requirements can be assured by a soil-covering layer of 50 cm. The landscaping work on eastern side of waste-rock pile of plant III. is currently being carried out. Soil covering of surfaces having their final morphology will start and planting will also begin. This waste-rock pile serves for disposal of materials and scraps that cannot be decontaminated.

Figure 6. *Heap leaching piles at the Mecsek Uranium Mines. See buildings for scale.*

Concerning the heap leaching piles (***Figure 6***), it was important to desalinate and destroy technological solutions present in large quantity. In order to protect Tortyogo potable water catchment area the waste-rock from Leaching Heap II was relocated (about 2.66 M m^3) onto the hydrogeologically safe eastern side of waste-rock pile III. Near heap leaching areas lower degree uranium and other types of pollution could be found.

During ore processing starting in 1962 about 19.5 Mt tailings was produced and stored in two tailings ponds. Together with the tailings more than about 30 Mm^3 technological solution with about 700 thousand tons of dissolved compound also got into the tailings areas. A considerable part of it is magnesium sulphate, a smaller part of it is sodium chloride. It does not contain toxic elements. Since the tailings ponds were not insulated some parts of them escaped into the environment. According to the data provided by the monitoring service uranium and radium content of ground water did not increase considerably but the total dissolved solid content increased to a great extent. It can endanger the neighbouring potable water catchment areas that play significant role in drinking water supply of town Pecs.

During and for a long time after remediation work contaminated water discharge is expected. These waters can be classified into two groups: (1) waters of high dissolved uranium content, and (2) other waters contaminated with inorganic salts. The first group involves mine waters, waters escaping from waste-rock piles while the second group involves technological solutions of heap leaching and tailings ponds and contaminated ground waters escaped into the environment endangering the neighbouring water catchment areas. Water treatment has been done since the end of 1960s. At present 0.8–1.2 Mm^3/y water is pumped and treated. In the future, presumably 0.7–1.1 Mm^3/y groundwater has to be pumped and its dissolved salt content is to be reduced by lime milk treatment.

Figure 7. *Monitoring system at the Mecsek Uranium Mines. Water and radiological monitoring on and around the mine site.*

The Hydrogeological Monitoring System extends through the West-Mecsek Mts. consisting of about 500 sampling points (***Figure 7***). The Radiological Monitoring System has been installed to monitor the state of environment before, during and after remediation and to keep the planned radiological parameters. Monitoring includes observation of air, soil, waters, flora and fauna.

Conclusions

In conclusion, Hungary has some significant problems associated with past and present mining and processing. During the last two years 260 mining waste sites and 8 ‘hot spots’ were selected for detailed investigation. These results together with the former mining waste survey promote mitigation of mining waste impact and solution of reclamation and support ongoing environmental activities on some of the sites.

The matter flow balance-based mining waste inventory, together with pre-feasibility and feasibility studies and plans for each dump and pond is necessary but their realization is hampered by the lack of funds at the moment. In addition, it would be important to carry out more detailed surveys and research for environmental risk assessment and risk management of mine waste sites. The new initiative of the Ministry of Economy and Traffic on the utilization of solid mining waste for construction of highways is a considerable incentive for improvement of the existing mining waste survey.

References and Bibliography

1. Central Geological Office: Mining waste and secondary mineral commodities of Hungary. 1991. (in Hungarian)
2. Fodor, B. (2001): Mining activity and toxic mining wastes in Hungary. 20-22 October, 2001, Ispra, Italy.
3. Fodor, B. (2002): Report on the first results of mining waste inventory according to the JRC, Hungary. 26-28 May, Lake Orta, Italy.
4. Hungarian Geological Survey: Hungarian Republic Mineral Yearbook, 2002.
5. Hungarian Geological Survey: Map series of Mineral Deposits, Mines and Hotspots of Hungary, 2002 (10 maps, 1:500,000).
6. Jordan G, Rukezo G., Fügedi U., Carranza E. J. M., Somody A., Vekerdy Z., Szebényi G. and Lois L. 2003: Environmental impact of metal mining an catchment drainage in the historic mining area of Recsk-Lahóca mines, Hungary. 4th European Congress on Regional Geoscientific Cartography and Information Systems, Bologna, Italy, June 17th – 20th 2003. Proceedings, Volume II. pp. 713-715.
7. Licskó, I., Lois, L., Szebényi, G. 1999: Tailings as a source of Environmental Pollution. Water Science & Technology vol. 39. no. 10-11, pp. 333-336.
8. Ódor L., Wanty R., Horváth I., Fügedi P. U. 1998: Mobilization and attenuation of metals downstream from a base metal mining site in the Mátra Mountains, Northeastern Hungary. Journal of Geochemical Exploration No. 6 pp. 47-60.
9. Szalay S. 1954: The enrichment of uranium in some brown coals in Hungary. Acta Geologica Hungarica 2, pp. 299-310.
10. Szebényi G. and Bodó B. 2001: Ruadeoro International Network. Introduction to the reference site – Recsk. On behalf of Municipality of Recsk by Balázs Bodó (Geonardo Kft.) Géza Szebényi (professional coordinator) Budapest, September 13, 2001. RUADEORO INTERNATIONAL NETWORK 2nd Workshop, Alagna 2001. September 10-13, Italy.