## Chapter 5 Compilation of Digital Spatial Data Sets and Information Disclosure

### 5.1 Current State and Evaluation of GIS Database at MEM

#### 5.1.1 Prehistory of Database Creation at MEM

The Department of Mining & Geology (DMG) has implemented a GIS-based government solution in order to provide a positive administrative environment that will support increased mining and development activity in Serbia through several projects (Table 5.1). In 2001, a text-based mineral resource database was created with GIS datasets through a project supported by the BRGM.

Table 5.1 Development of a GIS Database at MEM-DMG

| | Project name | Organization | Year |
|---|---|---|---|
| 1 | CISGEM: Computerized Information System for Geological Exploration & Mining | MEM | 2001 |
| 2 | Database of Central & South-Eastern Europe | BRGM | 2001 |
| 3 | Formation of a GIS-based database of mineral occurrences in Serbia | MEM | 2001-02 |
| 4 | GIS Software Application and Training | UNDP | 2002-03 |
| 5 | Digital Spatial Data for Serbia | MEM | 2004-05 |
| 6 | CISGEM project extension | MEM | 2006-07 |
| 7 | JICA M/P Study | JICA | 2007-08 |

#### 5.1.2 BRGM's Databases of the Mineral Deposits and Mining Districts of Serbia

The BRGM's databases for mineral deposits and mining districts of Serbia was constructed in 2001. Information on the mineral deposits and mining districts of Serbia is compiled with the collaboration of the Faculty of Mines and Geology of the University of Belgrade and the Geological Institute. The databases comprised information on mineral deposits and districts, which is stored in text-based databases (Table 5.2). The BRGM has also compiled GIS-based mineral resource maps with the scale of 1:750,000, and energy minerals, base and precious metallic minerals, and industrial minerals, as well as the main mining districts, are plotted on topographic and simplified geology maps.

Table 5.2 General Contents of the Databases Created by BRGM

Mineral Deposit Database :

| |
|---|
| ● Number of records: 199 |
| ● Geographic location of mineral deposits and occurrences |
| ● Geological data: typology, morphology, age and type of mineralization and host rock, mineralogical composition of the ore, gangue and hydrothermal alteration |
| ● Economic data: mine status, type of development, previous production, status of resources and reserves |
| ● Data on environmental hazards likely to be generated by the deposit |
| ● Bibliographic references |

Mining District Database :

| |
|---|
| ● Number of main mining districts : 12 |
| ● A list of the deposits located within the district |
| ● The main primary and secondary ore minerals (commodities or substances) present, each annotated with an assessment of the contained metal weight so as to enable an evaluation of the district's economic importance |
| ● The dominant typology or characteristic(s) of the district |
| ● The age of the mineralization and host rocks |
| ● A synopsis of the geological and economic data |
| ● Comments on the potential environmental releases and damage associated with the relevant mining and mineral-processing industry |
| ● The main bibliographic references |

The following items shall be considered and revised for the future use of BRGM's databases.

① Datasets of the BRGM's databases should be integrated in current GIS database of the MEM.

② Assessment and amendment for some datasets such as ore reserves and minerals shall be required.

③ Projection system used in the GIS datasets should be converted to either the world standard coordinate system (WGS84) or Gauss-Kruger which is commonly used in Serbia.

### 5.1.3 Current Database of MEM

In the current GIS database, information on mineral resources is stored in several linked tables with a relatively simple structure. The main contents are listed in Table 5.3. These mineral resource datasets are on 1:300,000 digital base maps created by the Military Geographical Institute (MGI). Geographic information provided by the MGI is transformed to the ArcGIS geo-database (Fig.5.1).

Table 5.3 Mine Datasets Stored in the Current GIS Database at MEM

| Items | Status |
|---|---|
| Geological maps | Scanned imagery |
| Metallogenic provinces | None |
| Mining sites | Exist（408 points） |
| Geological exploration sites (mineral resources) | Exist（403 points） |
| Geological exploration sites (water resources) | Exist（66 points） |
| Mining license areas | Exist（4 areas） |
| Mineral occurrences | Exist（275 points） |
| Areas requested for GIS information | Exist（35points） |
| Abandoned mines and reasons for abandonment | Exist |
| Infrastructural datasets: | Exist, more than 70 layers |
| Tailings dam sites | Exist |
| Monitoring data for mining pollution | Exist |
| DEM | SRTM: 90m intervals |
| Satellite imagery | Mosaic Landsat TM（3 bands） |

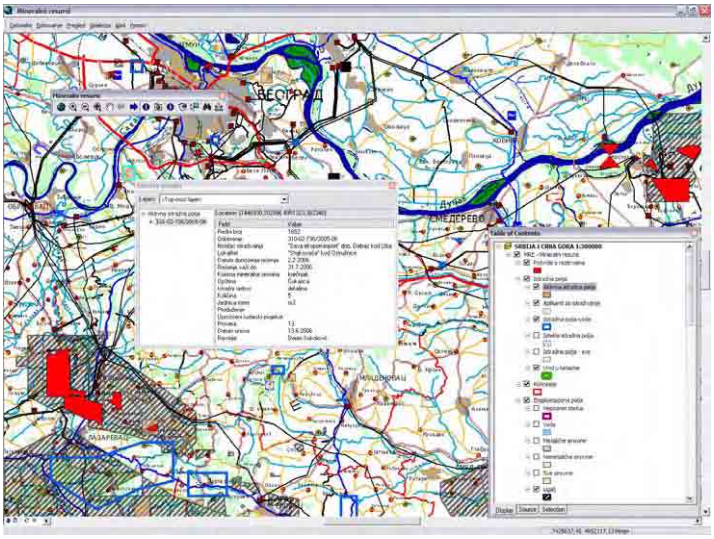


Fig.5.1 A view of the current GIS database at the MEM

### 5.1.4 Construction of a MEM GIS Database

As a result of discussions with the MEM staff, we agreed to extend the current GIS database through the following means:

1) Geological maps, topographical and geological index maps, and distribution of updated conservation and restricted areas, shall be added to the present GIS database as fundamental spatial information for mining license management and for foreign investors, and will be available on the

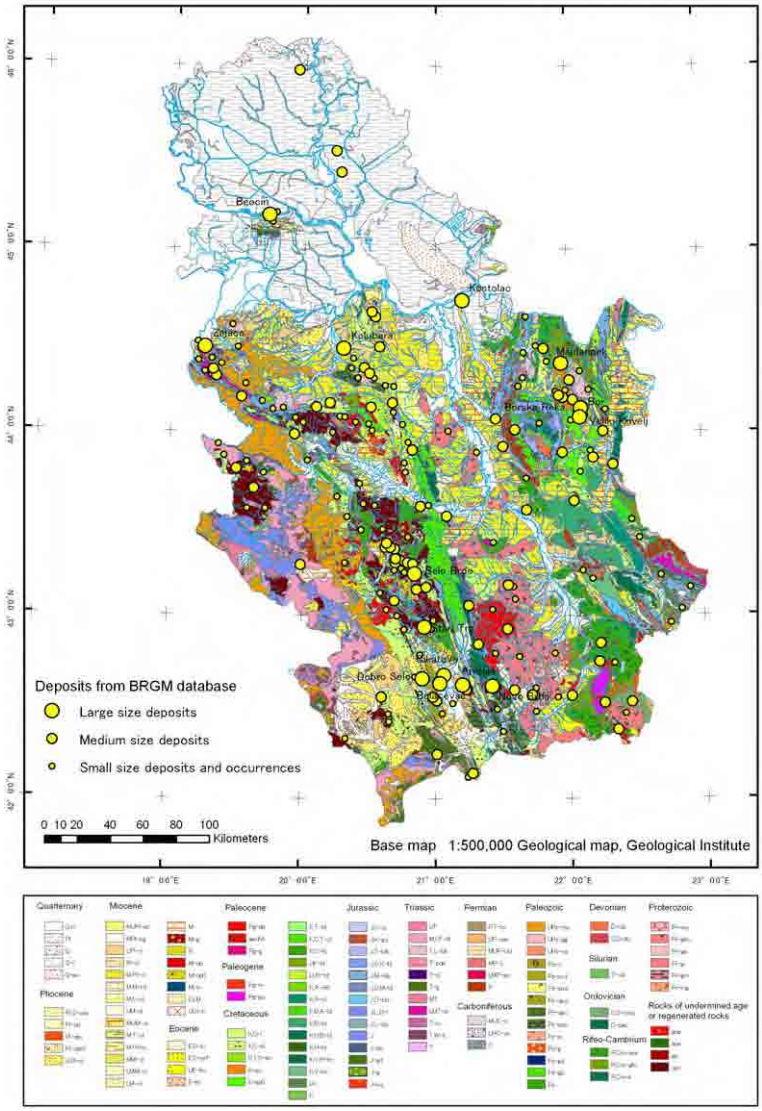



Fig.5.2 Geological Information for GIS Database with Mineral Deposits from the BRGM's Database

MEM website.

2) Six sheets of 1:500,000 geological maps were scanned and converted to shape files. Geological unit attribute information was added by the MEM and the JICA expert (Fig.5.2). The geological information was provided for the GIS database and web-GIS creation.

3) Paper-based maps of conservation and restricted areas such as national parks, nature parks, nature reserve areas, areas being considered for protection and so on provided by the Institute for Nature Conservation was added to the current GIS database.

## 5.2 MEM Website

### 5.2.1 Former MEM Website

The MEM website provides information on mining-related and energy sector activities which are government announcements, mining policies, related laws and regulations, taxes, organizations, active state/private companies, and etc. The content is revised and updated frequently through an appropriate checking system at the MEM. A web management tool has already been developed for the MEM staff to update contents, and contributes a lot to daily web management. On the other hand, some important information such as mining laws and related regulations was just put on the page without any instructions for clients, and there was a lack of a user's perspective. Furthermore, there were no spatial datasets such as geology, ore deposits and so on. Although the frame windows for future English content have been completed, there has been no actual construction plan and its progress has stopped.

### 5.2.2 Expansion of the MEM Website

Regarding the expansion of the MEM's mining sector website, the MEM and the JICA Expert agreed to construct an English MEM website. The general contents are listed in Table 5.4.

Table 5.4 General Contents of the Planned MEM-DMG English Website

| | Items | General specifications |
|---|---|---|
| 1 | Coverage of development | Development of an English version on the MEM-DMG website. http://www.mem.sr.gov.yu/ |
| 2 | Translation | ・ Translation of the present Serbian pages into English (shift those links to English translations of laws and regulations as they become available). |
| 3 | Web-GIS | ・ Web-GIS: for publication disclosure of spatial datasets from user-oriented point of view.<br>・ A new web-GIS portal site is pop-up from the current web-page.<br>・ Web-GIS site was developed based on the pilot web-GIS by MEM, adding various kinds of tools for web-GIS operation<br>・ Locations of GIS datasets on maps were converted on the WGS84.<br>・ Two web-GIS windows, "Quick web-GIS viewer" and "Full version of web-GIS"<br>・ Quick web-GIS viewer: quick accessible to spatial information (geology, mining license areas, infrastructure, satellite imagery)<br>・ Full version of web-GIS: accessible and retrievable to all spatial information<br>・ Licensed mining areas are plotted in the web-GIS window as points for each area.<br>・ Domain name: www.serbia-mining.info |
| 4 | Guideline for mining activities | User-friendly information instruction about mining laws and related regulations for foreign and domestic companies was included. |
| 5 | JICA report | The JICA final report will be presented on the webpage as a third-party evaluation of Serbia mineral potential and the state of mining activity. |
| 6 | Links | Linked with other related sites |
| 7 | Web-server | Lease is effective through February, 2008 |


Fig.5.3 Website of MEM-DMG

Through this study, the quality and quantity of the web site have been improved dramatically by creating an English version and web-GIS and updating the Serbian version (Fig.5.3).

The portal website of web-GIS developed in this study is linked on the current MEM website as shown in Fig. 5.4. We provided two kinds of web-GIS windows, "quick web-GIS viewer" and a "full version of web-GIS window". The quick web-GIS viewer was developed for clients who need only to browse the spatial information. The viewer is providing quick browsing of GIS information without retrieval function. However, similar levels of contents of spatial information as those of the full version of web-GIS window are provided for clients. Fundamental information such as geology, mining license locations, infrastructures and satellite imagery are provided for GIS information of for making decision of mining investment to Serbia. On the other hand, the "full version of web-GIS window" has a retrieval function for web-GIS database which stores all of spatial information with related attributes as shown in Fig.5.5. The web-GIS is designed based on a user-friendly concept and is also supported by "help windows", and it makes users possible to easy operation. Simultaneously, the website was designed to maximize retrieval and plotting speed of

web-GIS datasets by simplifying datasets and database structure, and this web-GIS provides comfortable response circumstances compared with other existing web-GIS websites. This website has been updated and improved in the cooperation of a JICA expert and MEM staff members, and web-GIS was opened to the public in January in 2008.

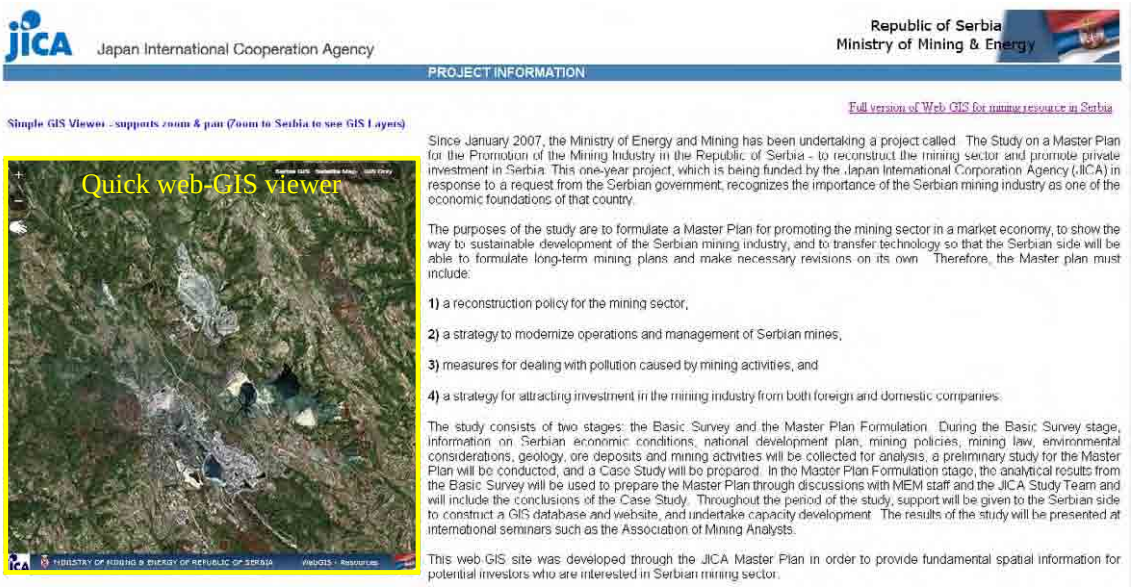


Fig.5.4 Portal Site for Web-GIS

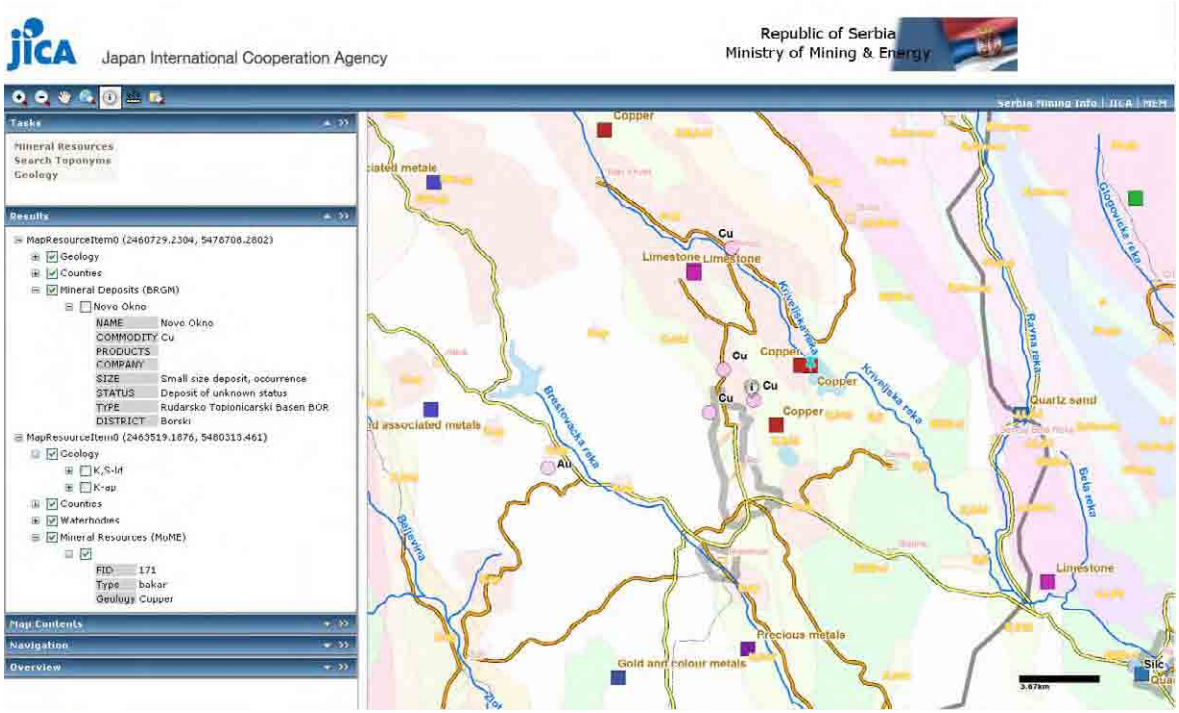


Fig.5.5 Geology, Road Network and Mining Information on the Full Version of Web-GIS Window

### 5.2.3 Web-server for the MEM

Web contents for the MEM are stored at a server of the InfoSky and are supposed to be transferred to a server managed by Serbian government. The web-GIS contents are stored at a server

in private company now. Hosting service for the web-GIS located at the server shall be transferred to a new server which is planed to be implemented by the MEM around the same time. Since the web server and the web-GIS server are transferred to servers managed by Serbian government, appropriate and prompt security actions will be implemented after it.

### 5.3 Some Approaches to Database Creation at MEP

In order to compile geological and mineral resource information, the former Ministry of Science and Environmental Protection (MSEP) had been conducting the following projects. The MSEP was subsequently divided into two ministries, i.e., Ministry of Environmental Protection (MEP) and Ministry of Science (MS), and these projects are now being handled by the MEP.

#### 5.3.1 GEOLISS Project

The MEP created a structure of geo-science database called “The Geological Information System of Serbia”, or GEOLISS with the cooperation with the University of Belgrade. GIS tools for the ArcGIS were also designed and programmed (Fig.5.6). The objective of the database is to establishing of integrated geo-science information database including not only geology and mineral resources, but also hydro-geological and geo-technical datasets. GEOLISS could become the backbone of geo-science databases in Serbia and will serve many uses also for mining sector. However, there might be some issues caused by institutional organization.

- Since infrastructural datasets are created and possessed by the Military Geographic Institute, they are not stored in the current database in GEOLISS.
- There is an insufficient amount of licensed software at the Belgrade University and at the Geological Institute, and proceeding of data-entry and training are very limited.
-

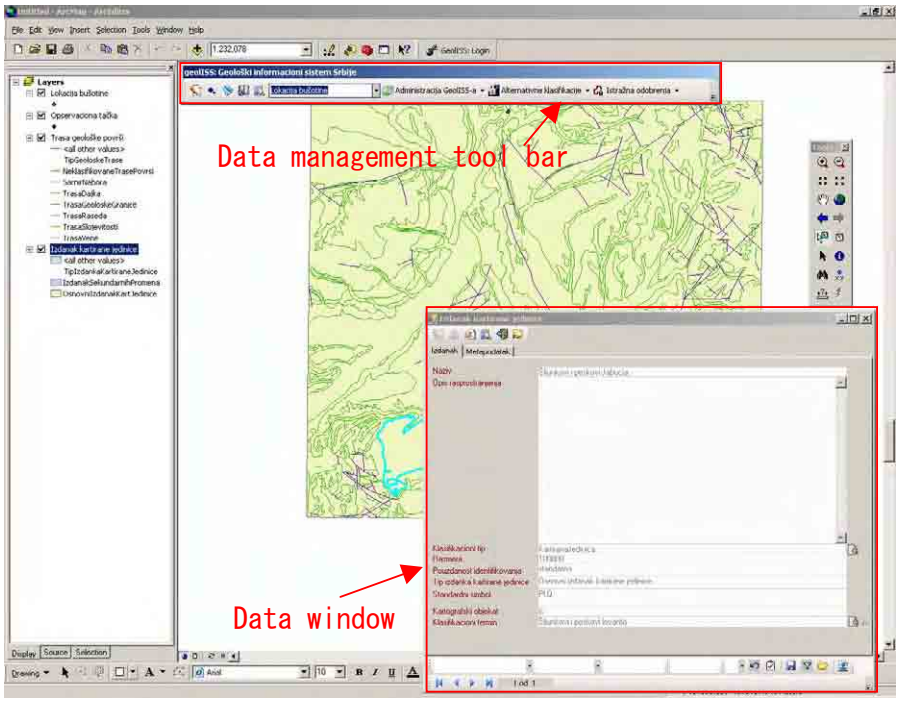



Fig.5.6 Operation Windows in GEOLISS

### 5.3.2 "Metallogenetic and Minerallogenetic Geological Economic Estimation" Project

The MSEP started project of the "Metallogenetic and Minerallogenetic Geological Economic Estimation in Serbia" in cooperation with the University of Belgrade and the Geological Institute. One of the themes is "Database of Mineral Deposits and Occurrences of Metallic and Non-metallic Mineral Resources of Serbia". Ore deposits and mineral occurrences for metallic (about 900) and non-metallic (about 600) resources will be stored in the GEOLISS's structure.

### 5.3.3 "Strategy for Sustainable Development of Mineral Resources in Serbia" Project

This project was financed by the EBRD, and covers 7 fields. One of tasks is to review ore deposits and mineral occurrences for metallic, non-metallic, and fossil fuels. Upon completion, it will be the most accurate geological information resource in Serbia to date. The project was undertaken with the cooperation of the University of Belgrade, the Geological Institute, and the MEM. It is currently in the final stage of data compilation.

## 5.4 Geological and Related Maps at the Geological Institute

The Geological Institute has produced geological maps, hydro-geological maps, and other maps of Serbia. As the Institute is one of the governmental organizations which has started to utilize GIS technology, the technical potential there is very high. The Institute is creating GIS datasets based on the GEOLISS structure with geological field surveys. However, the process of converting geological information to GIS datasets is moving slowly at the present time, because of a lack of budget and work force for field surveys and digitalization.

### 5.5 Topographical Maps by the Military Geography Institute

The Military Geography Institute (MGI) is proceeding to create topographic maps and thematic maps of scales from1/25,000 to 1/1,000,000 covering all Serbian territory and also to make GIS datasets and related digital datasets. In Serbia, the local geographic coordinate system has been used for topographical maps, but now a new pilot project has started to convert to the world standard coordinate system, WGS84. On the other hand, although there is considerable demand from other government offices and the general public for topographical maps, procurement and usage range are restricted by the present law. It is necessary to reform the law to increase the freedom to utilize basic information.

### 5.6 Current IT Utilization at Bor

The current status of IT utilization in the Copper Institute and the RTB Bor are investigated, and the assessment and issues resolved are summarized.

**1) Copper Institute**

- The Industrial Distributed Control System (IDCS) developed by the Institute has now been transferred to RTB Bor and is used for controlling and monitoring daily processing parameters.
- GIS database shall be implemented for information management of environmental monitoring
- The Institute makes considerable use of mining management software and provides a variety of technical support not only for RTB Bor, but also for the other mines in Serbia.
- Regular upgrading and procurement of basic IT equipment (PCs and GPS) should be made.
- The IT group at the Institute has the potential to expand its IT business for other business field.

**2) RTB Bor**

- Block models of each deposit have been made sequentially and used effectively.
- RBB is greatly reliant on IT technical support from the Copper Institute.
- Digitization of geological data should be made, and the data should be stored in a mining management system for integrated data management.
- Internal nurturing of operators or recruiting IT engineers should be started immediately.

### 5.7 Strategic Future Database Construction

#### 5.7.1 Mining License Management System

The processing and management of mining licenses will become a major part of present and future daily routines, and the GIS database at the MEM will need to be used as a mining cadastre management system. The MEM has carried out a pilot project to design a prototype database structure for a mining cadastre management system. It will be important to extend the current management style of paper-based application documents to a GIS database management system for more prompt, accurate, and complete management. At the same time, the Agency for Mining was established under the new Mining Law in 2007. Definition of work responsibilities and information sharing shall also be

considered from the aspect of management of mining sector information.

### 5.7.2 Information Management for Old Mining Licenses

Mining license information has been stored in the database gradually, while doing daily operation. At present, document information of mining licenses after 1997 is managed with license area information as GIS polygon datasets. However, more than 600 sets of mining license information from 1960 to 1997 are stocked in the Central Archives as paper-documents and maps. Thus datasets of past mining activities would be very informative and would accelerate current and future mining exploration and exploitation, provided that the stocked existing information is managed in digital format in the database and is provided for mining companies and investors. So, it is very important to digitize all of existing information and to store in the appropriate database, rapidly as possible. However, it is impossible to complete the digitalization of the tons of information for the present staff members while doing daily management for mining activities. Therefore, supports of international organization, for instance, expert dispatch or project, might be very effective for this achievement.

## Chapter 6 Environmental Considerations

### 6.1 Laws and Regulations related to Environment

There are said to be 100 or more environmental protection laws and regulations in addition to the basic four below.

1. Law of Environmental Protection
2. Law on Strategic Environmental Impact Assessment
3. Law on Environmental Impact Assessment
4. Law on Integrated Environmental Pollution Prevention and Control－IPPC

These four basic environmental laws are modeled on the EC standard. This will make it possible for Serbia to work easily with EC countries and eventually join the EC as a signatory country.

#### 6.1.1 Basic Environmental Laws

**a) Law of Environmental Protection**

The Law of Environmental Protection is the fundamental law for environmental protection, and has served as the basis for three other laws. The items regulated by this law include not only measures for prevention air, water, soil, noise and vibration pollution, but also provisions for waste control, radiation protection and chemical materials management. The law is also used to promote sustainable development of natural resources, maintain biodiversity, protect the ozone layer, and provide for a public participation system.

**b) Law on Strategic Environmental Impact Assessment**

The Law on Strategic Environmental Impact Assessment provides that the adverse effects etc., which a project has on the environment, are forecast beforehand and are evaluated, are prevented and are controlled, to makes compatible with Sustainable Development and the Environmental Protection (including the protection of natural resources, the spectacle and cultural asset, and biodiversity, etc.). At the same time it is to maintain the consistency with another field. The projects, plans and sector master plans that should execute the Strategic Environmental Impact Assessment are in the field of the spatial plan, the town planning or the land use planning, planning in the fields of agriculture, forestry, fishing industry, hunting, energy, industry, transport, the waste management, the water management, telecommunications, tourism, preservation of natural habitats and wildlife (flora and fauna). The master plan according to the mining field isn't included. We confirmed to the Ministry of Energy and Mining and the Ministry for Science and Environmental Protection that this master plan for Promotion of Mining Industry in republic of Serbia doesn't correspond to the master plan executing SEA.

**c) Law on Environmental Impact Assessment**

Law on Environmental Impact Assessment provides regulations concerning the environmental assessment procedure to the project that exerts a heavy influence on the environment.

That is, it provides for the content of the EIA study report, monitoring procedures, the participation of the public, and the exchange of information on the project with the possibility of the border transgression contamination to the neighbor countries etc. The execution of Environmental Impact Assessment is obligated to all projects that are planned in the natural resources protection area and in the cultural asset protection area. Also, the projects in the fields of industry, mining, energy production, transport, tourism, agriculture, forestry, the water management, waste management, and utility service are obligated. It is executed to each stage (at the time when the project is planned and executed, in the case of the exchange of the technology, reconstruction, the ability enhancing, the end of operation, and the abolishment of the project that has an heavy influence on the environment). The execution of Environmental Impact Assessment is obligated from the exploration stage in the mining field.

**d) Law on Integrated Environmental Pollution Prevention and Control－IPPC**

The Law on Integrated Pollution Prevention and Control is called IPPC in the EC countries. In the IPPC process, enterprises and organizations regulated by this law submit to the inspective organization the application with data, how to treat the materials that might cause harmful effects on the environment, and the number and amounts of substances are discharged into the environment. If, after an application is examined and approved by the inspecting organization, the enterprise or organization receives approval, it can begin operations. It is supposed that an actual emission limit values are decided under the inspective organization examinations.

### 6.1.2 Restrictive Laws and Regulations on Environmental Protection

There are laws on water, regulations on water classification and regulations on harmful substances contributing to water pollution. There are regulations on permitted noise levels. There are also laws covering waste substance handling. Environmental standards are provided for by acts of Parliament.

### 6.1.3 Laws and Regulations Related to Monitoring

Laws and regulations related to monitoring are divided into those that cover monitoring organizations, and those that cover collection of data, such as parameters measured and measuring methods. The former includes the regulations on establishing networks and the work programs of meteorological stations of interest for the entire country, regulations on detailed conditions which must be fulfilled by professional organizations performing emissions measurement, and the decree establishing Air Quality Control Programmes in 2004 and 2005. The latter includes regulations on limit values, emission measuring methods, criteria for sample spot selection and data collection, regulations on emission limits, and methods and timeframe for data measurement and notation. The Republic Hydro-meteorological Institute and Republic Health Institute are the organizations that execute environmental monitoring according to these laws.

### 6.1.4 Basic Specifications of Other Category Laws and Regulations

This group is includes basic laws and regulations in other categories. Examples include laws covering geological investigations, mining, energy, agricultural land, forestry, tourism, national parks, workplace safety, and public safety.

**6.1.5 Relevant Statutes Covering Related Organizations**

This group includes laws and regulations covering laws on ministries, autonomous province competencies, municipal activities, local self-governance. These law and regulations determine the division of authority and powers between local governments and the autonomous provincial government. Environment-related organizations include: the Ministry of Agriculture, Forestry and Water Management (Directorate for Agriculture, Directorate for Forestry, Directorate for Water, Directorate for Plant Protection, and Veterinary Directorate), the Ministry of Economy (Directorate for Industry), the Ministry of Health (public health section related to environment), the Ministry of Capital Investments (sections related to construction, roads, aircraft, railways, and water traffic), the Ministry of Energy and Mining (sections related to mineral resources and energy), and the Ministry of Culture (section related to cultural assets).

**6.1.6 Environmental Standards**

The Serbian regulations on water classification divide water quality into four categories according to purpose and usage (wastewater is a $5^{th}$ category).

Category I: Natural water that is drinkable and can be used for specialized fishing.

Category II: Natural water that is drinkable and can safely be used for bath water and leisure activities, food-related agricultural and industrial uses, and ordinary fishing.

Category III: Natural water that is available for non-food-related agricultural and industrial uses.

Category IV: Water for special agricultural uses.

The preferable water category for each river in Serbia has been decided (204 river districts have been specified), and environmental protection measures that maintain them have been executed. The categories of the main rivers are as follows: the Danube river (Category II), the Tisa river (Category II), the Sava river (Category II), the Lim river (Category II), the Kolubara river (Category IIa), the Velika Morava river (Category IIa), the Ibar river (Category IIa), and Juz Morava river (Category IIb).

Standards for surface water quality are detemined in each of the above-mentioned categories, including 13 general items (excluding radiation) and total 223 items that are regulated as harmful and dangerous substances. There are also 20 heavy metals that are closely related to mining.

Emission limit value (GVI) is regulated in the air pollution prevention. GVI values of heavy metals are Pb (250μg/$m^2$/day), Cd (5μg/$m^2$/day), Zn (400μg/$m^2$/day) and total deposited particulates (200μg/m2/day). Regulated dangerous and hazardous elements in the soil, (with

maximum permissible content in parentheses) are Hg (2mg/kg), Cd (3mg/kg), As (25mg/kg), Ni (50mg/kg), Pb, Cu (100mg/kg), and Zn (300mg/kg).

### 6.2 Environmental Monitoring System

The environmental management and environmental monitoring systems in Serbia are divided (as shown in figure 6.1) into organizations that execute environmental monitoring and one that manages and maintains environmental quality data. The former are third party organizations registered in Serbia (required to register with the relevant authorities), which apply ISO standards, including the Hydrometeorology Institute, the Public Health Institute, and the Copper Institute at Bor. These research organizations monitor national and regional area environmental conditions. The latter is the Serbian Environmental Protection Agency, which maintains environmental quality data collected from the environmental monitoring organizations, makes environmental reports to the government, and reports to European Environment Agency on the environmental status of Serbia.

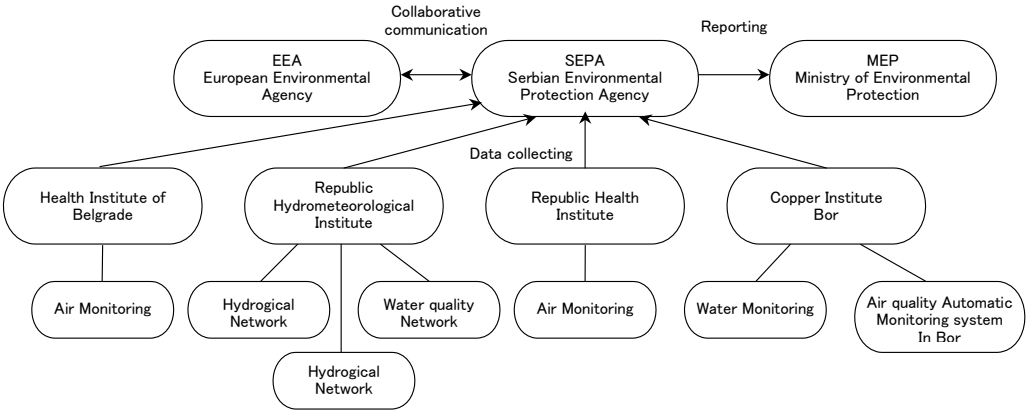



Fig.6.1 Environmental monitor system

The investigation system for requiring prevention countermeasures is insufficient, though some environmental monitoring and investigation are performed at large enterprises, like the Bor mine. Small and medium-sized mines are only required by law to perform environmental monitoring four times per year (every three months). Neither daily measurements of pH, EC, and turbidity, nor flow measurements are taken. These are necessary for environmental protection. Monitoring is quite infrequent.

#### 6.2.1 Serbian Environmental Protection Agency (SEPA)

The Serbian Environmental Protection Agency (SEPA) is an organization established by law within the Ministry of Environmental Protection in 2004. 23 staff make up two sections: the environmental status and information systems monitoring section, and the polluter monitoring section.

The main services are as follows.

- Collection of environmental information, and development and management of the environmental information system

- Processing of environmental data and establishment of appropriate environmental indicators
- Establishment of an automatic environment monitoring network
- Creation and maintenance of polluter cadastres
- Submission of annual reports on environmental status
- Cooperation with the European Environment Agency (participation in EIONET)

The Serbian Environmental Protection Agency (SEPA) collects various environmental information from the monitoring organizations including the Hydrometeorology Institute, the Public Health Institute, the Public Health Institute of Belgrade, the Public Health Institute of Novi Sad, the Copper Institute at Bor, the Institute for Serbian Nature Conservation, and the Municipal Directorate. The SEPA evaluates them, and creates indexes showing Serbian environmental status, and submits annual reports. These indices are also sent to the European Environment Agency (EEA).

**6.2.2 Hydrometeorology Institute (Hydromet)**

The Hydrometeorology Institute is a nationwide research institute organized. There are three main sections, related to meteorology, hydrology, and the environment.

The nationwide water quality monitoring network is an automatic surface water monitoring network with 12 measurement points. Measurement is done with daily sampling, and the measurement parameters are: water level, flow quantity, pH, dissolved oxygen, dissolved oxygen saturation rate, COD, electric conductivity, ammonia nitrogen, and nitrate nitrogen. Other water quality parameters are measured twice a month. Measurements are executed in accordance with the annual measurement plan..

In the monitoring network related to underground water, there is no automatic monitoring net. The monitoring of the water level of underground water has been measured at the frequency of 3-6 times per month on average with 431 monitoring points of 13 regions, which is mainly on the northern part region of Danube river and Sava river basin. The water quality of underground water measures by 30 parameters at frequency of two sample collections per year on average on 67 measurement points of 10 regions, which is the northern part region in Danube river and the Sava river basin, and the Morava river basin as well as the water level measurement network.

The monitoring network related to the air includes the automatic monitoring network in the Belgrade region and the monitoring network of the air quality of the whole country. The automatic monitoring network in the Belgrade region measures SO2, smoke, and NO2 with the day sample by the monitoring equipment set up in three places in the city. The air quality monitoring network of the whole country measures $SO_2$, smoke, and $NO_2$ with the day sample in the monitoring equipment set up in the meteorological stations (29 places) in the whole country.

**3) Public Health Institute, Copper Institute at Bor, and Others**

Public Health Institute is executing the environmental monitoring of the water quality of the surface water and the drinking water, the air quality, and noises in a large and local city area.

They execute the measurement of the air quality at 60 measurement points of 28 cities. The Copper Institute in Bor is executing the management related to the air of three automatic measurement stations and the sample collection and the analysis of the water quality and the soil. In the air quality monitoring in the local city, some or all of the parameters, which are the smoke, $SO_x$, $NO_x$, $CO_2$, ozone, a particulate material, and some of the heavy metals, are executed at twice per year on 76 measurement points of the 40 villages.

### 6.2.4 Industrial Wastewater

As for the monitoring of the industrial wastewater in a Serbia, it is only obligated to execute four times monitoring per year (every three months) for the enterprise who discharged. These monitoring data would be basically kept by the enterprise. It is cleared that the government does systematically not collect and keep these data. The inspection section of the Ministry of the Environment protection has jurisdiction over the poisonous substance in the water quality, and moreover, the inspection section of the Ministry of Health will check the quality of the drinking water (surface water and underground water), and the inspection section of the Ministry of agriculture, forestry, and the water management has jurisdiction over the general term of water. So, it is difficult to uniform in the inspection matter among these organizations.

The measurement parameters of the monitoring waste water, in case of the Grot mine, reaches 49 parameters in total. It is doubt that these many parameters should be obligated to measure on wastewater in mining. I judged that to increase the analysis frequency is better than to increase the analysis parameters on the view of managing wastewater in the mining.

## 6.3 Inspection System

The services concerning to the environment has the character that becomes complex easily in either country, because there are a lot of corresponding fields starting with the permit approval services. Especially, mining is easy to destroy a natural spectacle and the cultural asset etc., and therefore the environmental Impact Assessment Study is obligated before the development in order to prevent the environmental destruction. There is an inspection system as one of these preventive measures.

Considering the environment elements in mining, the air quality, the water quality, the soil, the noise and the vibration, and the subsidence of land, etc. are thought including the protection of the natural asset and the protection of a cultural and social property. The inspection section of the Ministry of Energy and Mining ministry divides into the geological group and the mining group, and the mining group has divided into three teams (the open pit mining, the underground mining and the electricity). Judging from the field investigation, environmental standards are regulated in the average density of the river, and the restriction by the discharge limit value is not done enough. Also, the waste disposer does not analyze it by oneself and the discharge control is not enough and moreover the inspect section does not cross-check neither by the attendance sample collection nor by

the sample collection without advance notice etc. Therefore, it is judged that it is impossible to understand the pollution situation during year by the four times measurement of the wastewater per year.

The inspection section of the Ministry of Environmental Protection is executing an environmental inspection of whole Serbian land by total 88 persons. The Ministry of Environmental Protection has unified jurisdiction about the air, the noise, the nature conservation, and the fishing area of the industrial field. It has jurisdiction over a part of the geological resource protection concerning underground water, though the split of service from the Ministry of Energy and Mining is lucidly not understood for me concerning the geological resource. Because the Ministry of Agriculture, Forestry and Water management has generally a jurisdiction of water management, the inspection section of the Ministry of Agriculture, Forestry and Water Management has a jurisdiction concerning general parameters of the water quality. However the inspection section of the Ministry of Environmental Protection has jurisdiction only over the matter concerning the poisonous substance about the water. Moreover, the Ministry of Culture has a jurisdiction concerning the cultural asset. These service segments are shown in Fig.6.2.

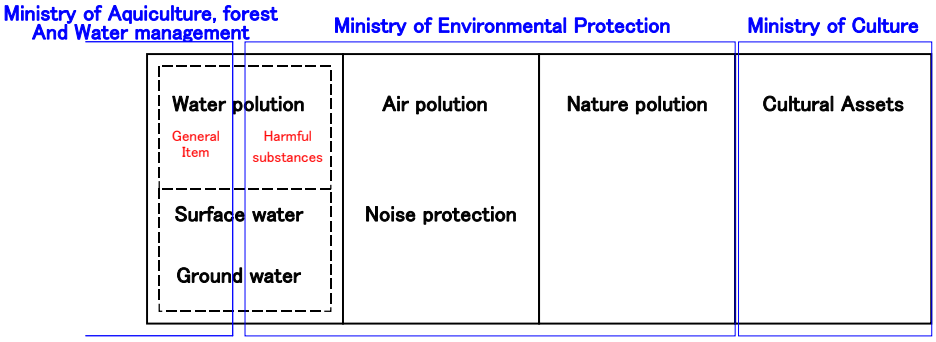



Fig.6.2 Service Segment in each Inspection Section that relates to Environment

The special training course of the inspector who executes the inspection does not exist, and the level of inspection depends on inspector individual's capacity. Moreover, there are little mutual enlightenments between the inspectors, too. As for this, the inspector of each ministry doesn't communicate, and either a inspection is separately performed. In the environment field, a inspection frequency can become substantial compulsion power in environmental management, then the system might be necessary, that each other of the inspector can report, even if the inspectors are in different ministry, by setting up the special training course of inspector, and reducing the difference of the content of the inspection.

**6.4 Environmental Status in Serbia and Environmental Problems in Local Mine**

Hot spots of pollution specified by UNEP include the following. These hot spots are taking measures to combat the pollution.

- Bor　　Leakage of insulation oil including PCBs from electrical substation equipment damaged by NATO bombing

Air pollution from the Bor smelter

- Novi Sad — Outflow of crude oil and petroleum products from an oil refinery
- Pancevo — Outflow of crude oil and petroleum products from an oil industrial complex
  Outflow of harmful substance from a fertilizer plant
- Kragujevac — Leakage of insulation oil containing PCBs from electrical substation equipment caused by NATO bombing

Moreover, pollution in mining is generated besides these, and the accident, that a part of the tailing dam of the Veliki Majdan mine was collapsed because of the heavy rain, was occurred in June, 2001. Environmental problems of Bor mine/smelter have been generated in each field of the air, the water quality, and the soil. Environmental problems of Bor mine/smelter have the possibility that the pollution diffuses transboundary, because this mine is near to the Romania border.

**6.4.1 Grot Mine**

The mine water of the Grot Mine is pH8.5, and is discharged at a rate of about $60m^3$/hr. Of this amount, $54m^3$/hr (90% of the discharged water) is sent to the dressing plant through the drift tunnel that is the haulage level. Most of this water is used in the plant, and the water that cannot be used is sent to the tailings pond. The remaining $6m^3$/hr water is discharged from the mine mouth on the other side.

The wastewater from the tailings pond that isn't recycled at the dressing plant (pH7.5), is discharged into the Juzna. Morava River through the Selecki Potok stream then into the Danube River and finally reaches Black Sea. There are two monitoring points until joining the Juzna. Morava River. Monitoring must be conducted four times per year (every three months) by a qualified organization. Other types of monitoring are not conducted. There was no problem with the analytical results at any of the monitoring points. Because the measurement frequency is too few, it cannot be judged if the environmental management is performed in a healthy manner.

The tailings dam is constructed of sand separated by cyclone separation. Three collecting pipes are set up in the tailing dam. Rainwater from outside of the tailings pond is kept out of the pond by an unlined street gutter, and drained together with overflow water of the pond through the collecting pipes. Moreover, there is no scarcement on the dam body, so sand piles up directly from the lower base to the upper part of the embankment. Plants grow thick on the side of the dam body and in the pond, and there is no deforestation. Therefore the impervious bed is not formed. Some problems exist. Moreover, there is not a watering device to prevent the dust generation from the body of the bank.

**6.4.2 Kizevak Mine**

There are many waste rock deposits around the open-pit (chiefly downstream part), and there are no soil and sand revetments. Acid water (pH2-4) flows out in some places from the lower

base bottom of the waste rock deposits into the stream and the river through the road and the mountain stream.

The equipment of the dressing plant is old, and flotation cells etc. are severely corroded. Moreover, it hasn't been maintained since the operations were stopped. Therefore it seems that restarting operations will be difficult if nothing is done. The conveying pump to the tailing dam is sometimes used for the wastewater management but we could not confirm on site.

There are two tailing dams, a new one and an old one. The new tailings dam is structured such that one body was constructed in the exit mouth, the dam body was built up with separated sand. The scarcement is not set up on the bank body same as the Grot mine. Moreover, the plants grow thick beside the dam body and they are not cut down. The supernatant water from the pond was recycled to the dressing plant. There is not a watering device to prevent the dust generation from the body of the bank.

**6.4.3 Rudnik Mine**

The tailings dam is structured such that one body was constructed at the exit mouth, the dam body was built up with separated sand. There are a lot of wells to measure the water level in the sand of the dam body. The collector pipe of the horizontal type is set up further in the skirt of the dam body. Rudnik Mine is the best equipped with measuring instruments among the small and medium sized mine that I surveyed this time. There is not a watering device to prevent the dust generation from the body of the bank.

**6.4.4 Lece Mine**

The Lece underground mine is now controlled by a bank and is not operating. The mine is pumping the mine water now for the maintenance of the underground equipment. The mine water is about pH5 and has some impurity. There is a little red in the riverbed where the mine water is discharged, so it is presumed that the water includes iron ions.Because the first crushing plant is near the drift, and there is much fine waste rock near the plant, there are concerns about the generation of acid water. Ore is transported between the crushing plant and the dressing plant by cableway, so there is a risk of soil pollution if the ore falls out of the cable car during transport. There are 8 tailings dams which are the structure enclosed on all sides by an embankment. Although the surface of the tailings pond was dry, there is the acidic seepage water beside the dam body of the same tailings dams.

**6.4.5 Bor Mine, Dressing Plants, Smelting and Refinery Plants**

RTB Bor is an integrated operation that includes everything from mine and dressing plant up to smelting, refining, and fabrication plants. RTB Bor has discharged air water and soil containing the various elements from each section. Therefore, contaminants widely exist in the air, water and soil, and the pollutions are mixed and formed complex situation. But the possibility of the noise problem is very few, because the dressing machines are in the building and the dressing plant is

away from resident's houses.

Two types of air quality monitoring are conducted: continuous monitoring and spot monitoring. $SO_2$ is measured every 15 minutes by the continuous monitoring at three measurement points. These measurements are sent to the Copper Institute of Bor, the Bor city office, and RTB Bor in real time. The Copper Institute of Bor compiles a weekly report containing data on $SO_2$ density, and wind direction and velocity, and also makes monthly reports with data on the amounts of dispersed particles and heavy metal (Pb, Cu, Mn, Ni, As, Cd, Zn) content. The two reports are submitted to the inspection sector of the Ministry of Science and Environmental Protection, the Bor city office, and RTB Bor.

All dust fall shows acidities, and the soil acidification is advanced. Moreover, heavy metal (Zn, Pb, etc.) content that is easily volatilized is high. So, it is shown that the collection of the dust extractor is inefficient. The $SO_2$ density in the exhaust gas of the reverberator of the present smelting process is about 1%. It is impossible to make sulfuric acid because of the low concentration of gas. There is a fundamental problem in that there are a lot of leakage gases. Therefore, the form of the furnace will be changed, then the $SO_2$ density will rise. The sulfuric acid production equipment also changes to the Double Contact type, then the $SO_2$ recovery yield will be improved. The capacity of the dust extractor is strengthened, then the amount of dispersion of dust will decrease. It is necessary to attempt a fundamental solution as mentioned above.

The main influence of soil pollution is the acidification of land, and soil pollution with heavy metals. The soil pollution originated from air pollution is direct, and the soil generally shows acidity, forms land not used as a cropland, and increases the area of such land. From soil pollution investigation results, in general the soil of this area has insufficient P content, and K content has been fulfilled. Moreover, the humus content and N content is middle depends on the cultivation situation. But the humus content shows the tendency to decrease in the soil by acidification.

The soil pollution by heavy metals that generates acid water, and the soil pollution by solids from the tailings dam and waste rocks deposited by wind and rain, then the soil pollution of the river bottom that is caused by flying solids. However, the investigation from this viewpoint is insufficient excluding investigation that deteriorated the bottom sediment due to water pollution. A systematic investigation is necessary.

The wastewater of the Bor mine, where various wastewaters are generated by the place, flow volume, and the chemical composition, flow into the Bor river or the Krivelj river and eventually reach the Black Sea through the Timok river and the Danube river. If these wastewaters are classified, it is possible to classify them into seven kinds as follows.

**A) Wastewater that Flows into the Krivelj River**

- Wastewater from open pit ”Veliki Krivelj”
- Wastewater from ”Saraka” stream

・Wastewater from open pit ”Bor”

・Wastewater from the pond of Floatation tailing dam ” Veliki Krivelj” 1A

・Wastewater from the pond of Floatation tailing dam” Veliki Krivelj” 3A

**B) Wastewater that Flows into the Bor River**

・Wastewater from ”Robule” lake

・Wastewater from open pit “Bor”, sulfuric acid plant, copper dry smelting plant, hydrometallurgy plant, and fabrication plant

Fig.6.3 shows the origin of these wastewaters.

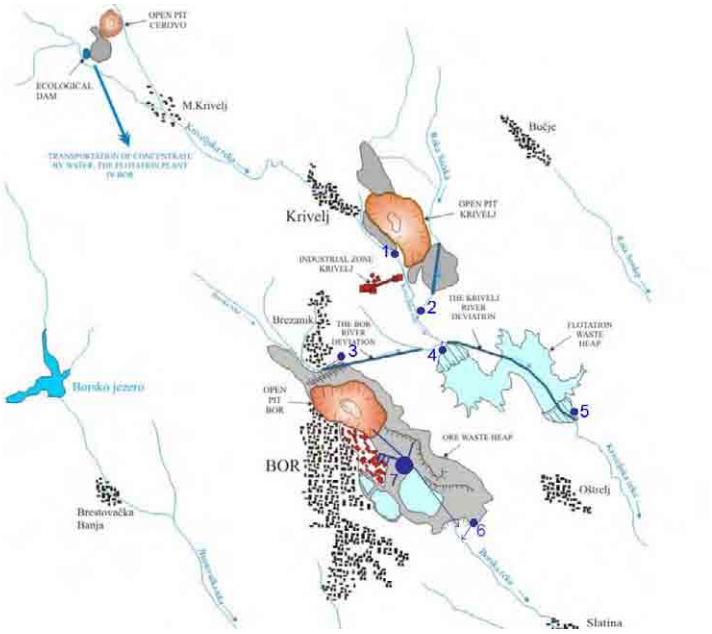



Fig.6.3 Origin Points of Wastewater

The wastewater from the hydrometallurgy plant is abundant with Fe, Ni, As, Al, Bi, Zn, Sb, Te, Pb, and Mn, besides sulfuric acid (16.63g/l) and Cu (4.8g/l), and the flow volume is 2,874m$^3$/year. The wastewater from the PM plant has abundant As, Te, Fe, Co, Zn, Pb, Sb, and Bi, as well as sulfuric acid (15.3g/l) and Cu (2.85g/l), and the flow volume is 1,946m$^3$/year. The wastewater of the regeneration factory have abundant Te, Fe, Bi, Zn, and Sb, as well as sulfuric acid (386g/l), Cu (15.15g/l), Ni (3.07g/l), and As (2.43g/l), and the flow volume is 1,071m$^3$/year. The wastewater of the sulfuric acid plant is sulfuric acid (0.81g/l), Cu (0.041g/l), and the flow volume is 34,944m $^3$/year. These wastewaters have been discharged as imperfect without treatment.

If these data are collected, it becomes as shown in Fig.6.4. The flow volume of a wastewater is large, then it is difficult to directly treat wastewater disposal. The principle of wastewater disposal separation of polluted water and non-polluted water, so that the high density polluted water is treated directly without dilution. It is important to investigate how to separate

polluted water from non-polluted water.

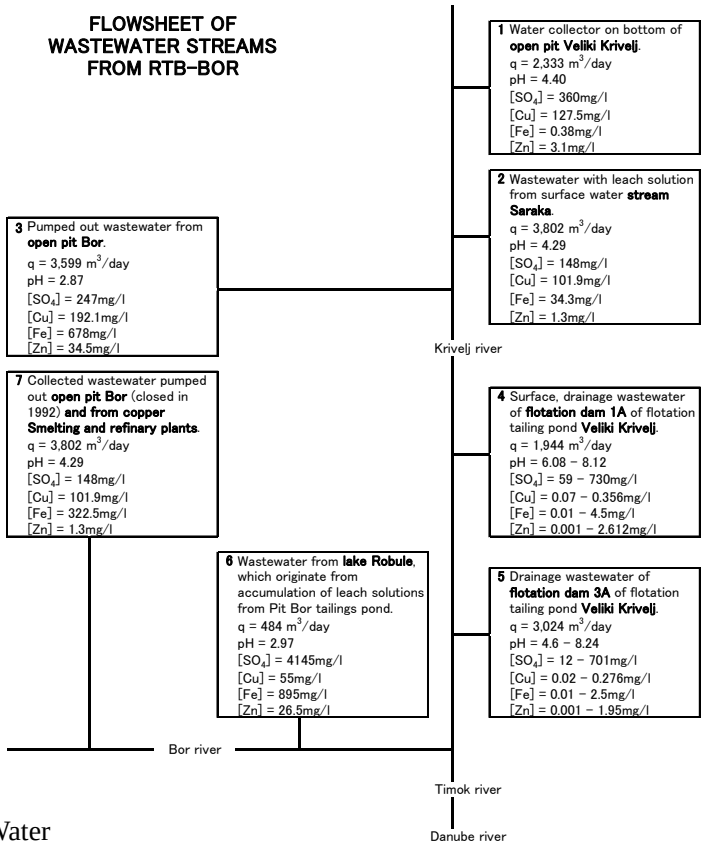



Fig.6.4 Flow of Polluted Water

### 6.4.6 Coal Mine and Cultural Asset

The Kostolac coal mine is a large surface coal mine of the Electric Power Industry of Serbia (EPS), and Drmno deposit exists at early stage of the development now. There are ruins (Viminacijum) on the martial station of Roman times. The majority of ruins in the development area will relocate and restore. If a part of the ruins cannot be moved by the survey of ruins, Drmno deposit is developed while maintaining the security distance by 100m from the boundary of its ruin. These measures are a mutual agreement between the Kostolac coal mine of EPS and the Ministry of Culture in the Environmental Impact Assessment study. It is expected about 250,000 Euro/year as for expenditure necessary for the relocation and restoration.

### 6.4.7 Prevention Measures of Environmental Deterioration for the Execution of Case Study

It is desirable to execute measures of the process improvement in the contents of the case study, because it means that the heavy-metal component (Cu, Pb, Zn) in tailings is decreased. On the other hand, the possibility to be included more in tailings becomes higher as for the another heavy-metal component (Fe and As, etc.) as impurities. In general, if the pH in the tailing pond is maintained to the pH zone where the hydroxides of these heavy metal elements are generated, the danger of the pollution by heavy metal becomes small. That is, the pH in the tailing pond is

maintained to the alkali side, and the installation of equipment of the neutralization of drain with acid is needed.

The recovery of copper and the recovery of gold are investigated for the utilization of untapped natural resources. But, There is danger of depraving the environment according to the recovering flow process, unless the following points are considered.

- The adoption of the cement copper extraction method for cupper recovery generates the acid drainage water that is included the a small amount of copper ion with higher content of iron ion after the precipitation, because the copper recovery of this method is so not high. This kind of drain often becomes voluminously, and it is necessary to treat enough processing.
- Although the CN leaching has advantage in the recovery of the Au leaching process, it is necessary to execute sufficiently the decomposing process of CN after the leaching.

In the former, though the SX-EW method is devised instead of the cement copper extraction method, because the copper concentration of the obtained solution is ordinarily low, it is difficult to maintain the economy. Therefore, it is necessary not to mix extra water at the same time as a means to raise the oxidation and extraction rate of copper as a means to raise the copper concentration. Basically, it is necessary to decide the process flow while considering the separation of copper dissolution liquid from other drains.

In the latter, it is necessary to provide the process flow considering the combination of the equipments for the CN leaching and the method to decompose the cyanides from viewpoint of the environmental protection. There are many procedures to decompose cyanides that are as Alkali Chlorination Process (Two Step Decomposing Method), Ferrician Blue Method (Hardly-soluble Complex Compounds Precipitation Method), Sublimation and Absorption Method, Ultraviolet Ray Decomposition Method, Electrolytic Oxidation Method, Hot Water Hydrolysis Method, Microbial Decomposition Method, and Combination Method of those techniques. The CN density of each method to be applied is different, and it is necessary to select the proper procedure.

## Chapter 7 Case Study

### 7.1 Preparation and Implementation of the Case Study

Target mines for the case study are listed in 1.6.2 in Chapter 1. Target mines selected in the Inception Report for the case study were impossible to study due to the rapid progress of privatization. Therefore, new targets were selected, based on discussion among the Ministry of Economy, Agency of Privatization, MEM and the Study Team. Mines and tailings ponds selected here belonged to bankrupt companies waiting for arbitration by the supreme court, or facilities that were not being privatized. The Agency of Privatization has mine data to analyze these selected mines (Grot and Suva Ruda). Therefore, the case study was carried out under limited availability of mine data. The case study was implemented during the 2nd and 3rd local surveys. Tailings ponds selected for the case study were from the RTB Bor (not privatized), and Lece Mine. It should be noted that sampling of active processing plants was done in the Grot and Rudnik mines to evaluate mineral processing.

### 7.2 Geology, Deposits and Exploration

#### 7.2.1 Grot Mine

**(1) Geology and Deposits**

This area is located in the Besna Kobila-Osogovo metallogenic zone of the Serbo-Macedonian metallogenic province. Important lead and zinc deposits occur in the metallogenic zone that runs 50 – 60km north to south. Gneiss, crystalline limestone, carbonaceous schist of Early Paleozoic (Ordovician to Silurian), and biotite-sericite schist and mica schist of Late Paleozoic overlie the Blagodat ore field, and Tertiary granodiorite, andesite and dacite intrude the strata. The Blagodat ore field is comprised of skarn-type lead and zinc deposits and vein-type zinc deposits, which formed in crystalline limestones and carbonaceous schists intruded by dacite-andesite and granodiorite. The ore field covers an area of 3km east to west and 4km north to south (Fig.7.1).

The Grot mine (formerly the Blagodat mine) includes the Blagodat, Đavolja Vodenica, Vučkovo, Đavolja Vodenica II, and Kula deposits. The Blagodat, Đavolja Vodenica、Vučkovo, and Đavolja Vodenica II are skarn-type deposits, and the Kula is a vein type. From 1974 to 2005, the Blagodat – Grot mine produced a total of 5.2 million tones of crude ore grading 2.9％Pb and 2.7% Zn. Skarn-type lead and zinc orebodies of the Blagodat, Đavolja Vodenica, Vučkovo, and Đavolja Vodenica II deposits form stratiform and lenses controlled in crystalline limestone, and are partly disseminated (Fig.7.2). The No. 2 orebody of the Blagodat deposit, the champion orebody, is 400m long and from 20m to 30m wide, and runs NW-SE. The orebody continues from 1,680m asl to 1,538m asl, 150m in vertical length. Other orebodies range from 10m to 15m long, 1m to 3m wide, and 5m thick. Ore grade varies from 7 – 8% lead and zinc (low grade) to 20 – 30% lead and zinc (high grade). High-grade ores tend to occur in the central part, with low-grade ores surrounding them.

The main ore minerals are galena, sphalerite, magnetite and pyrite.

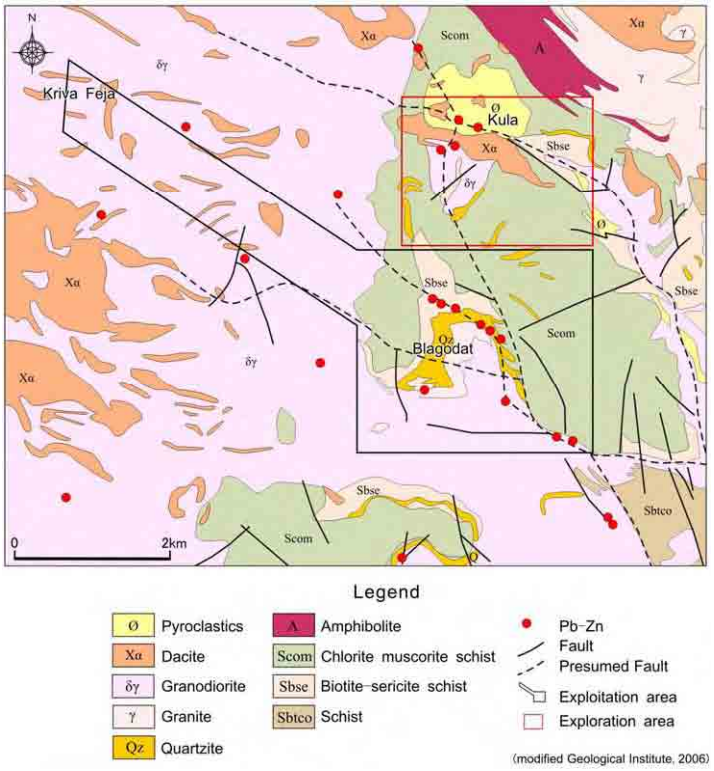



Fig.7.1 Geological Map of the Blagodat Ore Field

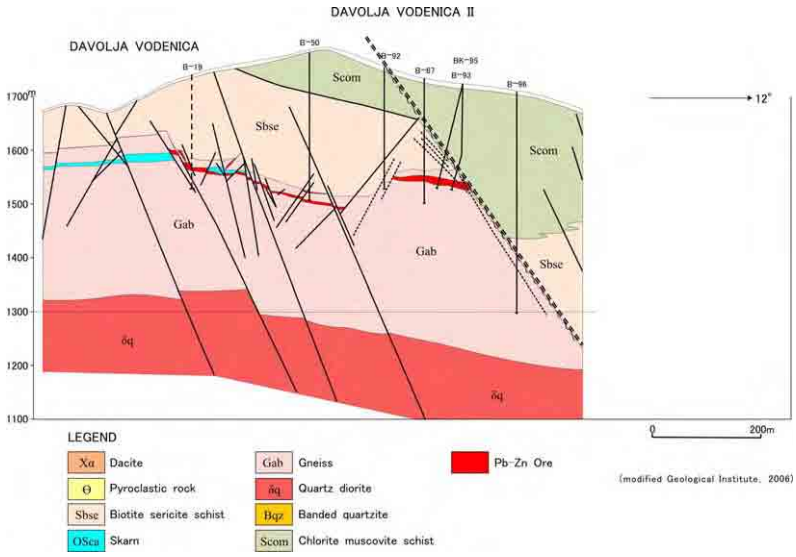



Fig.7.2 Geological Profile of the Blagodat Deposit

The Kula deposit is a vein type that is located 3km north of the skarn deposits. About 10 veins occur in an area of 700m east to west, and 600m north to south. All the veins strike N40 ° W and dip 75 ° to 80 ° to the east (Fig.7.3). The scale of veins ranges from 100m to 250m long, and maximum 3m wide. Parts of veins have formed echelons. Ore shoots of veins are oriented toward N50 ° – 60 ° E, and incline 20 ° –30 ° east. Ore grade ranges from 7 % to 8% Pb and Zn. The main

ore minerals are galena, sphalerite, magnetite and pyrite.

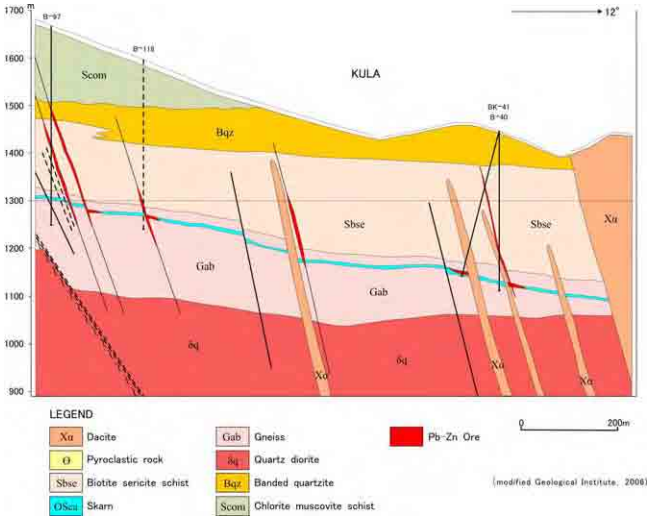



Fig.7.3 Geological Profile of the Kula Deposit

From 1974, when the Grot mine started operation, until 2005, the mine produced 5.2 million tonnes of crude ore with 2.94% Pb and 2.67% Zn, and 154,000 tonnes of lead and 140,000 tonnes of zinc (Geological Institute, 2006). Ore reserves at 31 December 1987, which is the latest data available for the mine, amounted to 113,000 tonnes with 6.14% Pb, 4.64% Zn and 188g/t Ag in classes A+B+ C1. Ore reserves at 31 December 2005, amounted to 345,000 tonnes with 4.84% Pb and 5.57% Zn in A+B+C1 category. At that time, probable resources (C2) were estimated to be 5.0 million tonnes (Table 7.1 and Table 7.2.).

Table 7.1 Reserves of the Grot Mine (as of 31.12 2005)

| Ore deposit | Category | Category (Western) | Category (Serbian) | Reserves t | Pb grade % | Zn grade % | Pb t | Zn t |
|---|---|---|---|---|---|---|---|---|
| Blagodat | Geological reserves | Proven | A | 115,028 | 5.44 | 4.72 | 6,258 | 5,429 |
| | Geological reserves | Proven | B | – | – | – | – | – |
| | Geological reserves | Proven | C1 | – | – | – | – | – |
| | | | A+B+C1 | 115,028 | 5.44 | 4.72 | 6,258 | 5,429 |
| Davolja Vodenica | Geological reserves | Proven | A | – | – | – | – | – |
| | Geological reserves | Proven | B | 58,940 | 3.18 | 4.50 | 1,872 | 2,653 |
| | Geological reserves | Proven | C1 | 20,794 | 3.55 | 4.90 | 737 | 1,020 |
| | | | A+B+C1 | 79,734 | 3.27 | 4.61 | 2,610 | 3,673 |
| Vuckov | Geological reserves | Proven | A | 38,836 | 4.05 | 5.19 | 1,573 | 2,016 |
| | Geological reserves | Proven | B | 50,997 | 5.71 | 9.64 | 2,915 | 4,712 |
| | Geological reserves | Proven | C1 | 20,803 | 4.54 | 5.45 | 944 | 1,135 |
| | | | A+B+C1 | 110,636 | 4.91 | 7.11 | 5,431 | 7,862 |
| Davolja Vodenica II | Geological reserves | Proven | A | – | – | – | – | – |
| | Geological reserves | Proven | B | 25,563 | 6.47 | 6.46 | 1,655 | 1,653 |
| | Geological reserves | Proven | C1 | 14,915 | 5.27 | 4.44 | 786 | 663 |
| | | | A+B+C1 | 40,478 | 6.03 | 5.72 | 2,441 | 2,315 |
| Total | Geological reserves | Proven | A | 153,864 | 5.09 | 4.84 | 7,830 | 7,445 |
| | Geological reserves | Proven | B | 135,500 | 4.75 | 6.66 | 6,442 | 9,018 |
| | Geological reserves | Proven | C1 | 56,512 | 4.37 | 4.99 | 2,467 | 2,817 |
| | | | A+B+C1 | 345,876 | 4.84 | 5.57 | 16,739 | 19,280 |

Table 7.2 Resources of the Grot Mine (as of 31.12 2005)

| Area | Location | Category (Western) | Category (Serbian) | Resources t | Pb grade % | Zn grade % | Pb t | Zn t |
|---|---|---|---|---|---|---|---|---|
| Kula | P–I | Probable | C2 | 1,254,866 | 3.20 | 3.80 | 40,156 | 47,685 |
| South of Davolja Vodenica | P–II1 | Probable | C2 | 45,000 | 3.20 | 4.60 | 1,440 | 2,070 |
| West of Davolja Vodenica | P–II2 | Probable | C2 | 27,000 | 3.20 | 4.60 | 864 | 1,242 |
| Vuckov | P–II3 | Probable | C2 | 405,000 | 4.90 | 7.10 | 19,845 | 28,755 |
| South of Davolja Vodenica II | P–II4 | Probable | C2 | 112,500 | 6.00 | 5.70 | 6,750 | 6,413 |
| North of Davolja Vodenica II | P–II5 | Probable | C2 | 900,000 | 6.00 | 5.70 | 54,000 | 51,300 |
| Southwest of Kula | P–II6 | Probable | C2 | 756,000 | 3.20 | 3.80 | 24,192 | 28,728 |
| Between Kula and Davolja Vodenica | P–III | Probable | C2 | 1,560,000 | 4.60 | 4.70 | 71,760 | 73,320 |
| Total | | | | 5,060,366 | 4.33 | 4.73 | 219,007 | 239,512 |

In the current structure there are only one geologist and one assistant. No underground maps have been compiled though the trackless underground method had been used to dig prospecting and developing tunnels during the last 2 years. There is no basic map for grade control. Production control of crude ore is insufficient due to the total lack of assay maps of new prospecting regions. Calculation of ore reserves in the Grot mine has been done by the Geological Institute, on the basis of the geological prospecting regulations. Reserves and ore grade of mines in Serbia are determined by the Reserves Verification Commission and even under the market economy the reserves and grade are still under state control. In a market economy, the government should take measures to reduce state control. Specifically, the government should establish the rules for estimating ore reserves, but mining companies should make the actual assessments based on these rules, and the system for certifying the reserves and grade should be changed from approval by the government to reporting to the government. It appears that a mining company or development company will assume the risks associated with finding reserves when a mine is being exploited.

Underground geological maps are insufficient, as are formation and structural analyses of deposits, due to the reductions in staff and lack of time to study the analyses. There is no chance to acquire new information as mining geologists lack knowledge. The short-term prospecting plan for the 5 million tonnes of estimated resources shown in Table 7.2, is not specific and diagrammed. The expected mine life is 3 years, based on 300,000 tonnes of ore reserves that are extracted at a rate of 100,000 tonnes per year.

The areas having particular mineral potential include the vicinity of the Đavolja Vodenica II deposit, the area around the Kula deposit and a sector between the Đavolja Vodenica II and Kula deposits. In future, underground drilling and drift prospecting will be needed in these areas. Optimally, this would involve detailed underground drillings of the 200 – 400m class and drift prospecting of the 1000 – 1500m class toward the presumed ore deposits in these areas. However, the Grot mine cannot afford exploration due to its present financial difficulties. Therefore, it would be desirable for the government to create a new system for supporting exploration through subsidies.

It is important to secure ore reserves not only at Grot, but at any mine, because ore reserves will determine the life of the mine. At present, there is an estimated 5 million tonnes of

resources in the abovementioned area in the Grot mine. The 5 million tonnes is the same amount of ore that had been excavated for approximately 20 years since 1974. Given the current high prices in the zinc and lead markets, this would be an excellent time to restart exploration activities. Exploration would also make a considerable contribution to the reconstruction of the Grot mine.

Estimates have already been made of ore reserves which can be obtained by drilling prospects around the deposits, assuming that the interval between drill holes is 50m, average length of drilling is 300m and 16 holes are drilled each year. After drilling a prospect around a deposit, mineralization of 30m in length would be hit per 300m of drill hole. The probability of hitting mineralization with each drill hole would be 1/5, meaning that an annual average of 3.2 drill holes (16/5) would find mineralization. In this scenario, the estimated total amount of ore reserves would be 58,000 tonnes per drill hole X 3.2. This estimate is derived from the following formula:

Per 300m long mineralized drill hole ------ 30m (length) x 25m (width) x 25m (height) x 3.1($t/m^3$) = 58,000t per drillhole X 3.2.

It is assumed that the ore reserves that are obtained will be reduced at an annual rate of 20% due to the reduction of areas for exploration.

Table 7.3 shows estimated values for ore reserves based on the assumptions that mining recovery is 0.76%, dilution is 18% and the amount of mined ore is at the same level (100,000 tonnes) as in 2006.

Table 7.3 Target Reserves to be Explored at the Grot Mine (unit: Kt)

| | 1st year | 2nd year | 3rd year | 4th year | 5th year | Total |
|---|---|---|---|---|---|---|
| Minable ore reserves | 345 | 364 | 396 | 372 | 332 | |
| Mined ore* | 100 | 100 | 100 | 100 | 100 | 500 |
| Obtained ore reserves | 185 | 148 | 118 | 94 | 75 | 620 |
| Obtained minable ore | 119 | 132 | 76 | 60 | 48 | 435 |
| Crude ore at year-end | 364 | 396 | 372 | 332 | 280 | |

In this estimation, 620,000 tonnes would be obtained, compared with 500,000 tonnes of ore that would be mined over a 5-year period. It is considered that approximately 5000m total length (300m X 16) would be a suitable amount of annual drill prospecting.

**7.2.2 Suva Ruda Mine**

This area is located in the Raska ore zone of the Serbo-Macedonian metallogenic province. In the ore zone, lead and zinc deposits occur in an area running 10km east to west, and 20km north to south. Tertiary volcanic rocks overlie the Raska ore zone, and consist mainly of andesitic-dacitic volcanic rocks and granodiorite. The eastern and western ends of the ore zone contact with serpentinite of the Jurassic period. Mineralization has been affected by lithology and structure, as a number of deposits are related to the fault system and fracture zone. Lead and zinc deposits occur in vein, dissemination, lens and network shapes (Fig.7.4).

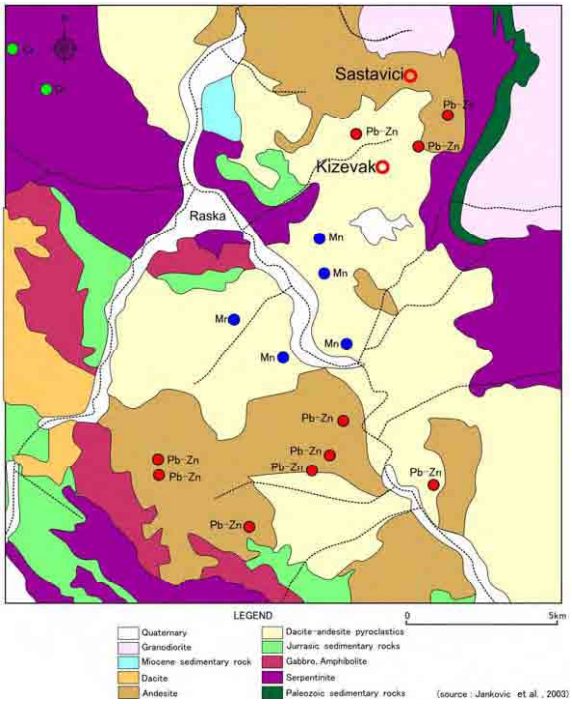



Fig.7.4 Distribution of ore drposits in the Raska Metallogenic Zone

The Kizevak deposit formed in dacitic to andesitc volcanic rocks, and is controlled by faults running NE-SW and E-W. Orebodies occur in irregular or extended lens shapes. The vertical extension of orebodies is 200m or more, and it has a NNE-SSW orientation with a dip of 60° to 70° to the east. Orebodies are 300m long, and vary in width from 1m to 50m. The average ore grade is 4% Pb+ Zn.

Like the Kizevak deposit, the Sastavci deposit also formed in dacitic to andesitic volcanics, and is controlled by the fault system trending NE-SW.

From 1984 to 1997, the mine produced 1.7 million tonnes of crude ore from the No.2 ore zone of the Kizevak deposit, and 40,000 tonnes from the Sastavci deposit, for a total of 1.7 million tonnes of ore containing 1.77% Pb and 3.3% Zn.

Since 1988, no report on geological exploration has been made. The ore reserve numbers in Table 7.3 are based on interviews with mine staff. Ore in the No. 1 ore zone of the Kizevak deposit has not been mined, and amounts to 2.0 million tonnes with 2.16% Pb and 3.9% Zn.

Table 7.4 Reserves of the Suva Ruda Mine (as of 1988)

| Ore deposit | Ore body | Reserves Kt | Pb % | Zn % | Ag g/t |
|---|---|---|---|---|---|
| Sastavci | | 340 | 2.07 | 5.56 | 45 |
| Kizevak | No.1 ore zone | 1,646 | 2.19 | 3.67 | 33 |
| | Intermediate zone | 340 | 2.03 | 4.87 | 328 |
| | Total | 1,986 | 2.16 | 3.88 | 84 |

Tunnel prospecting of 7,000m total length and drilling of 35,000m was implemented at the No. 1 ore zone of the Kizevak deposit in 1980'. However, there is still a chance to extract the 2 million tonnes of crude ore that still lies buried, because the mine was under the Trepca in 1996 and it was

separated from the Trepca in 2001, the mine loss an opportunity to exploit the No. 1 ore zone of the Kizevak deposit. At the present, it is needed to strip one million cubic meters of an overburdened soil for developing the No. 1 ore zone of the Kizevak deposit, and it is not a situation in which crude ore is put out at once. However, due to the high arsenic content (4.3% As of average grade in the Sastavci deposit), it caused trouble for mineral processing that zinc concentrate contained 18% As, and only 44,000 tonnes were treated in 1984, the first year of development. Therefore, approximately 340,000 tonnes of crude ore have not been developed. According to the manager of the mine, the gold grade in the Sastavic deposit is higher than in the Kizevak deposit, with an average grade of Au 6.6 g/t.

According to the information presented above, there may be a high-sulfide type gold deposit predominant in arsenopyrite in the deep part of the deposit. Therefore, it will be necessary to consider gold assay distribution, gold occurrence, and the relationship between gold and arsenopyrite. Specifically, it is advisable to investigate three-dimensional assay distribution and zonal distribution of alteration in the Sastavci deposit, especially the kaolinite and alunite alteration and the existence of porous silicified rocks. It is also desirable to confirm the mineralization down to 300 meters under the surface in the central zone of the gold mineralization by drilling prospecting. It is difficult for mines to conduct such mineral deposit studies due to the lack of staff and capacity. It is thus advisable for these studies to be implemented by a governmental institute, such as the Geological Institute. The Suva Ruda mine, which is bankrupt and reconstructed, is lacking funds for conducting exploration work and basic investigations of the mineralization of ore deposits. It would be desirable for state institutes to establish a supporting system to assist in the operation and reconstruction of mines.

### 7.3 Mining and Processing

#### 7.3.1 Grot Mine

The head office of the mine is located in Vranje City, Pcinja District, about 350 km from Belgrade and about 40 km from the border with Macedonia. There are many factories producing textiles, furniture, tobacco, etc. in Vranje City, which has a bustling economy. The Grot Mine is located in Kriva Feja Village which is 30 km from the city and about 750 m higher in elevation.

This mine was developed by

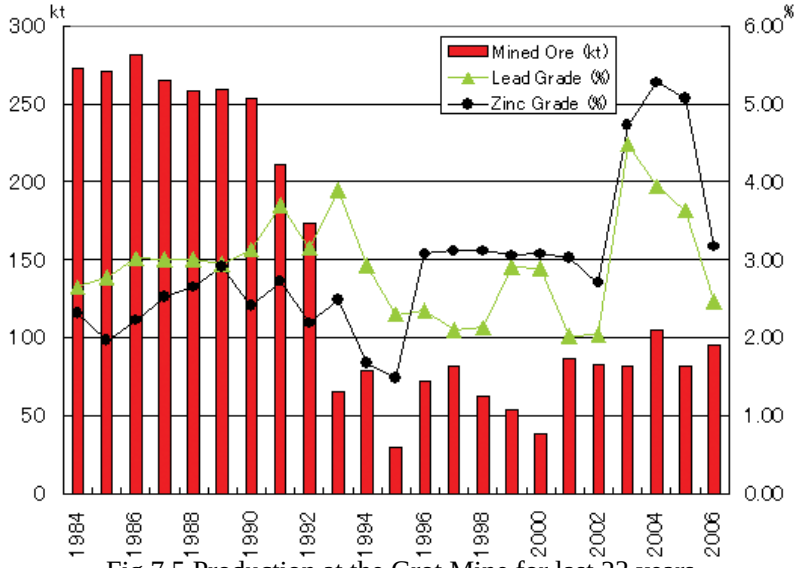


Fig.7.5 Production at the Grot Mine for last 23 years

the Trepca Lead Zinc Mining Complex in Kosovo in 1974, and all concentrates were treated in the Trepca Smelter. However, the mine became independent from Trepca in 1987 due to delayed payment for concentrates. In 1995, the Trepca Complex could not attain concentrate due to the Kosovo conflict, so the government ordered the mine to join to Trepca again to provide concentrates. And finally it became independent from Trepca in 2001. Fig.7.5 shows production at the mine for last 23 years.

The company fell into bankruptcy due to its accumulated debt on November 25, 2005, and is currently operating under the authority of the Agency for Privatization. A legal assignee was appointed president of the company by the agency. The total amount claimed by creditors is 15,780 million Dinars, including 7,004 million Dinars of interest. Current credit authorized by the court is 675 million Dinars, including 415 million Dinars of interest. Unpaid creditors have issued a statement of disagreement and begun the procedure for a new judgment.

In comparison with former production, current level is less than half, but the mine was operating in the black owing to high metal price, with profits of 60 million Dinars in 2005, and in 2006, it produced 2,000 t of lead concentrate and 3,900 t of zinc concentrate.

All concentrates are sold to Trafigura Ltd. of Switzerland, which had been sending them to the Plovdiv Smelter in Bulgaria. But the Plovdiv Smelter did not pay the concentrate charge last year, but the mine did not incur any damages from this, because the charge was covered by insurance.

There are 4 mining areas in Grot Mine; the Blagodat, the Djavolja Vodenica, the Djavolja Vodenica 2, and the Vuckovo mining areas from the west. There are 9 horizontal levels from 1,713m above sea level (Level 1) to 1,296m above sea level (Level 9). Schematic section shows in Fig. 7.6.

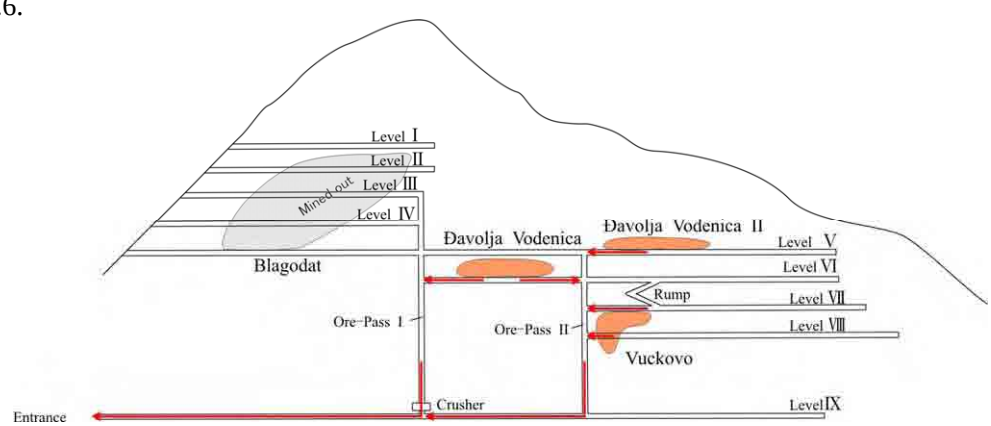



Fig.7.6 Schematic Underground Section of the Grot Mine

Characteristics of each mining area are as follows;

a. The Blagodat mining area

(dimensions: 400mW×600mL×178mH, average production grade: Pb＋Zn6%) This is the largest ore deposit in Grot Mine, but this area is already mined-out, except pillars, in 1994. The total mined ore was about 4 million tons.

b. The Djavolja Vodenica and Djavolja Vodenica 2 mining areas

(total dimensions: 300mW×1,300mL×135mH, average production grade: 8%, production weight: 50% from both mining areas) There are 3 veins with a strike of NW and dip 0f 45°.

c. The Vuckovo mining area

(dimensions: 15W×250mL×135mH, average production grade: 10%, production weight: 50% with 5 stopes)

Currently production is carried out in the Djavolja Vodenica, Djavolja Vodenica 2, and Vuckovo areas. Ore flow is indicated by red arrows in Fig.7.10. The haulage distance is about 6 km between ore chute 1 and the processing plant, about 1km between ore chutes 1 and 2, and about 1km between ore chute 2 and the Vuckovo mining area.

Ore deposits in the Djavolja Vodenica and Djavolja Vodenica 2 mining areas are very small. There are 10 stopes in the Djavolja Vodenica area with ore deposit heights of 0.5 to 3.0 m, and 2 stopes in the Djavolja Vodenica 2 mining area with ore deposit heights of about 2m. Therefore, mining can be mostly finished in these stopes by driving LHD drifts. The stopes of the Vuckovo mining area are comparatively larger. There are 4 stopes, but these stopes are in the same ore deposits. The current proven ore reserve is extremely small, so a great deal of effort is required to produce exploitable ore. It is unreasonable to expect a return to pre-1990 production levels. If proven ore reserves are not increased through urgent exploration, it might be difficult to maintain the current production level into the near future. Mining is done in combined shrinkage and room & pillars methods.

There are many old machines that were bought in 1960s to 1980s. Ventilation is important for underground operation, because many diesel engines have been used since a trackless mining system was introduced.

Medium/long term production plans have not been prepared, because the company went bankrupt without future perspective.

Compared to western mines, awareness of safety is not likely to be higher, because the underground is dark and drifts are not neat. In the stopes, there are no barricades to prevent falls. Miners wear helmets, but do not wear dust masks or safety glasses.

Mining operation efficiency was analyzed based on the work of 184 workers. Production was 94,938t in 2006, so the total underground efficiency is calculated to be 3.2 t/worker, which is amazingly low. When this is compared with a Japanese underground mine, it is less than half the 6.71 t/worker of the Tochibora Mine, Kamioka in 1965 before introduction of a trackless mining system. It should be noted that this Japanese mine made efforts to mechanize by adding a trackless mining system, and its total efficiency increased to 51.33 t/miner.

The main reason for the low efficiency at Grot Mine is excess workers, due to the 4-group 2-shift system. Unless efforts to decrease transportation time are taken, operation efficiency might remain low and mining costs might remain high.

The low efficiency of the Grot Mine is also due to low mechanization and the small capacities of the stope transportation machines. Increased operation efficiency might be expected with increased air pressure and water pressure. Regarding safety, ceiling fall may be the most important matter from viewpoint of the room & pillars method with large open spaces. If open space is regulated, cut and fill methods should be introduced without sublevel undercutting.

In the case of Japanese mines, each cost is shown as a percentage of the total mining cost as follows; principal mining materials 20%, labor 35%, repair of mining machines 15%, underground maintenance 7%, subcontractors 15%, and other costs 8%. Labor costs higher in Japan, but the cost of mining machine repairs is reportedly higher in Serbia.

Generally speaking, these figures are considerably lower than Japanese average efficiency. This is due to delayed mechanization.

There is detailed expenditure data in the head office of Grot Mine. However, this is for the total of all departments, including mining, processing, mechanical repairs, administration, etc. There is no data for only mining. So, the calculated and compiled data is not used for cost management. Expenditure items for mining are material costs, labor costs, repair costs, maintenance costs, subcontractor costs, and electricity costs. By checking variations in these figures over time, mining cost management is possible.

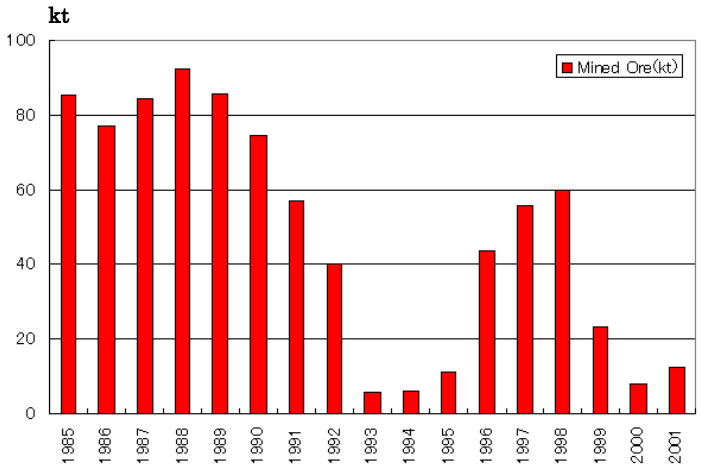
**7.3.2 Lece Mine**

The company is headquartered in Medvedja City, Medveda District, approximately 320 km from Belgrade. The mine is located in Lece Village. The mine dates back to 1934 when an English company started mining activities in this area. It was inactive during World War 2, but the government reactivated it in 1945. The mine was joined with the Trepca Group in the 1970s, but it later became independent. Then in 1991, it was rejoined with the Trepca Group. The mine stopped operations in 2001 due to the economic sanctions, and simultaneously became independent from the Trepca.

According to the data, in 1985, the ore reserve was 2 million tons (1.64％Pb, 3.16％Zn, 2.96g/tAu and 23g/tAg). The main ore body, Jezerina1, is 30% mined, and 70% unmined. There are 2 other ore bodies besides the main ore body.

There are two ore bodies; the Jezerina Orebody with 4 horizontal levels at vertical intervals of 50 meters, and the Rasovaca Orebody with 5 horizontal levels at vertical intervals of 35 to 70 meters. The main mining method was the Shrinkage Method at the beginning stage, but afterwards it was changed to the Sublevel Stoping Method. The mother rock is rigid with an excavation support ratio of only 10 % in the main levels.

Production of the mine was normal from 1957 to 1977. Annual production was kept at more than 80,000 tons with grades of Pb1.7%, Zn3.9%, Au4.2g/t and Ag16.5g/t. The high grades of gold and silver are particularly notable. Fig.7.12 shows production results from 1985 to 2001. Production peaked at 90,000 t/year in 1988, but by 1993 had fallen to a mere 6,000 t/year due to the economic sanctions imposed by the United Nations. After 1996, annual production had recovered to the 40,000 to 60,000 t level, but it dropped again in 1999 due to a second series of economic sanctions. Owing to a shortage of mining machines, production was stopped in 2002.




Ore mined in the underground was sent to the crushers, and then transported by ropeway to the ore processing plant located in another mountain. The reason for constructing the plant in another mountain was that there was insufficient space for the plant and tailings pond in Lece Village. Concentrate grades were 60%Pb in lead concentrate with 100g/t Au and 450g/t Ag, and 51% in zinc concentrate with 4.5 to 7.0g/t Au. All concentrates were processed in Kosovo at the Zvecan Smelter belonging to the Trepca Group.

Tailings have been deposited in a total of nine ponds. As mentioned above, crude ore had higher grades of gold and silver. The Mining Institute in Belgrade investigated the gold grade in the tailings by 4 drilling holes in the ponds. The results showed a grade of 1.1g/t Au and the volume of tailings was calculated to be 1.5 million tons. However, the actual tailings volume may be larger than this, because total production was 3 million tons.

### 7.3.3 Kizevak Mine

The Suva Ruda Mining Co. Ltd. which holds the Kizevak Mine is located in the Raska District of Raska City, about 300 km south of Belgrade. The company opened the Suva Ruda Mine and Suvo Rudiste Mine (Cu, Fe) nearby Kopaonik, currently national park, in 1970. The company name came from this

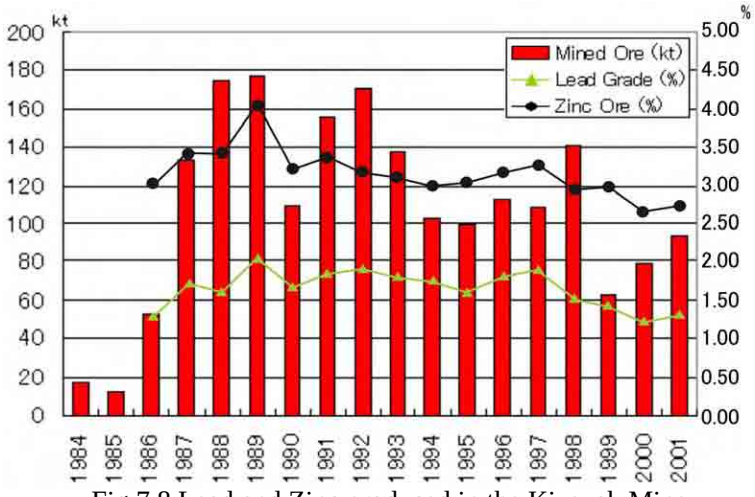



Fig.7.8 Lead and Zinc produced in the Kizevak Mine

mine. Both mines stopped operation in 1984 due to exhausted reserves. The total amount of mined ore was less than 2 million t for 14 years, but its grade was reportedly about 5%.

The company opened the Kizevak and Sastavci Mines in 1984. The Sastavci Mine is 3km north-northeast from the Kizevak Mine. Mined ore was processed in the Dona Rudnica Plant, which treated copper and iron ore. The ore from the Sastavci Mine contained more than 4% arsenic in ore, and 18% in concentrate. Therefore, Sastavci ore could not be treated alone, and was always treated together with Kizevak ore. However, the Sastavci Mine could not operate very much due to arsenic problems, and operated in only 4 years; 1984, 1988, 1989 and 1990. The total production was only 44,854t. Currently, it is impossible to go to the mine site by normal cars due to very bad road conditions. Therefore, ore was mined mainly from Kizevak Mine. Fig.7.13 shows the production. Production peaked from 1988 to 1992 with 160,000 to 180,000t/year. According to production data from 1984 to 1997, the total production was 1.74 million t with an average grade of 1.77%Pb and 3.31%Zn. Production data after 1998 was the amount treated in the Trepca Smelter.

The mine became independent by 1995, and transported the concentrate to the Zorka Smelter. In 1996, the mine joined with Trepca, and transported the concentrate to Trepca. After the mine became independent from the Trepca in 2001, the concentrate was sold to the Zletovo Smelter in Macedonia. The company went into bankruptcy in 2002, because they could not prepare ore-body No. 1 for new mining although ore body No. 2 was almost exhausted. Operation was not profitable due to low metal prices at that time, and debt accumulated.

The Kizevak Mine consists of the No.1 and No.2 ore bodies and a connecting part between them. Ore-body No.2 has continually been mined in the past. Ore-body No.2 has a pit about 100m long, 60m wide, and 120m high (12 benches with 10m high). For mining operations, there were five 30t dump trucks to transport ore in the pit, four 20t dump trucks to transport waste, two wheel loaders (one for ore trucks and one for waste trucks), and also drill machine made by Atlas Copco. The stripping ratio was 1:3 during normal production. When Ore-body No.2 was almost exhausted, they worked intensively to prepare mining in Ore-body No.1, including many exploration drifts and drilling for calculation of ore reserve. However, they did not have sufficient time to strip about 1 million $m^3$ of waste from Ore-body No.1, and the company went into bankruptcy.

One serious problem in Kizevak was ore dilution. For example, a total of 2 million t was mined for ore of 0.96 million in the No.11 mining zone, and ore grade accordingly dropped from 7% to 2%. It seemed to be caused by well separation between ore and waste due to the small dimensions and irregular shape of ore body.

Technical comments could not be given, because there was no detailed data, but some points could be identified as follows;

a. Failure in scheduling the production of Ore-body No. 1, in consideration of the residual amount of reserve.

b. Large ore dilution

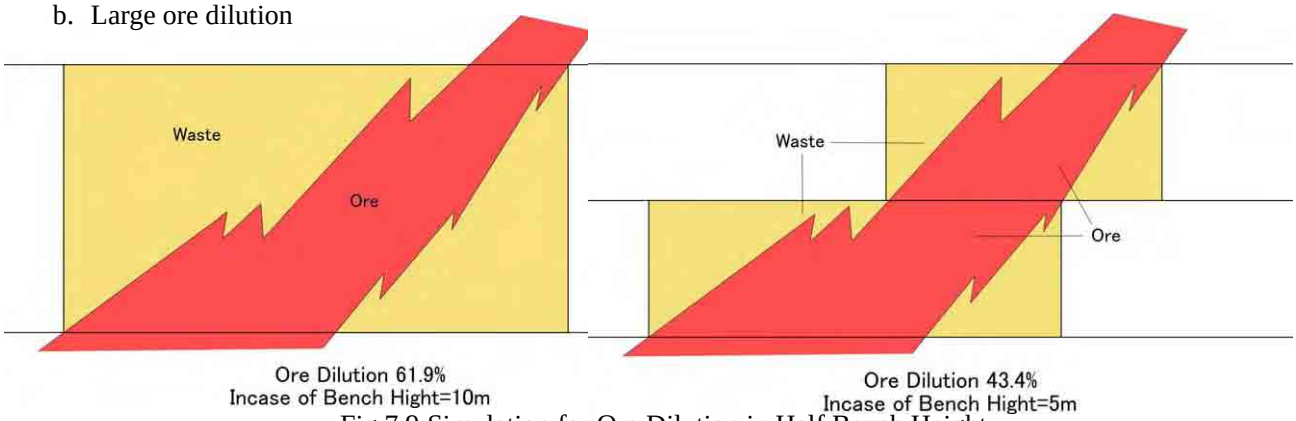



Fig.7.9 Simulation for Ore Dilution in Half Bench Height

c. Too many workers

d. Flexibility of the operation system according to the appropriate number of machines

**7.4 Processing Plant and Tailings Dam of the Bor Complex**

**7.4.1 Objectives of Study**

- Collect basic data and assess current Mineral Processing and Tailings Dam Management field conditions.
- Identify problem points.
- Identify possible overlap points with current World Bank projects.
- Collect data on unutilized resources.
- Conduct case study centered on introduction of leaching technology, and interpret analysis results.
- Analyze identified problems and suggest courses of action.
- Carry out Capacity Development related to Mineral Processing and Tailings Dam Management.

**7.4.2 Case Study Result**

**(1) Drilling Core Samples**

**(a) Old Tailings Dam at the Bor Mine**

At No.1 old tailing dam, 20 m depth core-boring at 8 points, of which at 6 points along with longitudinal and at 2 points along with transverse section, were carried out. Samples of each one meter depth were mixed up as one composite sample of bore hole. Analysis was made for sample from each one meter depth.

Fig 7.10 shows points of core-boring and sampling. And photos of BB1-BB4 are scenes of core-boring and sampling.

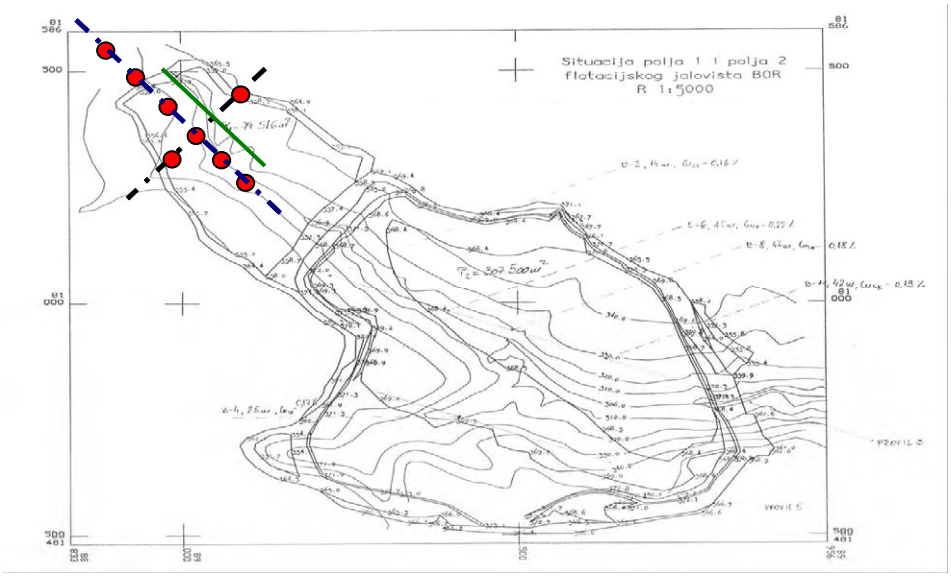



Fig. 7.10 Core-Drilling Points in the Old Tailing Dams at the Bor Mine

**(b) Results of Core-Drilling and Sampling**

- Each 20 m depth hole did not reach to the base rock zone.
- Analysis data of each hole composite sample from B1 to B8 is shown in Table 7.5. Cu grade is between 0.25% and 0.34%, and analysis data of composite sample of all 8 holes show 0.304 % of Cu grade as shown in Table 7.6.

Table 7.5 Chemical Composition of 8 Holes Partial Composites (Drilling Core Samples)

| DRILL HOLE | ELEMENTS | | | | |
|---|---|---|---|---|---|
| | Cu (%) | S (%) | Fe (%) | As (%) | Sb (%) |
| B-1 | 0.32 | 10.97 | 8.82 | 0.016 | <0.005 |
| B-2 | 0.32 | 9.90 | 8.12 | 0.011 | <0.005 |
| B-3 | 0.34 | 9.37 | 8.72 | 0.016 | <0.005 |
| B-4 | 0.32 | 13.52 | 11.40 | 0.010 | <0.005 |
| B-5 | 0.30 | 13.61 | 10.08 | 0.0095 | <0.005 |
| B-6 | 0.26 | 9.43 | 8.21 | 0.0097 | <0.005 |
| B-7 | 0.25 | 13.60 | 7.46 | 0.013 | <0.005 |
| B-8 | 0.32 | 13.21 | 10.90 | 0.010 | <0.005 |

Table7.6 Chemical Analyses Data of Composite Sample

| Overall composite | ELEMENTS | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | Cu (%) | S (%) | Fe (%) | As (%) | Sb (%) | Pb (%) | Zn (%) | Ag (g/t) | Au (g/t) |
| 40kg | 0.304 | 11.701 | 9.225 | 0.0119 | <0.0050 | / | 0.022 | 3.0 | 0.63 |

**(c) Lece Mine**

At Lece Mine there are 9 tailings dams numbered 1 to 9 as you progress downstream. 8 core drillings were initially planned on 3 older dams (from No.2 to No.4). However, dam No. 1 was not included. Drilling was conducted and was 20 m deep. Because machine access to dam No. 2 was difficult, 5 vertical and 5 horizontal hand-auger samples were taken. 20 m deep core samples were drilled at 6 points in dam No.3. Only 20m deep core sample could be drilled in the bush at the No.4 tailings dam. Core samples were taken at every one m for each hole and were

combined into 1 composite sample for each bore hole for leaching tests. We can say that despite low copper content (less than 0.1%), Au content is considerably high and in the economically viable range (in excess of 1g/t). (Drilling points are shown in Fig.7.11).

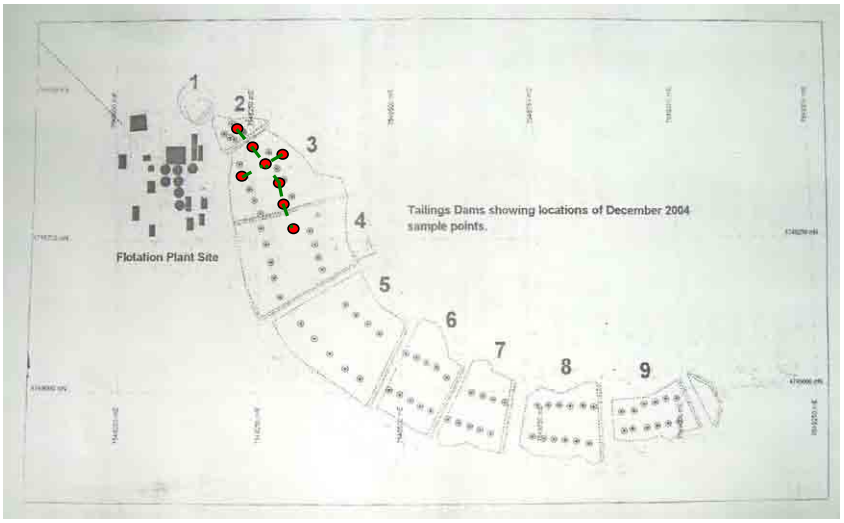



Fig.7.11 Core Drilling Points at the Lece Mine Tailings Dam

**(b) Result of Core-drilling and Sampling**

Each hole gets to base rock at around 15m, however, core-drilling works was kept until 20 m depth. Chemical analysis result of one hand auger sample (T-1) and seven drilling core samples (B-2 - B-8) are shown in Table 7.7. Grades of Pb, Zn and Cu are not high enough for exploiting economically, however, Au grades of T-1 sample is 4.0g/t, and B-2 to B-8 samples show from 1.1to 1.7g/t indicating extractable enough. The data of composite sample of all 8 holes indicate 1.33g/t Au as shown in Table 7.18.

Table7.7 Chemical Analyses Results of Drilling Core Samples

| Drill hole; Pipe sampler | ELEMENTS | | | | |
|---|---|---|---|---|---|
| | Pb (%) | Zn (%) | Cu (%) | Au (gr/t) | Ag (gr/t) |
| $T_1$ (Pipe sampler) | 1.10 | 1.07 | 0.072 | 4.0 | 12.0 |
| B-2 | 0.37 | 0.79 | 0.061 | 1.2 | 4.5 |
| B-3 | 0.28 | 0.52 | 0.030 | 1.4 | 4.0 |
| B-4 | 0.15 | 0.32 | 0.029 | 1.1 | 3.1 |
| B-5 | 0.19 | 0.32 | 0.027 | 1.3 | 5.1 |
| B-6 | 0.15 | 0.34 | 0.048 | 1.7 | 2.8 |
| B-7 | 0.16 | 0.29 | 0.025 | 1.3 | 3.3 |
| B-8 | 0.16 | 0.34 | 0.049 | 1.3 | 2.7 |

Table7.8 Chemical Analyses Result of Composite Sample

| Overall composite | ELEMENTS | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Pb (%) | Zn (%) | Cu (%) | As (%) | Fe (%) | S (%) | Au (g/t) | Ag (g/t) |
| 35kg | 0.21 | 0.42 | 0.038 | 0.049 | 4.15 | 1.09 | 1.33 | 3.64 |

**(2) Sampling, Analysis and Interpretation of Processing Plant**

**1) Grot mine**

**(a) Sampling Points**

Sampling points of Grot mine processing plant were planed five as shown in Fig 7. 12. However, finally, seven samples were taken adding two samples considering complex of process flow.

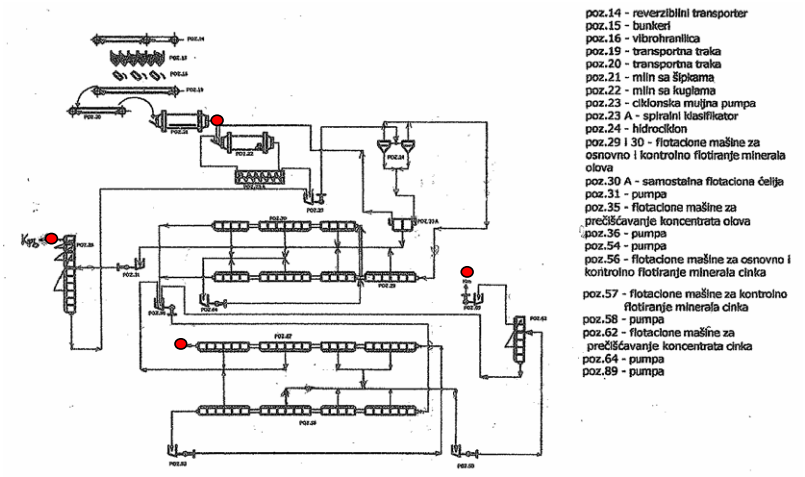



Fig.7.12 Sampling Points at the Grot Mine Processing Plant

**(b) Analysis Result**

Comparison between chemical analyses result in this study and previous 5 years' operation results is shown in Table 7.9.

The analysis results are summarized as follows;

- Zn grade of feed ore shows higher than past 5 years.
- Pb-concentrate grade is 5.6 points lower than past.
- Zn-concentrate grade is 5.6 points higher than past.
- Pb recovery is a little lower than past.
- Zn recovery is lower more than 15 points than past.

Table 7.9 Analysis Results of Processing Plant

| Parameter | Element | Period of sampling | Previous 5 years(*) |
|---|---|---|---|
| Elements concentration in ore | Pb, % | 2,26 | 2,0 – 3,0 |
| | Zn, % | 2,73 | 3,0 – 4,0 |
| Elements concentration in concentrate | Conc. Pb / Pb % | 70,16 | 73,5 – 76,0 |
| | Conc. Pb / Zn % | 10,30 | 2,5 – 3,0 |
| | Conc. Zn / Pb % | 3,19 | 4,0 – 5,0 |
| | Conc. Zn / Zn % | 53,59 | 50,3 – 51,3 |
| Recovery of elements in concentrate | Pb, % | 83,82 | 84 – 86 |
| | Zn, % | 71,98 | 86 – 88 |

(*) **Previous year's data are given based on Reports received from Authorized Staffs in Mine GROT**

Furthermore, following problems can be pointed according to the team observation on the operation condition.

- Feed size for flotation is fairly coarse (80% pas size might be 150-212μm).
- Slurry density for flotation is low as 30.5% (around 40% is desirable).
- Excess consumption of industrial water in the flotation stage was observed (Density of final tailing [Zn-T] was fairly low as 14.1%).

**2) Rudnik Mine**

**(a) Sampling Points**

Fig 7.13 shows main sampling points at the Rudnik Mine processing plant. As additional sampling had been needed for grasping actual state of operation condition at site, nine sampling points were decided adding four points.

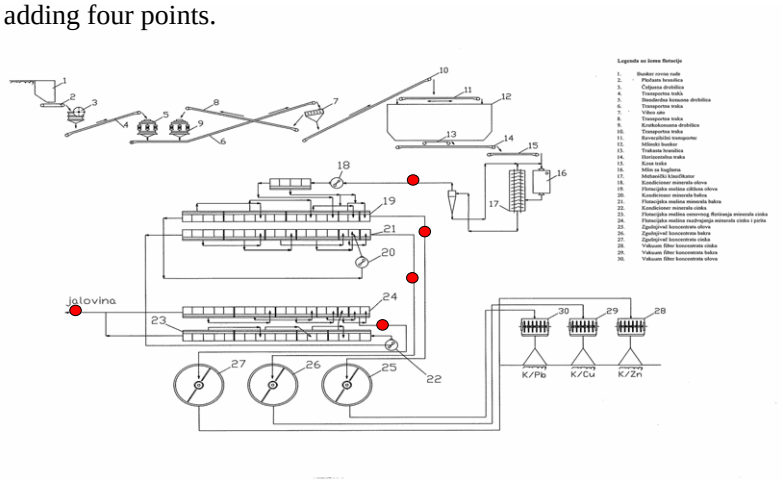



Fig.7.13 Sampling Points at the Rudnik Mine Processing Plant

**(b) Analysis Result**

Analysis result of process samples are shown in Table 7.10 comparing to past 5 years.

Table 7.10 Chemical Analysis Results of Snap Samples from Rudnik Processing Plant

| Parameter | Element | Period of sampling | Previous years(*) | | | | |
|---|---|---|---|---|---|---|---|
| | | | 2002 | 2003 | 2004 | 2005 | 2006 |
| Elements concentration in ore | Pb, % | 1,48 | 1,42 | 1,46 | 1,45 | 1,62 | 1,60 |
| | Zn, % | 1,58 | 1,53 | 1,50 | 1,65 | 1,76 | 1,62 |
| | Cu, % | 0,32 | 0,24 | 0,16 | 0,17 | 0,26 | 0,32 |
| Elements concentration in concentrate | Pb, % | 75,36 | 73,76 | 75,98 | 75,22 | 74,59 | 73,94 |
| | Zn, % | 54,69 | 48,06 | 47,99 | 47,47 | 46,73 | 47,47 |
| | Cu, % | 23,76 | 22,49 | 20,58 | 18,88 | 19,99 | 19,56 |
| Recovery of elements in concentrate | Pb, % | 88,41 | 93,10 | 91,95 | 90,23 | 88,98 | 89,43 |
| | Zn, % | 67,05 | 81,35 | 75,88 | 82,89 | 79,58 | 75,85 |
| | Cu, % | 59,79 | 62,51 | 50,84 | 45,82 | 49,21 | 55,16 |

(*) Previous year's data are given based on Reports received from Authorized Staffs in Mine RUDNIK

Analyses can be summarized as follows;

- Cu grade in the feed ore is higher lasting previous year than past five years even Pb and Zn grades are in the same range as past.
- Pb recovery tends to decrease in recent five years and the analysis result of snap sampling showed same tendency.
- Zn grade of Zn- concentrate is 7 points higher comparing to last five years, but Zn recovery is 10 points lower instead and tends to decrease.
- Cu grade in the Cu concentrate shows the highest value as 23.76%, and Cu recovery also shows high value since 2002.

Furthermore following items can be recommended.

- Feed size for flotation is a little coarse (80% pas size might be between 75 and 106 $\mu$ m).

- Excess consumption of industrial water in the Zn flotation stage was observed (Density of final tailing [Zn-T] was low as 25%).
- Final tailing consists of rougher flotation tailing of Zn flotation stage being mixed with cleaner tailing of Zn flotation. This combination might be obstacles of increasing recovery and may cause high Zn grade of final tailing.

**(3) Leaching Test**

48hr continuous Cu leaching test followed by SX-EW (Solvent Extraction-Electro Winning) method Cu recovery was executed using composite sample of core-drilling of RTB-Bor old tailing dam as feed sample. Fig 7.14 shows leaching test result. Cu leaching rate increase radically till 12 hrs and reach 60% just after 12 hrs. After 12hars, leaching rate tends to increase slightly up to 48hrs. Fe leaching rate is under around 10% even after 48hrs.

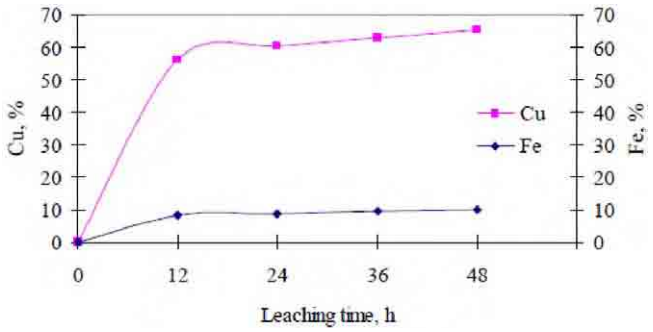


Fig 7.14 Leaching test result (Recovery of Cu and Fe)

**(4) Cu Solvent Extraction and Electro Winning (SX-EW) Test**

**1) SX-EW Test Method and Test Condition**

SX-EW test was carried out using pregnant solution from the bench scale leaching test which had been executed under pH 1 with -74μm as size, as feed sample. The test was carried out SX and SW in series.

**2) SX-EW Test Result**

SX-EW test result is shown in Fig.7.15.

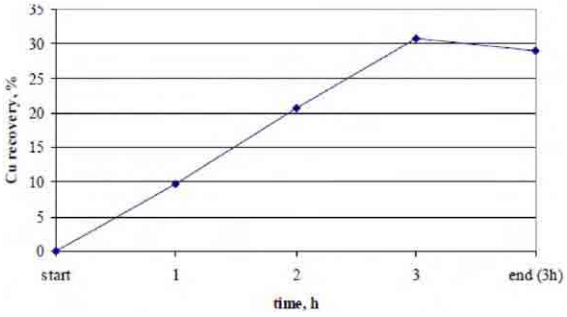


Fig.7.15 SX test result

Cu recovery rate by SX increase linearly and is obtained 31% for 3hrs. It is estimated that Cu recovery rate might show more than 90% during 9 hrs, extending this line.

Summarizing analysis results of core-drilling, leaching test results and SX-EW test results, Cu contents in the old tailing dam is 0.304%, max Cu recovery in the leaching stage is 65.38% and in the SX stage should be 99.78% applying world wide average in case of the test result keeps linear tendency. And the recovery in the EW stage could also be applied 98%. Quantity of the No.1 old

tailing dam is estimated as 4.5 million tons. Therefore recoverable Cu metal quantity in the No.1 old tailing dam could be estimated by following equation.

**0.304%×4.5million tons×65.38%×99.78%×98% = 8,739 ton Cu**

Namely, 8,700 tons of Cu is able to be recovered from No.1 old tailing dam, according to batch and bench scale test result.

**(5) Au Flotation and Cyanide Leaching Test**

According to the analysis result of core-drilling and sampling, 1.33g/t of Au contents in the Lece mine tailing dam was observed. Cyanidation test for efficient recovery of this gold was executed.

**1) Test Method and Test Condition**

Two steps Au recovery test was executed applying Au condensation by method of flotation with sulfurdization first, and then cyanide leaching. Au content in the Lece Mine tailing dam is 1.33g/t and stock amount is estimated as 2 million tons. Au recovery at condensation flotation stage was 85.11%, and Au recovery at Cyanide leaching was 95.68%. Therefore, amount of recoverable Au from the Lece Mine tailing dam can be estimated as following equation.

**1.33g/t×2million ton×95.68%×85.1% = 2.2 ton Au**

Namely, there is possibility to recover 2.2 ton of gold from Lece mine tailing dam, according to the results of batch test and bench scale test.

**7.4.3 Mineral Processing and Tailings Dam Management**

**(1) Bor Mine Tailings Dam**

RTB-Bor has old two tailings dams numbered as No.1 and No. 2 and utilizes alternatively. No.3 tailings dam is under application. Storage system is sand/slime separation method with cyclone classification which is standard and most stable method. No.1 tailings dam is used at the moment, however the dam storage quantity is approaching to its full capacity and collector installed the bottom of the dam has problem. Manager of the dam installs pumps and manages to treat overflow of the pond at the moment. The manager is planning to increase capacity of No.1 dam for more 8 years altering to use No.2 dam. Permeable water does not come out through tailing dams, however, acid seepage occurs in the old open pits, and acid seepage (pH 2.6) comes out from Over Burden stock yard (observed around $0.2m^3/l$). Acid seepage from Over Burden stock yard was taken as case study sample.

Damage of bottom culvert and/or overflow collector should be adjust quickly because the damage influences directory to discharge capacity of tailing dam and affects stability of the tailing dam.

Following items are recommendable for fixing bottom culvert of No.1 tailing dam.

- To treat polluted water which occurs during construction since over flow water or water from bottom culvert run into the river nearby directory.

- Bottom culvert should be designed for easy inspection and monitoring from inside and designed tough and safety for man patrol if possible.
- It is desirable to guide outside water as hill side precipitation discharge separately from inside water.

**2) Suva Luda Mine Tailing Dam**

In the Suva Luda mine, Cu flotation tailing dam and Pb-Zn flotation tailing dam are separated but installed side by side and Cu flotation tailing dam is piled one stage higher (around 8m) than Pb-Zn flotation tailing dam. Aquatic flora grows inside of dam. Furthermore, low bush trees as Tropa and Bagren were observed growing naturally from the foot of the bank and breeding toward upper part of the bank. Observation halls for underground water level were installed on the bank surface which shows underground water level monitoring. However, traces of erosion are observed at every where on the bank surface.

**(2) Lece Mine Tailings Dam**

The Lece Mine Tailings dam consist of nine parts with a series of No1 to No.9 forming a staircase with 3million tons in total. They said that the piling system had been used sand / slime separation method. All dams are covered bush except No.3. There is not observed surface erosion and shallow slope with less than 10m height difference and 70 to 80m length may confirm stable condition. However, underground water level control installing water level monitoring well and / or Piezo meter etc. is not applied.

**(3) Grot Mine Processing Plant, Tailings dam**

**1) Grot Mine Processing Plant**

Grot Mine Processing Plant is situated at 40 km from Vranje and 1,235 m high from the sea level. Ore fed to the plant and production are as follows,

- Grade of crude ore：Pb = 2 – 3 %, Zn = 3 – 4 %, Processes 100 thousand t / year.
- Produce：Pb – conc. = 2,250 - 5,170 t (Pb grade = 73.5 - 76.0 %)、Zn – conc. = 3,950 - 10,415 t (Zn Conc. 50.3－51.5 %).

Pb and Zn grade of feed changed around double at year 2003 and the grades are sustained. Pb grade of Pb – concentrate increased around 6% at year 2002, and Zn grade of Zn concentrate has sustained more than 50 % since 2001. Pb recovery was recovered the level of before 2000 (plus / minus 85 %), which had once fallen at year 2001. Zn recovery had improved drastically (nearly 15 %) at year 2002 (Table 7.11 and 7.12).

Table 7.11 Lead Flotation Result

| Year | 1996 | 1997 | 1998 | 1999 | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 |
|---|---|---|---|---|---|---|---|---|---|---|
| Feed Ore Pb (%) | 3.49 | 2.72 | 2.25 | 3.52 | 2.25 | 2.10 | 2.03 | 4.49 | 3.94 | 3.69 |
| Pb conc. Pb (%) | 69.9 | 67.6 | 69.6 | 68.8 | 69.1 | 71.0 | 75.7 | 75.1 | 76.0 | 76.5 |
| Pb-conc Pb-Rec. | 86.0 | 84.9 | 80.4 | 86.5 | 86.1 | 81.3 | 83.3 | 84.1 | 86.7 | 85.1 |

Table 7.12 Zinc Flotation Result

| Year | 1996 | 1997 | 1998 | 1999 | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 |
|---|---|---|---|---|---|---|---|---|---|---|
| Feed Ore Zn (%) | 1.94 | 2.80 | 2.37 | 2.46 | 2.37 | 3.00 | 2.71 | 4.72 | 5.30 | 5.00 |
| Conc. Zn Zn (%) | 46.5 | 47.0 | 48.2 | 46.9 | 47.5 | 51.8 | 51.9 | 50.3 | 51.4 | 51.5 |
| Zn-conc Zn-Rec. | 70.3 | 83.2 | 79.8 | 71.8 | 79.5 | 71.7 | 84.9 | 84.2 | 86.8 | 84.8 |

Feed ore grade of Pb and Zn are increasing, and concentrate grades also increase. However, the reason is not confirmed concretely. The origin of increasing grades should be analyzed and be utilized for quality control of exploiting and mineral processing while executing mineralogical study.

**2) Tailings Dam**

Piling system is sand / slime separation system using cyclone same as Bor and Lece Mines. Separation efficiency was good. However, under water level control was not introduced. In the near future, underground water monitoring tube and Piezo-meter were planned to install. Underground water monitoring and control should be commenced for keeping tailing dam stability urgently. And overflow water of the pond were observed to be turbid, which indicate the overflow control is insufficient.

**(4) Rudnik Mine Processing Plant and Tailings Dam**

The flowsheet of the Rudnik Mine Processing Plant is orthodox flow as follows; Crushing --> Grinding --> Pb flotation --> Zn flotation --> Tailing Treatment.

Equipment of the Rudnik Mine processing plant is considerable new being installed compact and rational, and installed auto-sampler at necessary place. There is a difference between the privatized company, which put the focus on the cost / performances, and state owned

The process flow, which can obtain higher concentrate grades than recovery, is applied. There is some space to improve recovery. In particular, Zn flotation circuit may have possibility to improve recovery 2 to 3 % higher than actual modifying and renovating its system. The latest 10 years processing result is shown in Table 7.13.

Table 7.13 The Latest 10 years Processing Result of the Rudnik Mine

| Year | 1997 | 1998 | 1999 | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 |
|---|---|---|---|---|---|---|---|---|---|---|
| Feed Ore Weight (t) | 207,115 | 210,085 | 173,225 | 192,897 | 195,903 | 181,089 | 104,980 | 111,240 | 162,481 | 171,769 |
| Feed Ore Pb (%) | 1.80 | 1.61 | 1.58 | 1.48 | 1.46 | 1.42 | 1.46 | 1.45 | 1.62 | 1.60 |
| Feed Ore Zn (%) | 1.73 | 1.60 | 1.66 | 1.59 | 1.63 | 1.53 | 1.50 | 1.65 | 1.76 | 1.62 |
| Feed Ore Cu(%) | 0.34 | 0.31 | 0.30 | 0.25 | 0.34 | 0.24 | 0.16 | 0.17 | 0.26 | 0.32 |
| Conc. Pb Weight (t) | 4,640 | 4,185 | 3,402 | 3,535 | 3,562 | 3,246 | 1,855 | 1,935 | 3,140 | 3,333 |
| Pb conc. Pb (%) | 74.1 | 73.5 | 72.9 | 73.0 | 73.0 | 73.8 | 76.0 | 75.2 | 74.6 | 73.7 |
| Conc. Zn Weight (t) | 6,040 | 5,785 | 5,015 | 5,205 | 5,581 | 4,690 | 2,490 | 3,205 | 4,870 | 4,446 |
| Zn conc. Zn (%) | 47.0 | 46.6 | 46.8 | 47.9 | 46.3 | 48.1 | 48.0 | 47.5 | 46.7 | 47.5 |
| Conc. Cu Weight (t) | 1,920 | 1,605 | 1,245 | 1,175 | 2,005 | 1,208 | 415 | 459 | 1,040 | 1,550 |
| Cu conc. Cu(%) | 19.4 | 18.5 | 19.7 | 21.3 | 21.5 | 22.5 | 20.6 | 18.9 | 20.0 | 19.6 |
| Pb-conc Pb-Rec. | 92.2 | 90.9 | 90.6 | 90.3 | 90.9 | 93.1 | 92.0 | 90.2 | 89.0 | 89.4 |
| Zn-conc Zn-Rec. | 79.2 | 80.1 | 81.5 | 81.3 | 80.9 | 81.4 | 75.9 | 82.9 | 79.6 | 75.8 |
| Cu-conc Cu-Rec. | | 45.6 | 47.3 | 51.8 | 64.6 | 62.5 | 50.8 | 45.8 | 49.2 | 55.2 |

Production for two years between 2003 and 2004 downed nearly half of other years' production. Similarly, Cu grade in the feed ore for same two years of 2003 and 2004 also downed half of other years. The decrease was caused by influences of the transition form state owned to privatize. However, operation result after privatization is same as that of state owned era. Still privatization effect does not appear for production improvement.

**(b) Tailing Dam**

Rudnik Mine tailing dam is operated introducing sand / slime separation system, Many Piezo-meters are installed on the bank and underground water level monitoring is executed

periodically. It can be said that under ground water level control is enough. Furthermore, overflow control is fine installing overflow water collectors at 4 points. A crest of the Bank level is more than 100m and surface of tailing stocks are reaching mountain ridges which consist tailing dam, and capacity rest seems not to be enough. There are a couple of private houses and passing by national road in front of the bank, there is in danger to arise disaster once collapse would happen. Tailing dam management should therefore be done severely.

**(5) Issues Identification and Interpretation in Processing Plant and Tailing Dam Management**

**1) Issues Identification and Interpretation in Processing Plant Management**

**(a) Bor Mine Processing Plant**

Bor Mine processing plant has operated Cu treatment only during 1972 to 1986, and has treated Pb and Zn for 1986 to 1002. The operation result has gone down caused operation rate decreasing by equipment aging. Renewal of old equipments is under preparation to be executed 6 months later, however the plan is suspended because of investment shortage.A Russian consultant company has done feasibility study on the Mjdanpek processing plant improvement. The report had recommended that expansion and improvement could realize for two years with three million Euro. Fig 7.16 shows the tendency of mine production and Cu grade of feed ore of the Bor Mine, and tendency of Cu concentrate grade and Cu recovery are shown in Fig 7.17.

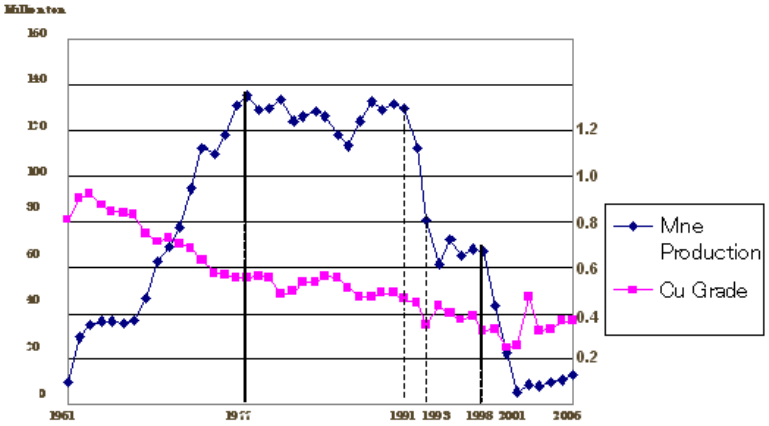



Fig 7.16 Tendency of the Bor Mine Production and Cu Grade

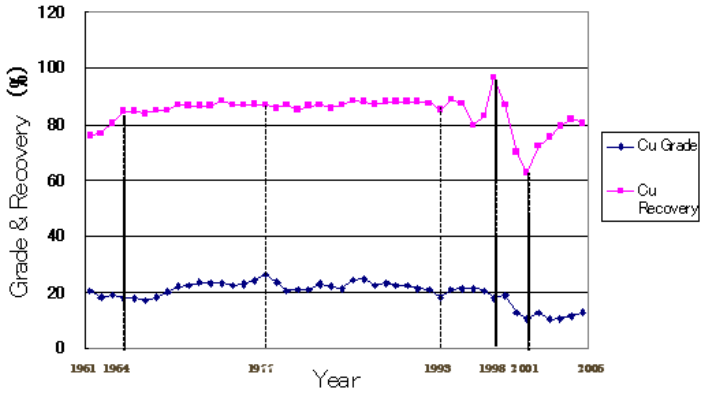



Fig 7.17 Tendency of Cu Grade of Cu-Concentrate and Cu Recovery

Cu grade in the feed ore was decreasing since the year 1963 when the grade had shown over 0.9 %. However, the tendency rebound to increasing at an opportunity of 0.22 % in the year 2001 and is getting 0.4 % in 2006. Cu grade in the feed ore has slightly decreasing during 1977 and 1991 when mine production rate has kept 12 thousand ton/year but comparatively stable between 0.58 and 0.46 %. Simultaneously, Cu grade in the Cu concentrate has been kept between 21 and 26 %.However, Cu grade of Cu concentrate has been less than 20 % since 1998. On the other hand, Cu recovery has been stable as 86 to 87 % since 1964, but began disturbance condition hunching between 88% and 62% since 1993. The recovery has improved gradually since 2001, however still is lower less than 80 %.

Recently the operation result has redacted largely comparing to past stable condition, origin of the decreasing of the grade, and its influences on the processing should be clarified by mineralogical study and appropriate processing condition should be confirmed by mineral processing test. Continuous operation keeps stable operation result in the processing plant. However, since 1991, feed rate has become nearly half of plant capacity and the state affects on the operation result. Now, plant side is managing to operate one line flotation system of two lines. However, big capacity of milling stage is difficult to precise quantity control to fit appropriate condition causing decrease of operation result. Therefore, continuous operation with step driving fitting mill capacity (i.e. 4,000t/d, 8,000t/d, 12,000t/d etc.) should be employed considering multiple parallel system from mill stage to filtering stage which can be fitting fluctuation of throughput.

**(b) Grot Mine Processing Plant**

The analysis result of snap sampling with operation results of past 5years are shown in Table 7.140.

Table 7.14 Analysis Result of Grot Mine Processing Plant Samples

| Parameter | Element | Period of sampling | Previous 5 years(*) |
|---|---|---|---|
| Elements concentration in ore | Pb, % | 2,26 | 2,0 – 3,0 |
| | Zn, % | 2,73 | 3,0 – 4,0 |
| Elements concentration in concentrate | Conc. Pb / Pb % | 70,16 | 73,5 – 76,0 |
| | Conc. Pb / Zn % | 10,30 | 2,5 – 3,0 |
| | Conc. Zn / Pb % | 3,19 | 4,0 – 5,0 |
| | Conc. Zn / Zn % | 53,59 | 50,3 – 51,3 |
| Recovery of elements in concentrate | Pb, % | 83,82 | 84 – 86 |
| | Zn, % | 71,98 | 86 – 88 |

(*) **Previous year's data are given based on Reports received from Authorized Staffs in Mine GROT**

Based on the plant observation and analysis result of the snap sampling, following problems are pointed out relating the Rudnik Mine processing plant.

- Flotation feed size looks some how coarse.
- Zn flotation flow was composed grade preference and seems to get lower recovery.
- Solid density of flotation is generally low.

- Consumption of industrial water seems to be extreme.

Therefore, it is needed to revise operation management system.

### 7.4.4 Acquisition of the Data of Unutilized Resources

Indium which was analyzed from the gold coarse concentrate (9.4g/t Au, 2.4% Zn ) attained from the Lece Mine tailings dam was 17.8g/t. If In is assumed to be associated by sphalerite, Zn concentrate (about 50% Zn) may contains In of 370g/t, or more than 100g/t In may be included in Zn concentrate at least. It should be ascertained. The more In is contained in Zn concentrate, the higher evaluation the Zn concentrate contract can attain. Generally, smelters can recover In from Zn concentrate if In is contained more than 5g/t. Above-mentioned data indicates possibility of recovery in smelters.

### 7.4.5 Summary of the Study Result

**(1) Mineral Processing and Tailing Dam Management**

Problems related to mineral processing are as follows.

Fluctuation of mine quantity, which is out of processing plant control, affects instability of plant operation (Grot and Bor Mines). Aged equipment accelerates making operation result worse (Grot and Bor Mines). Partially operation by decreasing of mine production forces operation condition become worse and causes equipment corrosion and air leakage (Grot and Bor Mines). Furthermore, veterans are relied on for operation management and alteration of generation is delayed (Grot and Bor Mines). Some plant is put priority first on the concentrate than recovery (Rudnik Mine).

Generally, necessary measurement for daily operation control (flotation feed size, slurry density, pH) is not carried out and operation is controlled by experiences and feeling (Grot, Rudnik and Bor Mines) (Fig 7.11 and 7.12). Investigation for the cause when the operation condition and the result fluctuate drastically, in particular, mineralogical study is needed.

Problems related to tailing dams are as follows.

Many mines do not monitor underground water level by monitoring hole and Piezo-meter. Protection for erosion should be needed (Suva Ruda Mine). Improvement for effluent discharge capacity should be applied (Suva Ruda and Bor Mines). Tailing dams of some mines hold acid Reachate. Once, water balance measuring reachate quantity, evaporating rate, permeable water quantitiy etc. should be checked. Several places out side of tailing dam cause acid reachate (Old open pit, Overburden stock yard etc). As for acid water, monitoring for environmental impact around including penetration into underground is needed

**(2) Case Study**

As the result of case study, following items can be said.

- Cu grade in the old tailing dam No. 1 of RTB-Bor is 0.304 %. According to Cu leaching test result, Cu recovery is 65 % and Cu recovery with SX-EW test result is more

than 97 % and total recovery was estimated more than 63 %. This calculation estimates that approximately 8.7 thousand ton of copper would be attained from 4.5 million ton of tailings in the old tailing dam No.1.

- There exist not only No.1 tailing dam but also No.2 and they say total tailing amount is 24 million ton. Furthermore exist waste rocks, some of which contains more than 1 g/t of Au. Cu, Au grades and quantity synthetic investigation and recovery test from waste should be confirmed. Those waste cause water pollution by generating acid water and harmful heavy metal ions.

Table 7.16 Waste of RTB-Bor

Waste Condition in RTB-Bor

| | Overburdens | | | | | | Total |
|---|---|---|---|---|---|---|---|
| | Tall deposit | North deposit | RTH deposit | Inner deposit | V.Krivelj deposit | Cerovo deposit | |
| Quantity (Million tons) | 150 | 20 | 60 | 28 | 170 | 22 | 450 |
| Cu (%) | 0.15 | > 0.3 | < 0.1 | 0.2 | < 0.1 | 0.18 | 0.11 |

Table7.17 Tailings of RTB-Bor

Tailing Condition in RTB-Bor

| | Flotation tailings | | | Total |
|---|---|---|---|---|
| | Old flotation tailing | RTH flotation tailing | V.Krivelj flotation tailing | |
| Quantity (Million tons) | 27 | 50 | 130 | 207 |
| Cu (%) | 0.24 | < 0.2 | 0.15 | 0.15 |

- Au flotation test result of Lece tailing shows more than 96 % of Au recovery, and cyanide leaching test result indicates more than 85 % Au recovery. Toatal Au recovery is estimated as more than 80 %. Therefore, approximately 2.2 ton of gold would be recoverable from 2 million tons of Lece tailing dam. Since this time case study was carried out according to No.2,3 and 4 tailing dams and commented on the whole tailing dams from No.1 to No.9. It is recommended, therefore, to execute synthetic study which coveres on the whole tailing dams to confirm this case study result.
- Grot Mine processing plant samples were taken just after beginning operation, Pb grade and Zn recovery were inferior than those of past 5 years. This result indicates that unstable operation affects on insufficient result and continuous operation is needed to keep stable operation.
- As for Rudnik Mine operation plant, flotation feed size is some how coarser, lower Zn recovery by flow of Zn grade priority first. Slurry density in the flotation stage is generally lower and extreme industrial water consumption is worried. Those are operation improvement issues.
- According to very rough financial calculation, as for the Cu recovery from old tailing dam of RTB-Bor, under conditions of 1,000 t/d, 15 years life and Cu price of 2,400 US$/t, IRR resulted more than 30% indicating very high feasibility. On the other hand, as for Au

recovery from Lece tailing dam under conditions of 500 t/d, 15 years life and Au price of 400 US$/Oz, IRR resulted also more than 30% pointing very high possibility and feasibility. These estimation were calculated using the best condition of laboratory test results and rough market conditions which had been obtained for short period. The team strongly recommends to realize more accurate economic estimation acquiring more accurate data with executing continuous pilot plant test and exact market research.

Table 18 and 19 show examples of DCF-IRR estimation applying 2,400US$/t of Cu price, 1,000t/d of thoroughput and 15 years of life for Cu recovering from RTB-Bor mine old tailing dam and applying 400US$/t of Au price, 500t/d of thoroughput and 15 years of life for Au recovering from Lece mine tailing dam

Table 7.18 DCF-IRR estimation example of Cu recovering form the Bor mine old tailing dam

**DCF/IRR Calculation Table (In case of 1000 t/d)**

Unitario:US $

| Items \ Year | | | -1 | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| [Income] | | | | | | | | | | | | | | | | | | | | |
| | Sales revenue of Concentrates | *1 | | | 3,038 | 3,038 | 3,038 | 3,038 | 3,038 | 3,038 | 3,038 | 3,038 | 3,038 | 3,038 | 3,038 | 3,038 | 3,038 | 3,038 | 3,038 | 45,563 |
| | Others | 1 % *2 | | | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 30 | 456 |
| | Income Total | | 0 | 0 | 3,068 | 3,068 | 3,068 | 3,068 | 3,068 | 3,068 | 3,068 | 3,068 | 3,068 | 3,068 | 3,068 | 3,068 | 3,068 | 3,068 | 3,068 | 46,018 |
| [Cost] | | | | | | | | | | | | | | | | | | | | |
| | Inicial Investment | 1,433 ) *3 | ( 550 ) | 1 | | | | | | | | | | | | | | | | 1 |
| | Operation Cost | *4 | | | 1,942 | 1,942 | 1,942 | 1,942 | 1,942 | 1,942 | 1,942 | 1,942 | 1,942 | 1,942 | 1,942 | 1,942 | 1,942 | 1,942 | 1,942 | 29,135 |
| | Depreciation | 143 *5 | | | 143 | 143 | 143 | 143 | 143 | 143 | 143 | 143 | 143 | 143 | 0 | 0 | 0 | 0 | 0 | 1,433 |
| | Tax (%) | 16 *6 | | | 486 | 486 | 486 | 486 | 486 | 486 | 486 | 486 | 486 | 486 | 486 | 486 | 486 | 486 | 486 | 7,290 |
| | Interest (%) | 10 *7 | | 143 | 129 | 115 | 100 | 86 | 72 | 57 | 43 | 29 | 14 | 0 | 0 | 0 | 0 | 0 | 0 | 788 |
| | Others (%) | 5 *8 | | | 153 | 153 | 153 | 153 | 153 | 153 | 153 | 153 | 153 | 153 | 153 | 153 | 153 | 153 | 153 | 2,301 |
| | Cost Total | | ( 550 ) | 144 | 2,854 | 2,840 | 2,825 | 2,811 | 2,797 | 2,782 | 2,768 | 2,754 | 2,739 | 2,725 | 2,582 | 2,582 | 2,582 | 2,582 | 2,582 | 40,947 |
| [Benefit] | | | | | | | | | | | | | | | | | | | | |
| | Yearly Benefit | | ( -550 ) | -144 | 214 | 228 | 243 | 257 | 271 | 286 | 300 | 314 | 329 | 343 | 486 | 486 | 486 | 486 | 486 | 5,071 |
| | Acumulate Benefit | | ( -550 ) | -144 | 70 | 298 | 541 | 798 | 1,069 | 1,354 | 1,654 | 1,968 | 2,297 | 2,640 | 3,126 | 3,612 | 4,098 | 4,585 | 5,071 | |
| [Net Present Value: NPV] | | | | | | | | | | | | | | | | | | | | |
| | (Oportunity losse 1) | 15 % | ( ) | -144 | 186 | 173 | 159 | 147 | 135 | 123 | 113 | 103 | 93 | 85 | 105 | 91 | 79 | 69 | 60 | |
| | (Oportunity losse 2) | 5 % | ( ) | -144 | 204 | 207 | 210 | 211 | 212 | 213 | 213 | 213 | 212 | 210 | 284 | 271 | 258 | 246 | 234 | |
| | IRR: 30% | Yearly Benefit: | -550 | -144 | 214 | 228 | 243 | 257 | 271 | 286 | 300 | 314 | 329 | 343 | 486 | 486 | 486 | 486 | 486 | |

Table 7.19 DCF-IRR estimation example of Au recovering form the Lece mine tailing dam

**DCF/IRR Calculation Table (In case of 500 t/d of Lece taling dam)**

Unitario:US $

| | Items \ Year | | | −1 | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| [Income] | Sales revenue of Gold | | *1 | | | 17,416.84 | 17,416.84 | 17,416.84 | 17,416.84 | 17,416.84 | 17,416.84 | 17,416.84 | 17,416.84 | 17,416.84 | 17,416.84 | 17,416.84 | 17,416.84 | 17,416.84 | 17,416.84 | 17,416.84 | 261,252.66 |
| | Others | 1 % | *2 | | | 174.17 | 174.17 | 174.17 | 174.17 | 174.17 | 174.17 | 174.17 | 174.17 | 174.17 | 174.17 | 174.17 | 174.17 | 174.17 | 174.17 | 174.17 | 2,612.53 |
| | Income Total | | | 0.00 | 0.00 | 17,591.01 | 17,591.01 | 17,591.01 | 17,591.01 | 17,591.01 | 17,591.01 | 17,591.01 | 17,591.01 | 17,591.01 | 17,591.01 | 17,591.01 | 17,591.01 | 17,591.01 | 17,591.01 | 17,591.01 | 263,865.19 |
| [Cost] | Inicial Investment | 6,001 | *3 | ( 0.00 ) | 6,000.50 | | | | | | | | | | | | | | | | 6,000.50 |
| | Operation Cost | | *4 | | | 11,427.67 | 11,427.67 | 11,427.67 | 11,427.67 | 11,427.67 | 11,427.67 | 11,427.67 | 11,427.67 | 11,427.67 | 11,427.67 | 11,427.67 | 11,427.67 | 11,427.67 | 11,427.67 | 11,427.67 | 171,415.01 |
| | Depreciation | 600 | *5 | | | 600.05 | 600.05 | 600.05 | 600.05 | 600.05 | 600.05 | 600.05 | 600.05 | 600.05 | 600.05 | 600.05 | 600.05 | 600.05 | 600.05 | 600.05 | 9,000.75 |
| | Tax (%) | 16 | *6 | | | 2,786.70 | 2,786.70 | 2,786.70 | 2,786.70 | 2,786.70 | 2,786.70 | 2,786.70 | 2,786.70 | 2,786.70 | 2,786.70 | 2,786.70 | 2,786.70 | 2,786.70 | 2,786.70 | 2,786.70 | 41,800.43 |
| | Interest (%) | 10 | *7 | | 600.05 | 540.05 | 480.04 | 420.04 | 360.03 | 300.03 | 240.02 | 180.02 | 120.01 | 60.01 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 3,300.28 |
| | Others (%) | 1 | *8 | | | 175.91 | 175.91 | 175.91 | 175.91 | 175.91 | 175.91 | 175.91 | 175.91 | 175.91 | 175.91 | 175.91 | 175.91 | 175.91 | 175.91 | 175.91 | 2,638.65 |
| | Cost Total | | | ( 0.00 ) | 6,600.55 | 15,530.37 | 15,470.36 | 15,410.36 | 15,350.35 | 15,290.35 | 15,230.34 | 15,170.34 | 15,110.33 | 15,050.33 | 14,990.32 | 14,990.32 | 14,990.32 | 14,990.32 | 14,990.32 | 14,990.32 | 234,155.62 |
| [Benefit] | Yearly Benefit | | | ( 0.00 ) | (6,600.55) | 2,060.64 | 2,120.65 | 2,180.65 | 2,240.66 | 2,300.66 | 2,360.67 | 2,420.67 | 2,480.68 | 2,540.68 | 2,600.69 | 2,600.69 | 2,600.69 | 2,600.69 | 2,600.69 | 2,600.69 | 29,709.57 |
| | Acumulate Benefit | | | ( 0.00 ) | (6,600.55) | (4,539.91) | (2,419.26) | (238.60) | 2,002.06 | 4,302.72 | 6,663.39 | 9,084.07 | 11,564.75 | 14,105.43 | 16,706.12 | 19,306.81 | 21,907.50 | 24,508.19 | 27,108.88 | 29,709.57 | |
| [Net Present Value: NPV] | (Oportunity losse 1) | 15 % | | ( ) | (6,600.55) | 1,791.86 | 1,603.52 | 1,433.82 | 1,281.10 | 1,143.84 | 1,020.58 | 910.02 | 810.94 | 722.22 | 642.85 | 559.00 | 486.09 | 422.68 | 367.55 | 319.61 | |
| | (Oportunity losse 2) | 5 % | | ( ) | (6,600.55) | 1,962.52 | 1,923.49 | 1,883.73 | 1,843.40 | 1,802.63 | 1,761.57 | 1,720.33 | 1,679.02 | 1,637.75 | 1,596.60 | 1,520.57 | 1,448.16 | 1,379.20 | 1,313.53 | 1,250.98 | |
| | **IRR: 33%** | Yearly Benefit | | 0.00 | (6,600.55) | 2,060.64 | 2,120.65 | 2,180.65 | 2,240.66 | 2,300.66 | 2,360.67 | 2,420.67 | 2,480.68 | 2,540.68 | 2,600.69 | 2,600.69 | 2,600.69 | 2,600.69 | 2,600.69 | 2,600.69 | |

## 7.5 Issues in Serbian Mining Companies

The most serious problem of the mining company's management in Serbia is accumulated debt. How to treat and handle such debt can be recognized as the most important point in the mining company's management. In this report, the debt problem is to be investigated.

### 7.5.1 Accumulated Debt of Mining Sectors

Mining companies in Serbia have gone bankruptcy mainly due to their accumulated debt. In the case of Grot mining, when they changed their status from a child company of Trepca to an independent company, the part of debts of Trepca was compulsory transferred to Grot, which, in turn, becomes a big burden for Grot management. In another words, at the beginning of starting as an independent company, Grot had already so heavy burden of debt that they were supposed to go bankruptcy in the near future due to such debt. If the debt of mining sectors in Serbia is treated usually as the debt to be repaid, it would be quite difficult for the mining companies in Serbia to improve their management and to find investors on such companies with a heavy burden of debt. As one of the solutions of debt problem, Debt-Equity Swap can be suggested as follows:

### 7.5.2 Debt-Equity Swap

The term 'Debt-Equity Swap' means a method that allows a creditor to exchange a monetary claim against company with shares of stock in that company. It is a method to exchanges debt with equity under an agreement between a creditor and a debtor. The transaction has a built-in mechanism to restructure the debtor's business in a manner more amenable to the creditors than the simple waiver of claims.

The following conditions would be required, provided that the Swap be adopted to the

mining sector in Serbia;

**(1) The Swap is adoptable only to the company that issues shares.**

Since the Swap is a method to exchange debt with equity, it can be adopted only to the stock company that can issue shares. So far, the status of the mining companies in Serbia is a so-called social company that does not issue shares. Thus, the Swap can not be adopted, unless its status is changed to the stock company. For the adoption of the Swap to mining company in Serbia, its status needs to be changed to that of share stocked company.

In the mean time, the Serbian government has a policy to privatize mining companies at present. It seems that the privatization of Serbian government is the same meaning as the selling of the company itself. To our understanding, the privatization takes place in such manner that shares owned by the state are sold, wholly or partially, to the public. In this regard, the privatization in Serbia seems to be deferent from such cases. In the privatization, there are a few cases that some measures are taken to raise the value of the company's shares, if the company to be privatized has a negative worth. For instance, the debt is transferred to the special purpose company that is established to take over that debt, or the debt is reduced by the Swap. It is deemed that the privatization in Serbia means the sell of the company itself, not the sell of company's shares. It would be confirmed at our next site survey as to the system of social company's privatization in Serbia that is not issuing shares.

**(2) The possibility should exist that the company successfully restructures its business.**

The Swap is the method to provide the company with the opportunity to restructure successfully its business and the creditor with the opportunity to recover an amount equivalent to or more its claim. The Swap should be adopted only to the company that is expected to have a prospectus business future, if the debt is reduced. Whether or not, the Swap is adopted to a company, should be decide based on its potential business future.

**(3) Restructuring of the management**

The company that adopts the Swap requires to restructure and strengthen the management. The restructuring of its business after the Swap should be made in every department including accounting, business promotion, and productivities. In order to succeed in this restructuring, the restructuring of the management is also required.

**(4) Adoption of the Swap to the Grot Mine**

The Grot mine is under procedure of bankruptcy and continuing the operation under the supervision of the bankruptcy agency of Serbia. If the potential growing scenario was accepted and the Swap was applied to the Grot, there would existed some possibility of avoiding the bankruptcy.

In the case of Grot, their accumulated debt amounts to approximately 15 billion Serbian Dr. Compared to the company size, it is too huge amount (Table7.20). In order to apply the Swap to the Grot, the debt should be decreased. The decrease of debt would be possible if the responsibility

of creditors is taken into account. To some extent, the creditors must be responsible for the accumulated debt of the Grot, because they continued giving credit to the Grot ignore ring financial situation of the Grot.

If the Swap is adopted after the decrease of debt, another scenario could be possible, because the Grot is presently making profit with the accumulated debt separated under the bankruptcy procedure.

Table7.20 Balance Sheet of the Grot as of 2006- Unit-1,000 Dinars

| | |
|---|---|
| **Assets** | |
| Fixed Assets | **247,387** |
| Real estates, equipments, machinery, etc | 247,380 |
| Biological Assets | 7 |
| **Liquidity Assets** | **217,105** |
| Inventories | 104,577 |
| Cash, deposits | 84,419 |
| Advance payment (tax) | 28,109 |
| **Total Assts** | 464,492 |
| | |
| **Assets** | |
| Fixed Assets | **247,387** |
| Real estates, equipments, machinery, etc | 247,380 |
| Biological Assets | 7 |
| **Liquidity Assets** | **217,105** |
| Inventories | 104,577 |
| Cash, deposits | 84,419 |
| Advance payment (tax) | 28,109 |
| **Total Assts** | 464,492 |
| | |
| **Liabilities** | |
| Long term debts | **6,902** |
| Long term loans | 0 |
| Other long term debts | 6,902 |
| **Short term debts** | **123,566** |
| Short term loans | 12,478 |
| Other short term debts (business) | 89,284 |
| Other short term debts (others) | 10,246 |
| Tax (VAT,etc) | 11,558 |
| Total Liabilities | 130,468 |
| | |
| **Capital** | **334,024** |
| Paid up capital | 222,841 |
| Provisions | 38,404 |
| Retained earnings | 72,779 |
| **Total of Liabilities and capital** | 464,492 |

(Source: Grot Mine)

### 7.5.3 Improvement of Grot Management

#### (1) Review of Financial Performance.

According to the Privatization Agency, the privatization of the Grot Mine is to take place next March and the detailed financial data is not made public before that time. Under the situation, the detailed financial data is not available at present. The review of financial situation of the Grot is made based on the financial data available from the present management. In the meantime, it seems

that such detailed data as notes to B/S, P/L have not been prepared in good order, because such data are required only in terms of accountability of management to shareholders and creditors in capitalism system.

Under the socialism time, mining companies were called social companies and their owners were the society including workers. It meant that society had no substance as owners of mining companies and there existed no distinction between the owner (capitalist) and management. Therefore, the management had no accountability to the owners and the detailed financial data were not required to be prepared.

For instance, even the Rudnik Mine, which is only one mining company listed at the Belgrade Stock Exchange with very good performance, do not prepare and submit to the Exchange such detailed data. In replying to our question if the Exchange requests such data to be submitted, they explained that as far as we were making profits as expected, there were no need to prepare and submit such data. Considering from the case of listed company, it would be not incorrect to judge that the Grot has not prepared the same.

Following is the financial situation of the Grot before the bankruptcy during 2001-2005.

Table7.21 Grot Mine P/L Statement for 5 Years（in 1,000 Dinars）

| Period | 2000 | 2001 | 2002 | 2003 | 2004 | 2005* |
|---|---|---|---|---|---|---|
| Business incomes | 0 | 81,967 | 92,947 | 135,200 | 299,215 | 354,155 |
| Business expenditures | 314 | 87,594 | 93,951 | 137,529 | 314,751 | 268,174 |
| TOTAL Business Activities | (314) | (5,627) | (644) | (2,329) | (15,536) | 85,981 |
| Financial incomes | 0 | 14 | 53 | 0 | 1,052 | 573 |
| Financial expenditures | 0 | 1,150 | 1,722 | 606 | 1,218 | 1,403 |
| TOTAL FINANCIAL ACTIVITIES | 0 | (1,136) | (1,669) | (606) | (166) | (830) |
| BUSINESS AND FINANCIAL ACTIVITIES TOTAL | (314) | (6,763) | (2,313) | (2,935) | (15,702) | 85,151 |
| Other (non-business) income | 0 | 1,608 | 66 | 247 | 34,632 | 1,035 |
| Other (non-business) expenditures | 0 | 2 | 0 | 460 | 18,930 | 0 |
| OTHER ACTIVITIES TOTAL | 0 | 1,606 | 66 | (213) | 15,702 | 1,035 |
| Profit before tax | (314) | (5,157) | (2,607) | (3,148) | 0 | 86,186 |
| Tax | 0 | 0 | 0 | 0 | 0 | 12,066 |
| NET TOTAL | (314) | (5,157) | (2,247) | (3,148) | 0 | 74,120 |
| *data for 2005 are for 21.11.2005 (day of starting procedure of bankruptcy) TAX for 2005 is projected amount | | | | | | |

（source: Grot Mine）

The actual state of the Grot Mine management can be guessed from the P/L statement to be as follows;

During years of 2001－2004, as the result that the expenses exceeded the revenue, profit/loss account continued to be red figures or zero before tax.

Table 7.22 Grot Mine P/L Statement for 4 Years

| Year | Revenues | Expenses | Profit/Loss |
|---|---|---|---|
| 2001 | 83,589 | 88,746 | (5,157) |
| 2002 | 93,066 | 95,673 | (2,607) |

| | | | |
|---|---|---|---|
| 2003 | 135,447 | 138,595 | (3,148) |
| 2004 | 334,899 | 334,899 | 0 |
| 2005 | 355,763 | 269,577 | 86,186 |

The reason of the continued red figures was that the production cost and other cost were keeping going up year after year.

Table7.23 Weight of Production Cost in Sales (in 1,000Dinars)

| Production Cost | 2001 | 2002 | 2003 | 2004 | 2005 |
|---|---|---|---|---|---|
| Material for Production | 6,889 | 5,321 | 3,391 | 10,334 | 16,631 |
| The basic material | 15,143 | 7,465 | 21,592 | 70,176 | 49,588 |
| Supplies | 0 | 1 | 36 | 173 | 0 |
| Waste | 177 | 0 | 5 | 918 | 900 |
| Earnings of workers | 22,342 | 22,365 | 29,203 | 86,361 | 80,818 |
| Nourishments of employee | 1,548 | 1,766 | 2,296 | 3,584 | 1,059 |
| Transportation expenses | 4,455 | 5,827 | 4,289 | 20,749 | 17,268 |
| Research expenses | 0 | 529 | 453 | 10,787 | 9,730 |
| Total | 50,554 | 43,274 | 62,266 | 203,082 | 175,994 |
| Sales Products | 76,529 | 91,262 | 130,590 | 294,247 | 415,614 |

（source: Grot Mine）

The ratio of production cost to sales products changes as follows;

Table 7.24 Ratio of Production Cost to Sales (%)

| year | 2001 | 2002 | 2003 | 2004 | 2005 |
|---|---|---|---|---|---|
| Ratio of production cost | 66 | 47 | 48 | 69 | 42 |

In 2002, 2003 and 2005, the ratio were keeping around 40%、but in 2001 and 2004, it exceeded 60%. This increased ratio was caused by basic material cost in 2001 and 2004. Particularly, in 2004, the basic material cost amounted to 70,176 thousand dinars. Compared to 2003 and 2005, this basic material cost was extraordinary high.

Table 7.25 Material Cost in Sales

| Year | 2001 | 2002 | 2003 | 2004 | 2005 |
|---|---|---|---|---|---|
| A)basic material | 15,143 | 7,465 | 21,592 | 70,176 | 49,588 |
| B)Product Sales | 76,529 | 91,261 | 130,590 | 294,247 | 415,614 |
| C) A ÷ B | 19.8% | 8.2% | 16.5% | 23.8% | 11.9% |

The ratio of production cost fluctuated greatly every year due to basic material cost and it would be very difficult to anticipate the profit /loss account if it continues fluctuating by year. Basic material and earnings of the workers are main items of production cost. If basic material cost fluctuates greatly, the production cost would be affected unexpectedly by year, and the management would not be stable. In order to make the management stable, some measures should be taken, such as strengthen the purchasing section, hedging way for price, etc.

Table7.26 Other Expenses in Sales (1,000 Dinars)

| Year | 2001 | 2002 | 2003 | 2004 | 2005 |
|---|---|---|---|---|---|
| Other expenses | 8,683 | 17,840 | 38,159 | 65,149 | 61,011 |
| Depreciation | 8,359 | 5,650 | 6,454 | 7,406 | 32,832 |
| Earnings management | 5,032 | 6,139 | 8,175 | 31,248 | 32,437 |
| Fuel, lubricating | 7,486 | 11,626 | 10,292 | 12,247 | 17,949 |
| Electricity | 8,632 | 11,619 | 14,252 | 15,770 | 22,323 |

| | | | | | |
|---|---|---|---|---|---|
| Total | 38,192 | 52,874 | 77,332 | 131,820 | 166,552 |
| Total÷Sales | 50% | 57.9% | 59.2% | 44.8% | 40% |

As shown above, the ratio of other cost is very high and due to this fact, the productivities as manufacturing company is so low. Especially, in 2002 and 2003, the other cost (indirect cost of production) exceeded the production cost (direct cost of production). It means that the productivities of Grot were very poor and ineffective.

Table 7.27 Production Cost and Other Expenses in Sales

| Item | 2001 | 2002 | 2003 | 2004 | 2005 |
|---|---|---|---|---|---|
| Product cost | 66% | 47% | 48% | 69% | 42% |
| Other expenses | 50% | 57.9% | 59.2% | 44.8% | 40% |

It seems that other cost included miscellaneous expenses required for restructuring, because Grot faced serious crisis before bankruptcy in 2005.

However, it should be noted that a manufacturing company should keep indirect expenses (other cost) smaller than direct cost (production cost).

In addition, it matters that earnings of management kept going up for the past five years, while the company did not make profit. Earnings of management should change based on the performance of the company.

In 2006. Grot made profit before tax of 2,245,000. dinar for the first time after separated from Trepca in 2001.

Table 7.28 Grot Mine Profit & Loss Account in 2006 (1,000dinars)

| | | | | |
|---|---|---|---|---|
| (Business incomes ) | | | | |
| 1. Sales of products | | | | 397,533 |
| 2. Sales of products | | | | 27,740 |
| 3. Other business bincome | | | | 84 |
| **Total** | | | | **425,357** |
| | | | | |
| 4. Material | | | | 108,683 |
| 5. Labor charge | | | | 139,248 |
| 6. Depreciation | | | | 41,579 |
| 7. Other business expend | | | | 134,223 |
| **Total** | | | | **423,733** |
| | | | | |
| **Business profit** | **425,357** | **－** | **423,733** | **＝ 1,624** |
| | | | | |
| **(Other income/non business income)** | | | | |
| 8. Financial incomes | | | | 5,039 |
| 9. Financial expenditures | | | (－) | 7,299 |
| 10. Other (non-business) income | | | | 2,896 |
| 11. Other (non-business) expenditures | | | (－) | 15 |
| Total | | | | 621 |
| | | | | |
| **Profit before tax** | **1,624** | **＋** | **621** | **＝ 2,245** |
| | | | | |
| **(Net Profit after tax)** | | | | |
| 12. Tax | | | | 1,712 |
| 13. Refundment tax | | | (＋) | 3,088 |

| | |
|---|---|
| **Total** | **3,621** |

（Resources of data：the Grot mining）

The ratio of profit before tax is only around 0.91%, but the fact that Grot turned out to be a profitable company is important. According to the explanation of Grot, this profit is after deducting the debt repayment of 88 million dinar to the private company. Without such debt transferred from Trepca, the Grot would have gained approximately 90 million dinar, which is corresponding 22.6% to sales of products. In this meaning, the Grot changed as a good company owing to the efforts of the new management. The detail of cost is as follows;

Table 7.29 Grot Mine Income and Expenditure Account (Unit：1,000 dinar)

| Production Cost | 2006 | Other Cost | 2006 |
|---|---|---|---|
| Material for Production | 13,136 | Other expenses | 14,898 |
| The basic material | 43,400 | Depreciation | 41,579 |
| Supplies | 17 | Earnings management | 39,672 |
| Waste | 692 | Fuel, lubricating | 15,317 |
| Earnings of workers | 99,576 | Electricity | 21,874 |
| Nourishments of employee | 5,847 | Total | 133,340 |
| Transportation expenses | 5,103 | | |
| Research expenses | 13,611 | | |
| Total | 181,382 | | |
| Sales of Products | | | 397,533 |

① The ratio of production cost to sales products

The ratio of production cost to sales products is around 45.63%、and the ratio of basic materials to sales of products is around 10.9%. Both of them seem to remain at the reasonable level.

② The ratio of other costs to sales products

The ratio of other costs to sales products is 33.5%, which is the lowest for these 6 years. This must be the reason why the profit could be made in 2006. It would be very important for manufacturing companies to reduce the indirect cost. On other hand, the earnings management is increase by 7 million dinar compared to that of 2005, which should be reviewed if reasonable or not.

**(2) Advices to the Management of Grot.**

In preparing the advices, the interview was made with the management of Rudnik mining that has a very successful result after privatization. The following was a summarization referring to their actual experiences and practices in managing Rudnik mining;

The cost management would be one of the most important factors for manufacturing companies. The main purpose of cost management is to grasp the cost accurately and try to reduce the cost.

The detailed cost list is made and data base management system is adopted at Rudnic mining. They are reviewing and booking every day the costs and making a monthly report submitted to the management. For this data base management, one staff in charge of cost management is

assigned at the factory and one accounting expert is appointed to check and analyze it at the head office.

In addition to the normal cost management system, they are trying to reduce the cost by increasing the production volume. It is their policy that the more the production volume is, the less the unit price is. Actually, the product volume in 2006 exceeded that of 1983, when their production volume was the highest. In spite of the production volume increase, the number of workers is to be planned to decrease from 376 to 330. As instructed by the instance of Rudnic mining, it would be possible to reduce the cost by the efforts and trial by the management. It would be suggested and advised to organize a cost

Management committee and make efforts to reduce the cost at Grot mining.

**(3) Moral and Discipline of Workers.**

One of the most difficult problems the management of Rudnic faced was the moral and discipline of workers. The president director of Rudnic told that not only in mining sectors, but also in all industrial sectors, the management system in 1990's was wrong. As the result of wrong management system, the moral and discipline of works were very poor. Working rules were ignored by workers and effective production was impossible. It took the management long time to improve the situation. It would be advisable to the management of Grot to make definite employment contract, job description, and working rules and establish a training system in order to improve moral and discipline.

**(4) Management System**

More difficult problem than the moral and discipline of workers was the management system at Rudnic mining. In the past, when workers participated the management of the companies, and some manager class and high class workers still keeping such mind as they can participate the management and policy making process. Sometimes, they had an objection to the policy of the company and did not follow that. As the result, the management was obliged to fire some managers. It would take long time to change the staff's mind that was familiar with old management system. In order to proceed with the change of their mind smoothly, it would be a good way for the management of Grot to prepare and distribute the educational guidance book on the new management system.

**(5) Disposal of Accumulated Debts**

In case of Rudnic mining, there is no problem of accumulated debts, because the new owner bought the company with the debt paid off. But, Grot has still problem of accumulated debts, which is disputing in court. The debt is amounting to 15 billion dinar and the management of Grot will not succeed with such heavy debt. Even if the debt is to be decreased to some extent, the heavy debt is expected to remain. The detail of the debts, consisting of 36 creditors, is as shown below and a financial device, such as Debt-Equity Swap, would be required to solve the problem.

**(6) Projection**

It is just two years since the Grot became a company under bankruptcy agency supervision. But the Grot already turned out the profitable company. Judging from the financial statement, it seems that the Grot could keep such financial situation. It is expected that the Grot prepare the future plan and projection of the company based on the survey of mining potential and production prospect in order to give the incentives to workers and good impression to creditors for advantageous discussion with them.

## Chapter 8 the Master Plan

### 8.1 Policy and Purpose of the Master Plan

The policy for the Master Plan has been materialized by the past surveys, discussion with counterparts and Progress/Interim Workshop, has been confirmed by MEM and MEP, and has been also consented by the related organizations and international organizations. The Master Plan has been formulated, taking account of the current state of transferring period of the mining management from state ownership to private sector under a market economy as well as the future after privatization.

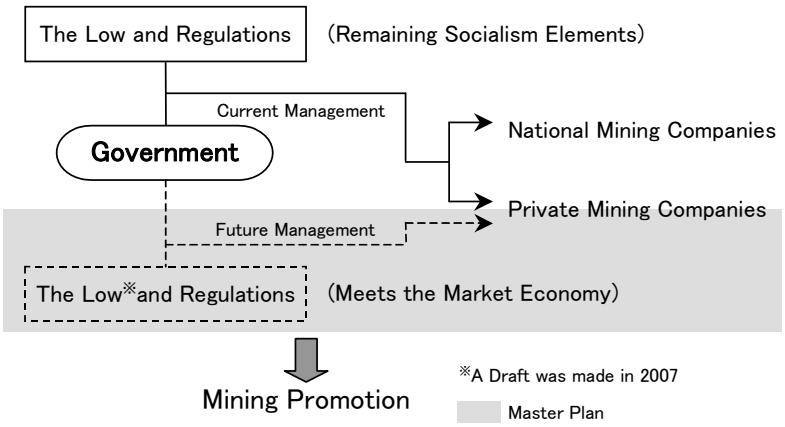



Fig.8.1 Relationship between Current Mining Management and the Master Plan

As the purpose of the Master Plan is to promote the mining sector, it must help realize mining activities, increase employment, and link with economic growth. Therefore, specific measures have been considered for mining organization, investment promotion, private sector management, developing private sector human resources, and the interactive effects between the mining institute and mining policy.

The highest priority for promotion of the Serbian mining sector is to reform the existing socialist era structure of the institute, and strengthen and systemize it to manage the mining sector under a market economy.

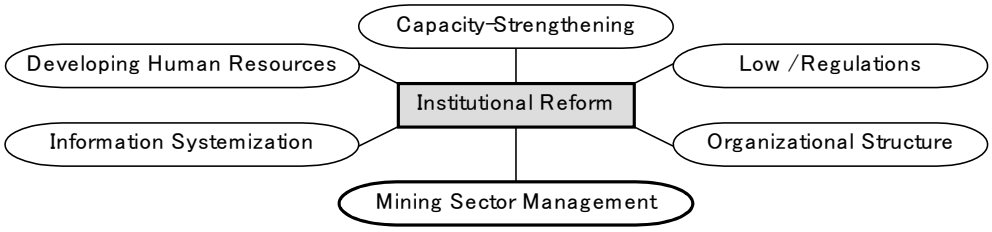



Fig.8.2 Roles of the Institutional Reform

The basic policy for the Master Plan is as follows:

- The period of the Master Plan is 10 years under smooth private initiative.
- The first period (5 years) is the mining sector building period, and last period (5 years) is the mining promotion period.

- Concrete measures composing of the Master Plan will be materialized by self-funding, not by dependence on donor countries/organizations.

The Master Plan will be begun in 2008, and will be completed in 2018. A target in 2018 is to achieve 10% of the GDP by mining activities.

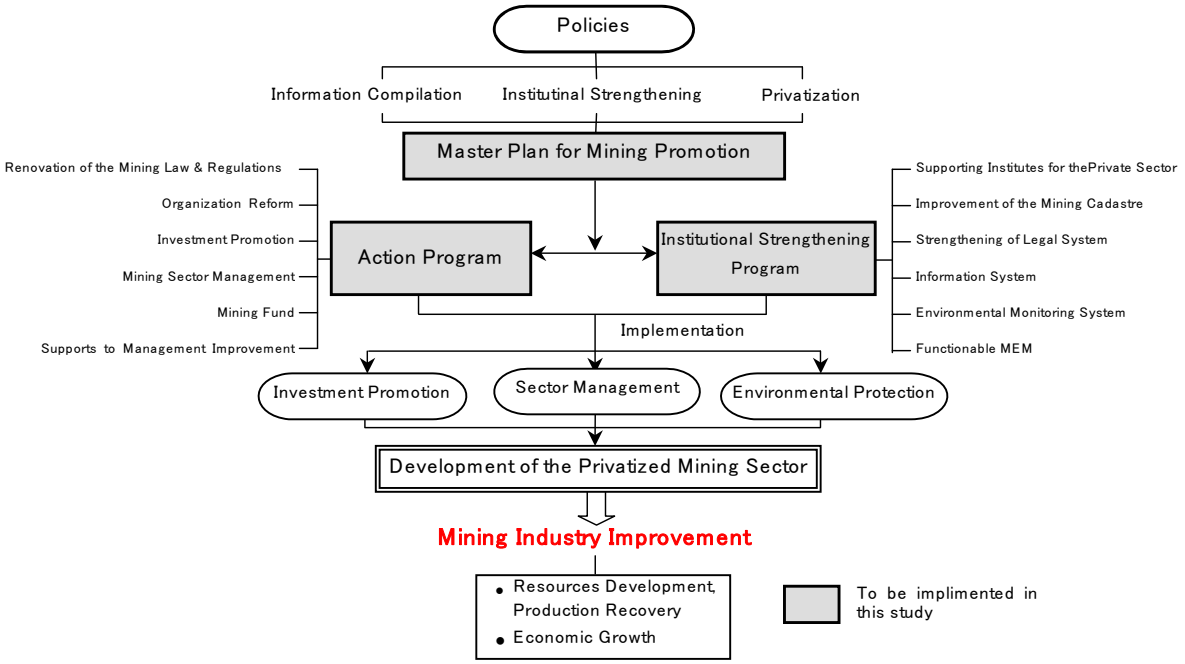



Fig.8.3 The Master Plan for Improvement of the Mining Sector

The Master Plan has a 10-year period to transfer mining management smoothly from state ownership to the private sector, to complete institutional reforms, and to increase the mining sector's contribution to GDP to 10% after 10 years, which would link with reform of the mining sector. The Master Plan has specific measures such as the 5-year Action Program to materialize solution for urgent matters, including a part of the Institutional Reform Program which would be continued and expanded in the mining promotion period.

The Master Plan is divided into 2 periods, a mining sector building period (the first 5 years) and a mining promotion period (the second 5 years) (Table 8.1).

Table 8.1 Schedule for the Master Plan, Action Program and Institutional Reform Program

| Year | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
|---|---|---|---|---|---|---|---|---|---|---|
| Master Plan | Mining Sector Building Period | | | | | Mining Promotion Period | | | | |
| Action Program | ← | | | | → | | | | | |
| Institutional Reform Program | | | | ← | | | | | | → |
| Mining Activities | ← Promoting Exploration | | | | | | | | | → |
| | ← Recovery of Productivity | | | | → | ← Enhancing Development | | | | → |

The Action Program will be implemented in the first 5 years and the Institutional Reform Program will be mainly implemented in the second 5 years. The financial resources for these programs are mainly taxes and royalties. Therefore, to assure the financial resources, it is necessary

to advance both production recovery and management of the mining sector (private sector) harmoniously (Fig.8.4).

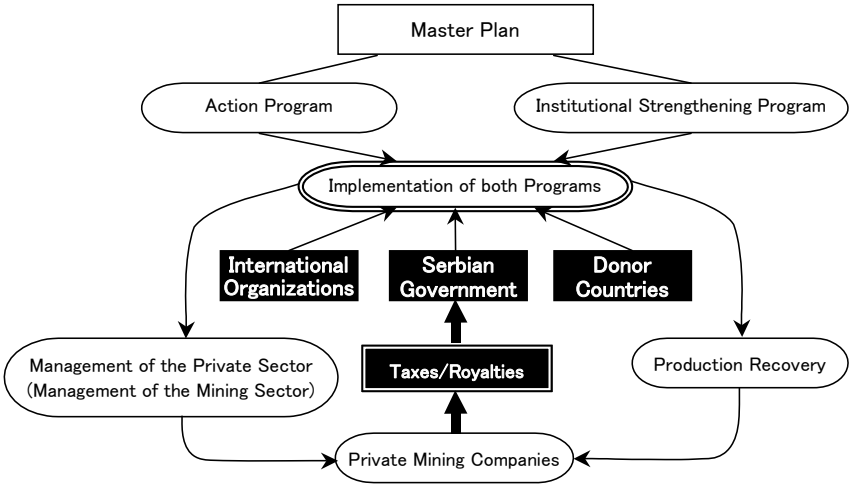



Fig.8.4 Financial Resources to Implement each Program

Table 8.2 Scheduling for Reconstruction and Promotion of the Mining Sector

| Years | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
|---|---|---|---|---|---|---|---|---|---|---|
| Privatization | Completion | Rehabilitation, Reconstruction | | | | Complete Privatization, Production Expansion | | | | |
| Mining Low* | Study | Implementation | | | | Review | Revise | Effective | | |
| Mining Policies* | Study | Implementation | | | | Review | Revise | Implement | | |
| Management of the Mining Sector | Conduct the I.S.P | | | | | | | | | |
| | Conduct the Action Program | | | | | Stabilize Management of the Private Sector | | | | |
| Mining Organizations | Study | Reorganize | | New Organizations | | Activate and Stabilize the Organizations | | | | |

Starting Point to implement the Master Plan (2008)

Note : I.S.P : Institutional Reform Program *Draft was made in 2007 by supports of the World Bank

## 8.2 Mining Sector Institutional Strengthening and Visions

Mining sector institutional reform, which is the highest priority task in the mining sector building, will create the foundation for mining promotion. It will be the basis for promotion of investment in mining exploration and development under the market economy, and production sector management for the private companies (Fig.8.5).

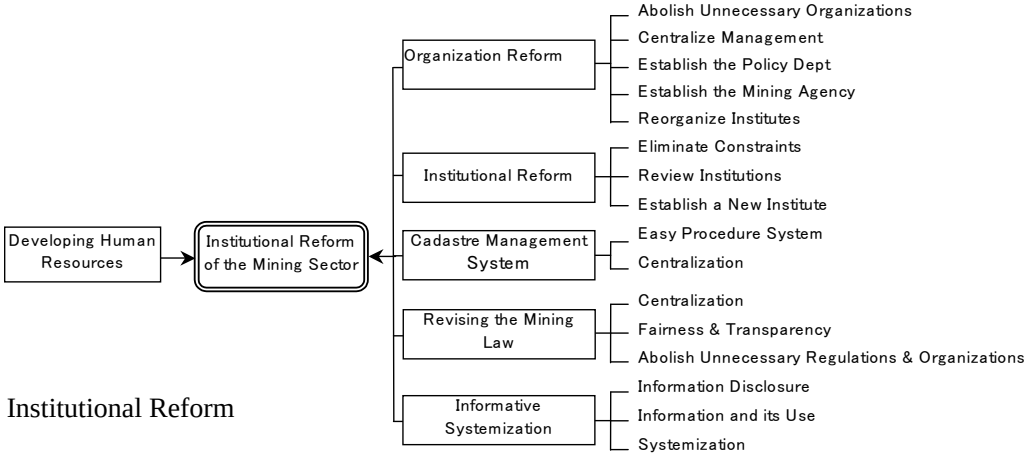


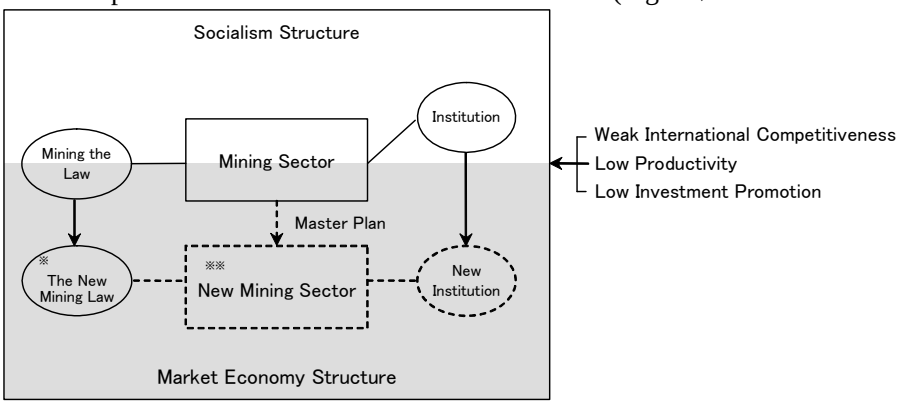

Fig.8.5 Institutional Reform

**(1) Organizational Reform**

It is necessary to review, unite and activate organizations such as the MEM, MEP, Mining Institute, Geological Institute, and related organizations to promote mining activities mainly by the private companies.

**(2) Institutional Reform**

Restrictions and regulations of the former socialism age must be eliminated and existing institutions must be reviewed. It is necessary to formulate concepts for the institutions to activate mining activities, find out tasks to establish these institutions, and clarify effects to be obtained by establishment of these institutions. There is a concrete example for necessity of the institutional reform in excess management of the national/privatized mines such as obligatory reports for exploration/production, etc. The concept for the institutions must be formulated from the viewpoint of the private sector management in fostering human resources, managing the mining concessions, , exploration, development, compiling information, etc. in order to help reforming the whole mining sector. The current stance of the mining sector is in the border between the old socialism and market economy. Therefore, it should be moved completely to the market economy by the Master Plan. The current mining sector is low in productivity and weak in competitiveness. Investment promotion cannot be expected under the current stance of the sector (Fig.8.6).




※ This draft was made in 2007.
※※ It will match up to the Market Economy.

Fig.8.6 Stance of the Mining Sector before and after Implementing the Master Plan

**(3) System for Managing Mining Concessions**

The management of the mining concessions based on the current Mining Law needs complicate procedures without transparency, and demands a lot of time and work. It may be even a barrier to improve stagnated mining activities. Therefore, it is necessary to simplify and consolidate procedures and management of the system. In other words, it is necessary to materialize the modernized system used IT based on the new Mining Law. It is necessary to design the complete systemized mining concession management, taking account of simplification of application for the new mining concessions (Fig.8.7) as well as management of approved mining concessions.

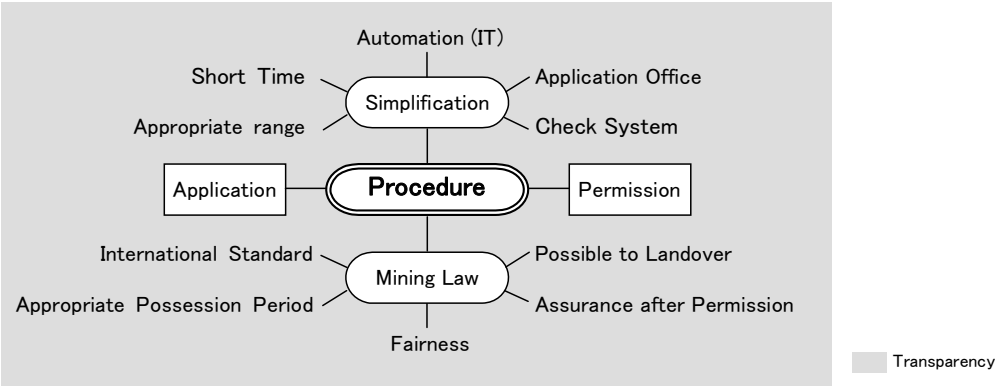



Fig.8.7 Viewpoint of Improvement for Management System of the Mining Concession

**(4) Revising of the Ming Law**

A draft for the new Mining Law is currently formulating. The current Mining Law is not effective for promotion of mining activities, because it has not fairness and transparency. Therefore, it is necessary to enact urgently the new Mining Law based on the international standard. The Mining Law has a strong relation with issues of the institutional reform and the management system of the mining concessions.

**(5) Compilation of Information**

There exist a large amount of information which have been accumulated in the Geological Institute, the MEP and the MEM in Serbia. Although a part of the information is converted into and managed in GIS database, a plenty of mining-related information is still stocked in analog form such as reports and documents and is not computerized. Therefore, such information shall be integrated, and be utilized effectively in multipurpose and be systemized by specifying usage approach.

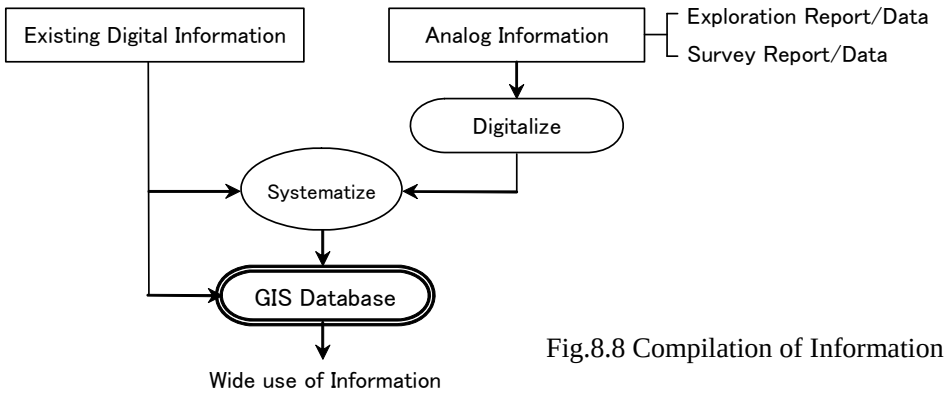



Fig.8.8 Compilation of Information

**(6) Fostering Human Resources**

There are several places to foster human resources for mining activities. For example, they are the existing research facilities and skill training fields such as open pits, underground mines, smelters, and environmentally contaminated areas, etc. However, each institute has an independent budget in principle, so the role to foster human resources is disappearing. If there is no

fostering of human resources, it cannot be linked with vitalizing the mining sector.

### 8.3 Action Program and Institutional Program

Purpose of the Action Program is to solve urgent issues for construction of the mining foundation to activate mining activities under the market economy through reconstruction of the existing mining industry.

The Institutional Reform Program consists of programs related to the institutional reform and strengthening, and urgent matters to take priority are included in the Action Program. It is important for the Serbian mining sector to change the current existing institutions to the competitive institutions suitable for the market economy.

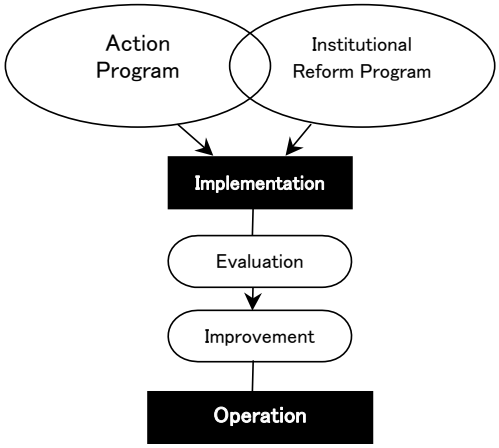



Fig.8.9 Relation between the Action Program and Institutional Reform Program

Table 8.3 Action Program and Institutional Reform Program

| | Program | Target | Implementation Period: Sector building (5yrs.) / Promotion (5yrs.) |
|---|---|---|---|
| Action Program | 1. Mining Organization | functionalize the sector management | |
| | 2. Investment Promotion | Expand mining investment | |
| | Investment Seminar | Intrduce foreign investment | |
| | one-stop-shop | Provide information to investors | |
| | Publication of maps, etc. | Provide information to investors | |
| | Periodical publication | Provide late trend to investors | |
| | 3. Management of the mining sector | Abolish old institutions | |
| | 4. Foster humanresources | Continue mining wokers training | |
| | 5. Mining Fund | Support the privatized companies | |
| | 6. Two-step-loan | Help privatized companies | |
| | 7. Instruction of Accounting System | Healthy mining activities | |
| | 8. Establishment of the Mining Association | Activate the privatized companies | |
| | 9. Rehabilitation of the tailings dams and monitoring system | Environmental protection | |
| | 10. Concession management system | Simplify procedures for application | |
| | 11. Technical Training Center | Foster human resources (skilled workers) | |
| | 12. Support for Management Reconstruction | Improve the privatized companies | |
| | 13. Mining Training Sessions | Attain knowledge and technologies | |
| Institutional Reform Program | 1. Supporting Institution for the Private Sector | Promote exploration and development | |
| | Subsidy for Exploration | Promote exploration by Serbian companies | |
| | Loan Institution for Exploration | Promote exploration (around mines) | |
| | Loan Institution for Development | | |
| | 2. Regional Exploration Institution | Acqure basic information | |
| | 3. Management of the Mining Cadastre | Improve efficiency of mining concessionmanagement | |
| | 4. Strengthening of Legal System | Review and renovate the Mining Law | |
| | 5. Information System | Network in MEM and MEP. | |
| | 6. Monitoring System | Environmental protection | |
| | 7. Dsiclosure of Information | Disclose environmental information | |
| | 8. Strengthening of MEM Function | Abolish old institutions | |
| | 9. Reviewing of the Mining Tax System | Activate mining activities. | |

These programs consist of each detailed measures shown in Table 8.3, the mining industry will be reconstructed and its basis will be rebuilt by implementing each measure, exploration and development will be enhanced, and finally the mining industry will be promoted under the achieved targets. Relationship between each basis building, reconstruction and promotion of the mining industry, enhancing of exploration and development, and others are shown in Fig.8.10.

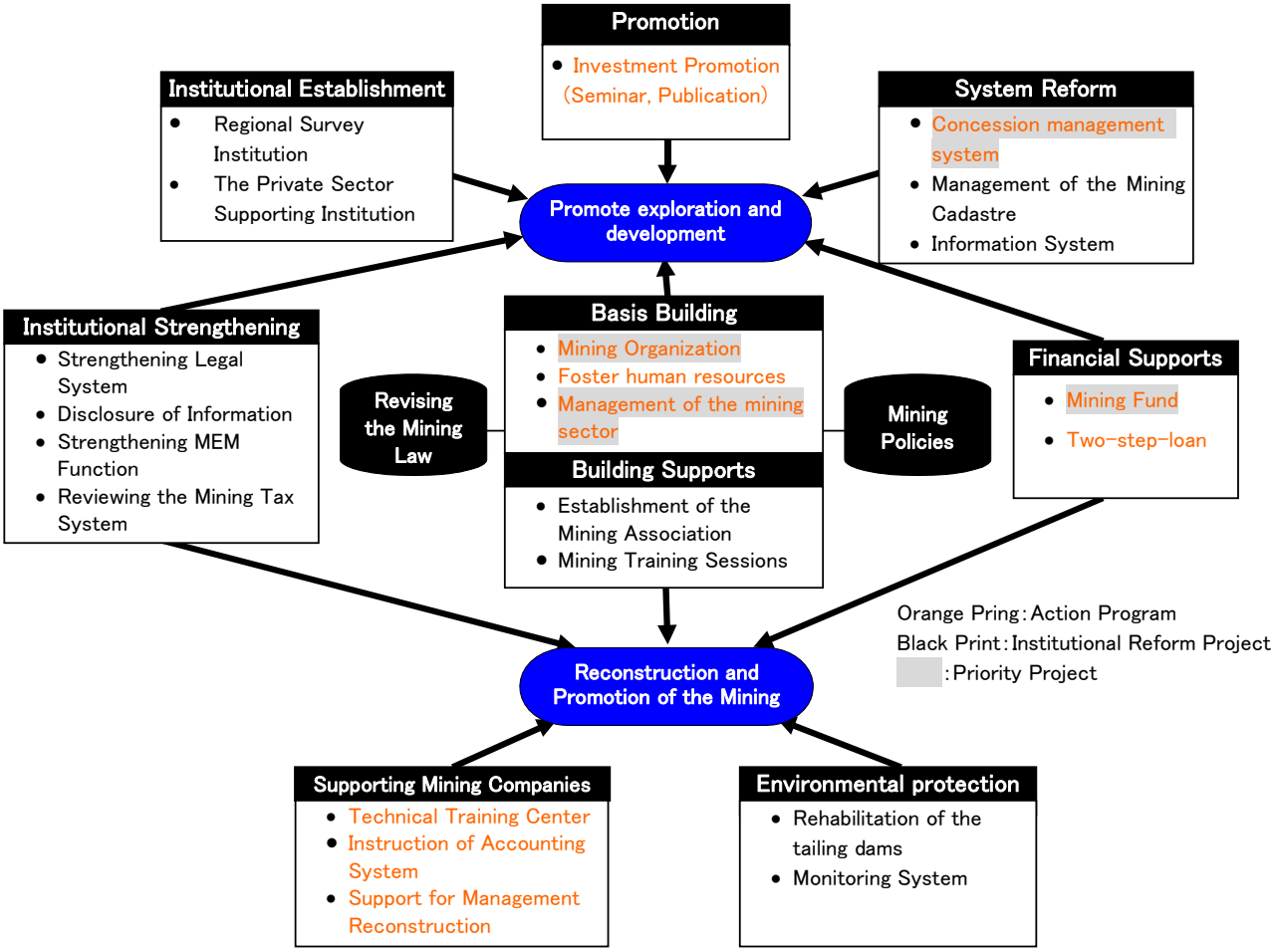



Fig.8.10 Location of each Measure of the Master Plan

These measures have an organic mutual relationship. Therefore, if the measures will be materialized with mutual cooperation, they will link with the management of the mining industry and supports of the private sector and finally promote the mining sector. In other words, it is possible that the mining sector will occupy 10% in the GDP after 10 years (Fig.8.11).

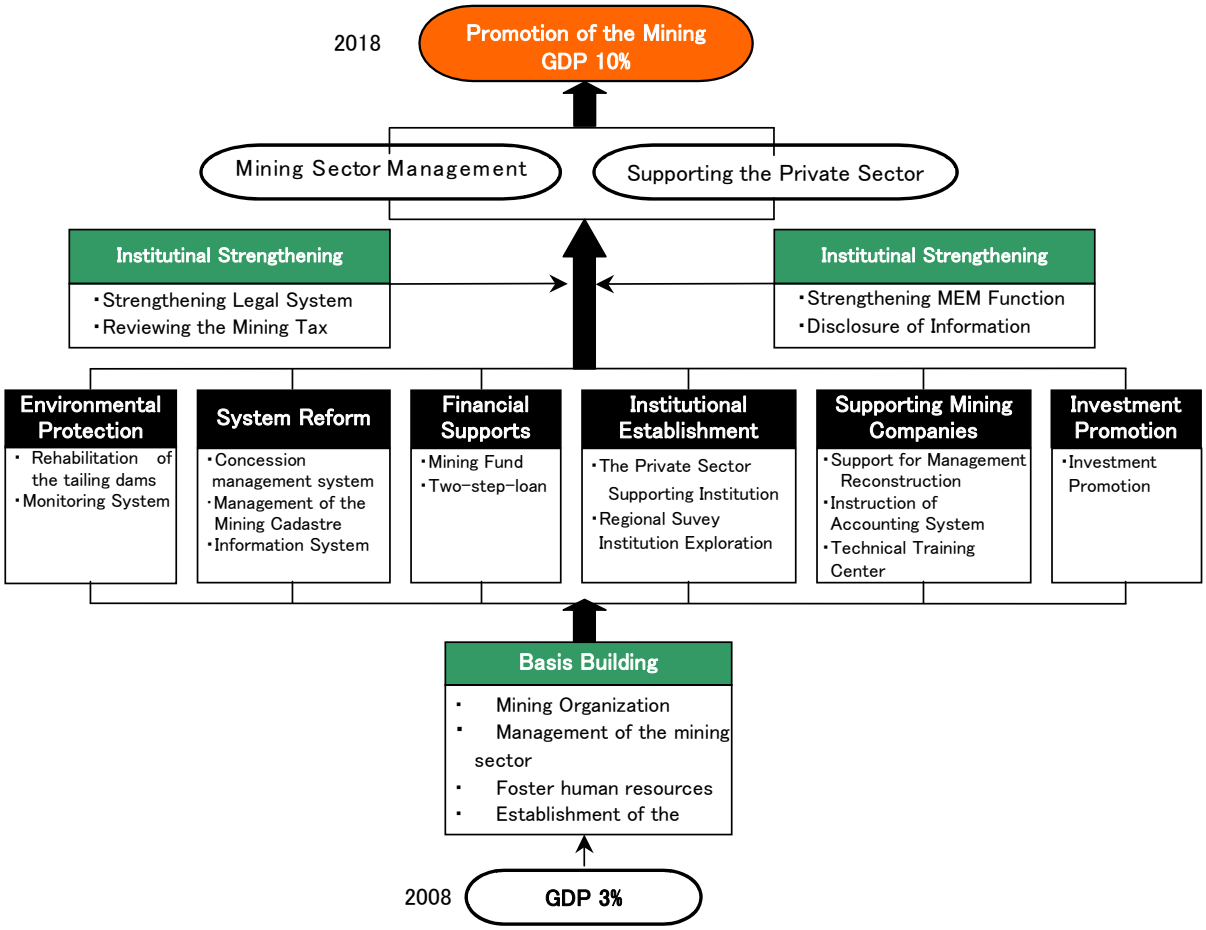



Fig.8.11 Measures and Mining Promotion

### 8.4 Implementing Organization

The Master Plan must be approved by the government after it is reviewed and examined by MEM and MEP. Approved items include an implementing organization to be described here.

The Master Plan Committee consisting of members from the associated organizations will be set up to implement the Master Plan.

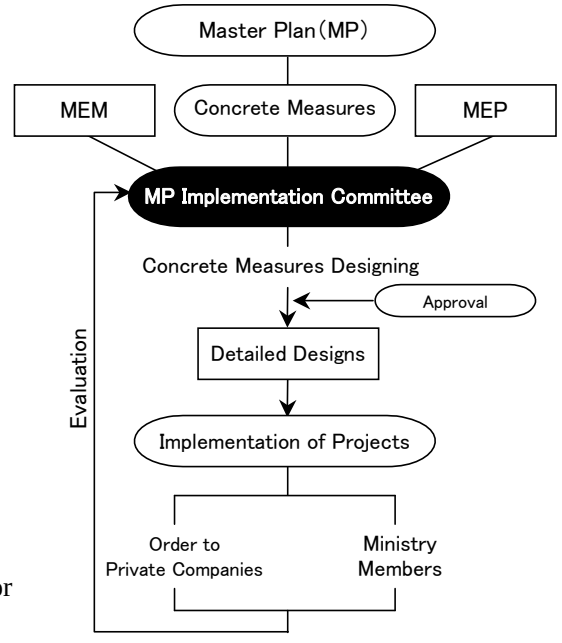



Fig.8.12 Implementation Organization for the Action Plan

## 8.5 Action Program

Each measure should be examined in the future through series of operation such as basic design, budget estimation and detailed design after discussing their roles and effects from the viewpoint of creating a systematic and organic relationship.

### (1) Mining Organization

The current Serbian mining organization and national management were formed during the self-management socialist era and are not appropriate for the present privatization situation or the future. The New Mining Law defines the establishment of a Mining Agency, so it is preferable to assign the Mining Agency to the routine work of mining management, and the MEM to the mining policy. Also, the Mining Institute and Geological Survey should belong to the MEM, which will administrate and manage the mining sector.

The Mining Agency will manage the entire mining sector. It will consist of mine management, concession management, information center, mine pollution measures, environmental preservation, technical management and mineral development. The MEM's work will focus mainly on institutions, policy, laws, and regulations. The Mining Institute will play a role in technical development, technical evaluation, and training for related people. The Geological Survey will create a mining cadastre, and collect and compile resource and geological maps and information.

#### 1) MEM Organization

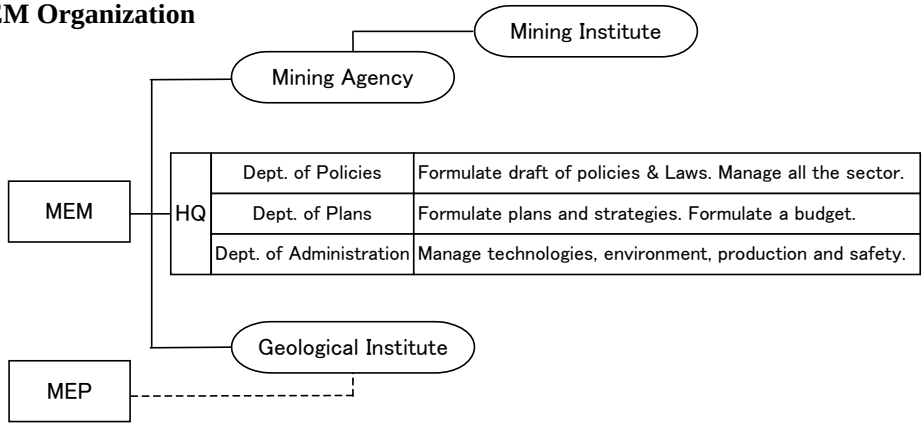


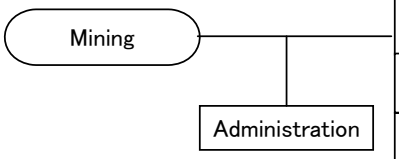

Fig.8.13 Unitary Government Organization Concept for the Mining Sector

#### 2) Mining Agency Organization

The Mining Agency will be an operational unit for the mining sector. In other words, the agency will manage and coordinate all mining activities from the government's standpoint. The following considerations should be taken account when establishing the Mining Agency;

- Define the roles and locations of the Mining Agency and associated organizations, and the network between them.
- Employ staff who work in the Mining Agency.
- Incorporate the partial research institutes into the agency.
- Activate the relation between the Mining Agency and MEM, and manage sufficiently

the sector.




| | |
|---|---|
| Mines | Manage active and closed mines, Mine safety. |
| Concessions | Manage issues and registration of mining rights. |
| Technical Management and Development | Evaluate, manage and develop technologies. |
| Survey | Regional survey, Concession monitoring, Resources register. |
| Environmental Protection | Manage monitoring, measures for pollution. |
| Information | Collect, analyze and compile necessary information. |

Fig.8.14 Organization of the Mining Agency

**(2) Investment Promotion**

Investment promotion includes information disclosure to the potential investors, holding seminars, preparation of investment promotion brochures, and management of the website. The Information Center within the Mining Agency can handle such functions and also work with the SIEPA. A "one-stop shop" (described later) should be established at the Information Center to assist investors gathering and evaluating information.

If the investment climate and mining foundation were insufficient, the true investment promotion could not be materialized. The Serbian current state for the investment promotion is listed in Table 8.8..

Table 8.4 Main Issues with and Current State of Investment Promotion

| Issue | Current state |
|---|---|
| Mining policies | • Prepared by a World Bank consultant |
| Mining organization | • Necessary to re-organize and be functional |
| Geological information | • Much information, but insufficient to be compiled<br>• Necessary to study how to use information. |
| Laws and regulations | • World Bank's consultant prepared a draft of Mining Law (no final Mining Law and no regulations) |
| Tax system | • Defined by the new Mining Law (May 2006). |
| Infrastructure | • Almost constructed.<br>• No barrier for investment promotion. |
| Exploration and development institution | None |
| Foster experts | • Few experienced workers in business under the market economy<br>• No organized fostering system |
| Investment promotion | • Implemented by SIEPA, but it is not defined by the Mining Law.<br>• Insufficinet disclosure of information |

**a. Investment Seminars**

It is desirable to hold investment seminars in London and Belgrade once or two times a year. Also representatives of the Serbian government should participate in the PDAC (Prospectors and Development Association of Canada) which is held in March every year at Toronto, Canada. In

these seminars, the Serbian mining industry, resource potential and other topics should be covered to attract foreign investors. The Information Center will hold the seminars and it will help to attract Serbian companies' interest in the seminars.

**b. One-stop-shop**

It would be desirable to have a function of one-stop-shop for investment promotion at the Information Center during the 5 years of the mining sector building period. In the Mining Agency Organization mentioned above, it was expressed as "Division of Publication/Sales/Investment-Promotion". The roles of investment promotion are considered to be as follows:

- To hold seminars, and prepare materials and litereature for seminars.
- To update materials for seminars, and continue issuing and distributing Newsletters.
- To make a list of global mining/exploration companies.
- To collect information on investment trends.
- To determine investment targets in the Serbian mining sector.
- To make materials for investment promotion.
- To hold investment sessions and instruction seminars to guide Serbian companies.

**c. Publication of Maps, etc.**

There are many geological maps in Serbia. However, they are not published, and it is not easy to obtain the required maps. Basic information like geological maps should be published and provided to people who need them. Not only geological maps but also books such as ore deposit maps, geological structure, etc. are necessary for investors, so such information should be published as well

**d. Transmission of Information (Periodicals and other Publications)**

Currently, MEM intends to publish newsletter as periodical paper publication as well as the website in order to transmit the Serbian mining activities. If MEM or MEP continues to publish periodicals in association with SIEPA after this project is completed it could be an effective way to link it with investment promotion..

**(3) Management of the Mining Sector**

Privatized companies are currently managed in the same manner as in the state-run era, submitting requested exploration reports, development schedules, etc. For example, ore reserves in privatized mines are self-managed, so the Commission for Verification of Reserves is not necessary. Therefore, such organizations should be abolished, and objectives and methods of management by national organizations must be reviewed. Also, procedures for applying for concessions and exploration licenses should be simplified. A roundtable meeting (described later) between the

government and private sector should be established to exchange opinions on mineral policy and institutions. Furthermore, it is desirable to establish a Mining Committee which consists of experienced mining professionals and mining parties to examine administrational renovation such as policy changes, revision of the Mining Law, etc. A private organization, such as the Mining Association (described later) will play an important role in the management of the mining sector, as a window between the government and private companies. The mining sector must be managed so that the activities of the private sector can be conducted actively and safely and will solidly contribute to economic development.

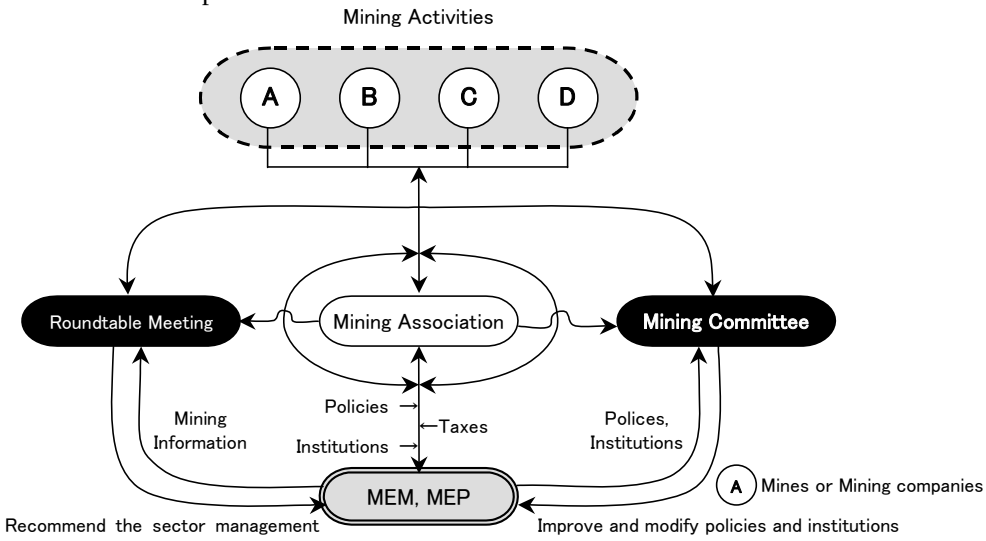



Fig.8.15 Schematic Diagram for Management of the Mining Sector

**(4) Reorganization of Research Organizations**

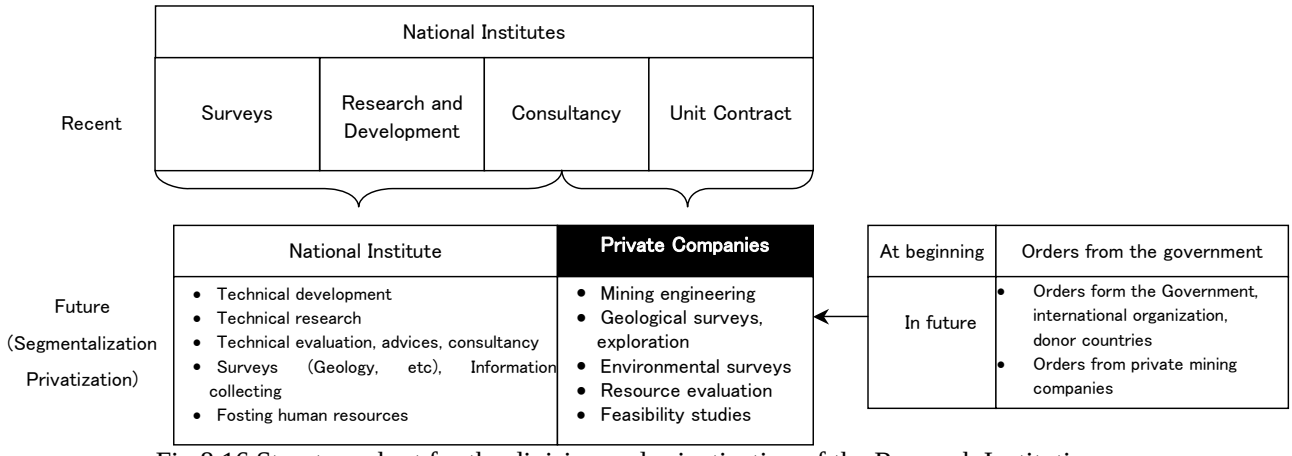



Fig 8.16 Structure chart for the division and privatization of the Research Institution

Research organizations related to the mining sector are the Mining Institute, RTB Bor Copper Institute, Geological Institute and universities. Compared with the current mining activities, there may be too many organizations. It is necessary to reorganize these research organizations in order to clarify their roles as follows;

Duties as a national organization to reorganize these institutes under a market economy

must be selected. For example, the Mining Institute and RTB Bor Copper Institute should be combined into the National Resources Institute with two departments, metals and coal.

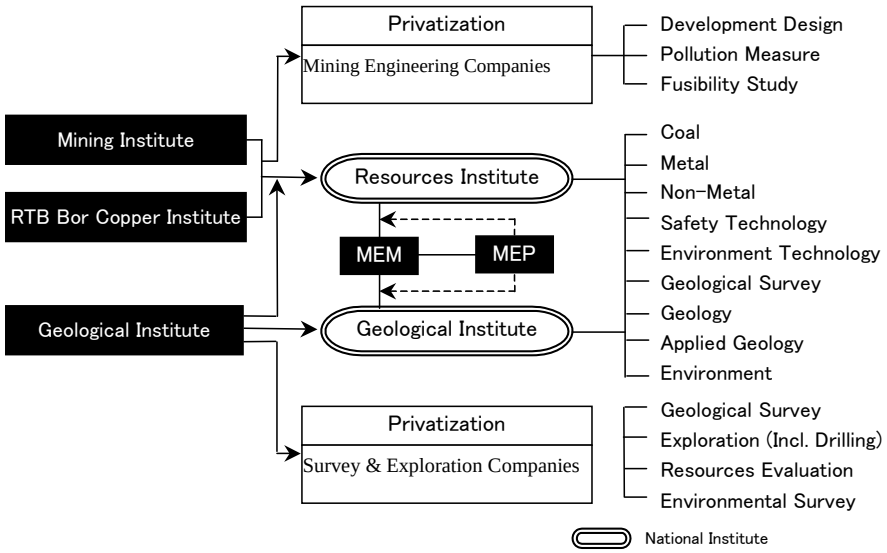



Fig.8.17 Concept for Breakup and Privatization of National Institutes

It should have a role in fostering human resources and Serbian private mining companies, along with the faculty of the Mining and Geology department of the University of Belgrade. If it could also provide training for other countries with limited training facilities, like Japan, it might become an international mining training center.

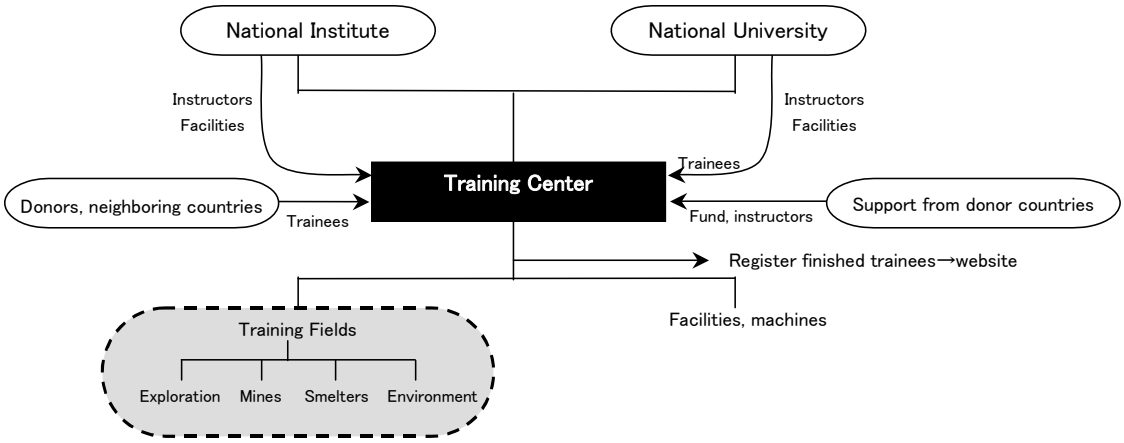



Fig.8.18 A Concept for Fostering Human Resources

**(5) Mining Fund**

The Mining Fund supports improvements to capacities, restricts business, and prevents environmental pollution in the exploration, development, and production activities of local mining companies. Support subjects, institutions, guarantee of funds, and management methods need to be studied when the basic design for the fund will be discussed.

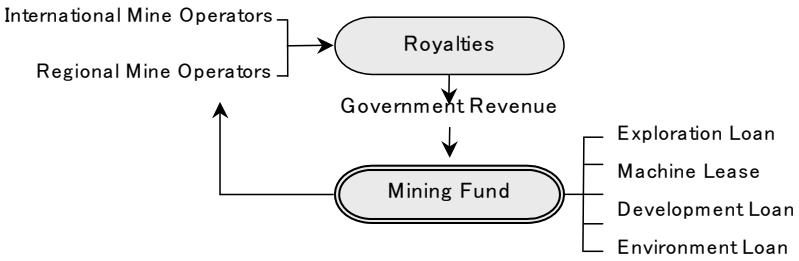



Fig.8.19 Mining Fund Concept

The following matters should be considered regarding the Mining Fund:

- Institutional regulation of the Mining Fund
- Extent , targets, kinds of the fund use
- Estimate of the fundamental fund
- Management organization, framework and method
- Institution and organization for check system of the fund
- Condition for concession loan, loan and technical supports
- Preparation of annual report for the fund using

**(7) Two-Step Loan**

The Serbian government will obtain a low-interest loan from international organizations, such as the Japan Bank for International Cooperation (JBIC), and will principally finance medium/small mines through the Mining Fund mentioned-above. It will function as micro-financing.

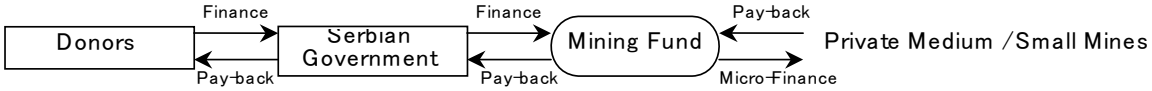



Fig.8.20 Two-Step Loan

If the Mining Fund is available, the Two-Step-Loan will be managed more easily. Payback of loan from the donors will be frozen for 5 to 10 years with low interest, and the payback period is long (15 to 30 years), so it may be used to foster the local mining companies.

**(8) Accounting System Training**

An international accounting standard has already been introduced, but it has not become widely used yet. However, mining is a business which deals with international goods. Therefore, the international accounting standard must be firmly fixed to expand mining activities by the Serbian companies in the future. For that purpose, it is necessary to carry out accounting system training. Global accounting training, including international accounting standards, how to make the financial statements, and strategic accounting for financial management, should be carried out regionally. Trainees should include the staff of medium/small mines, mining-related companies, and government organizations such as the MEM and the MEP.

**(9) Establishment of the Mining Association**

The government and private companies should work together to improve the mining industry. Communication between private companies and the government is vital. Private companies also need to understand the policies and institutions formulated by the government. A Mining Association should be established consisting of private companies to maintain communications with the government..

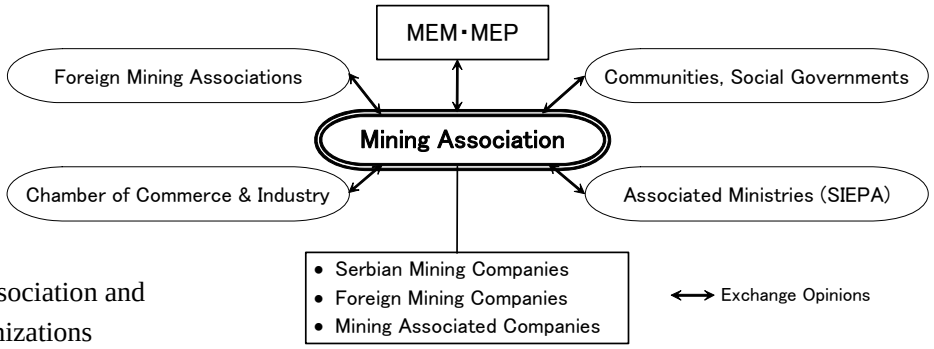



Fig.8.21 The Mining Association and its related organizations

**(10) Refurbishing of Tailings Dams and Monitoring System**

The case study points out the possibilities of environmental contamination and the failure of the tailings dams. To prevent dam failures, like those in Rumania and Macedonia, rehabilitation of the tops of tailings dams, repairing water collection pipes, and the installation of a monitoring system is urgently needed. The government must construct a monitoring GIS database from regional data and mines data, and mining companies must build a monitoring system for dam bodies and side ditches of the tailings ponds. It will also be necessary to construct a system for emergency response by linking the two monitoring systems.

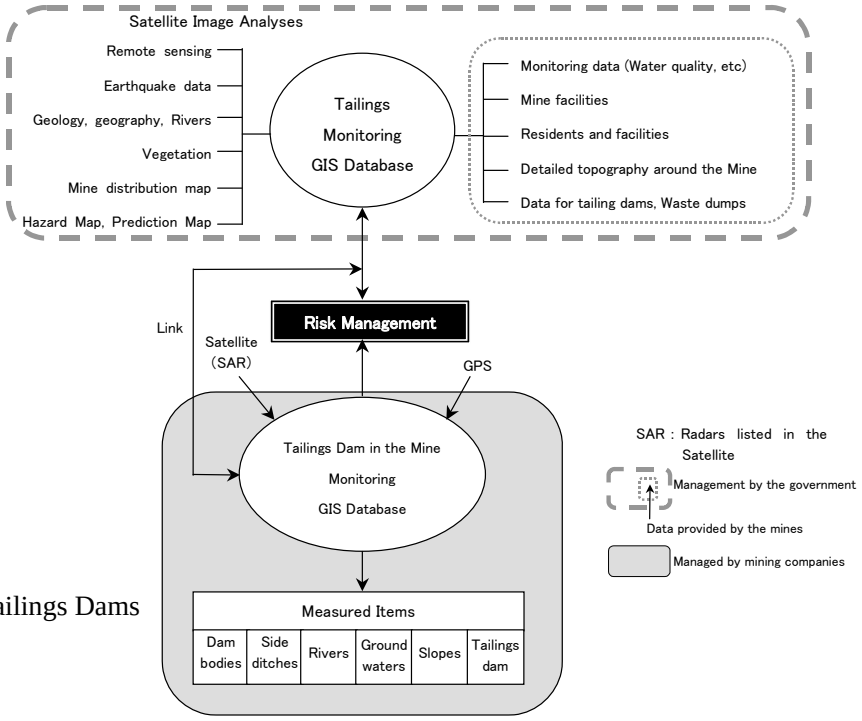



Fig.8.22 Monitoring System for Tailings Dams

**(11) Concession Management System**

A system to simplify the current concession management system needs to be implemented as it would have a positive effect on investment promotion. Mining laws need to be revised and linked to expansion of the GIS database. It is necessary to simplify procedures for obtaining permits and mining rights as much as possible.

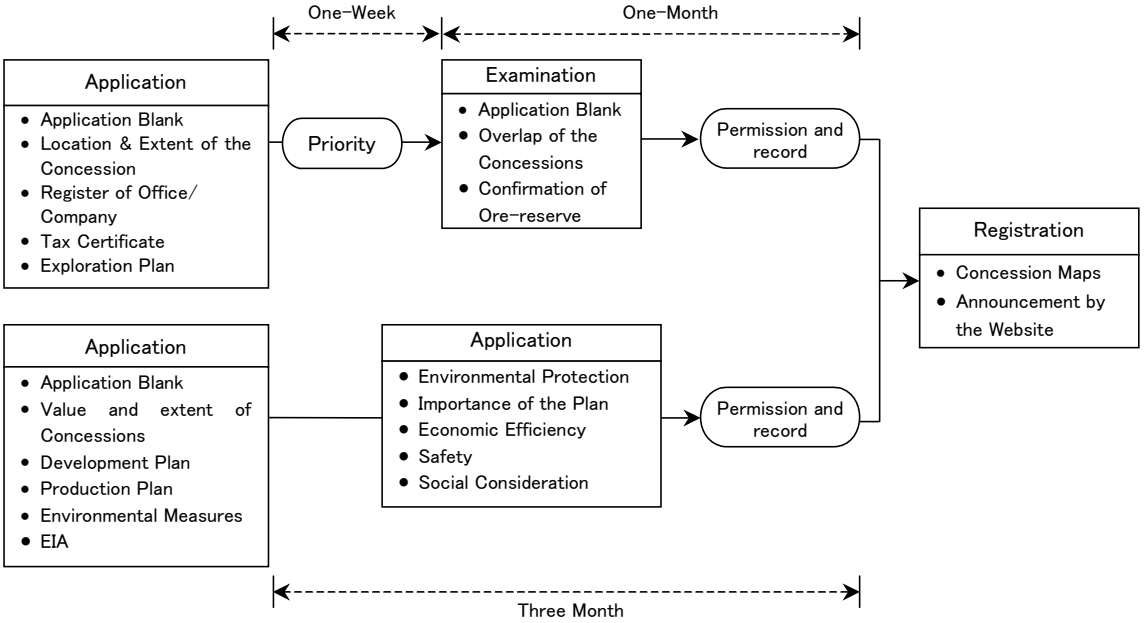



Fig. 8.23 Flow of Procedures to Acquire Mining Concession

**(12) Technical Training Center for the Mining Industry**

Due to internal fighting, over the 15 years Serbia has lost opportunities for mining technicians to pass on their mining skills on the next generation. The current mining technicians are elderly. It will be difficult to continue mining activities without developing young technicians. Technicians have roles to work in the front lines in mines, supporting engineers. In Serbia, young people are leaving the mine sites owing to stagnated mining activities. Therefore, it is indispensable to foster technicians in the Technical Training Center as well as foundation and promotion of the mining industry.

**(13) Support for Management Reconstruction**

Privatized mines, especially locally-held mines and smelters, have little management experience under a market economy. Some consulting will be needed to support improvements to management and reconstruction, similar to the TAM EBRD program at the Rudnik Mine.

**a. Management Improvement**

Mines must be managed with competitiveness under the market economy. It is indispensable to foster experts who can instruct managers necessary management skills under the market economy such as mining system, technologies, effective use of information, strategic formulation, reviewing of cost, financial management and system, strategic accounting, improvement of

productivities, budget management and formulation, formulation of medium/long term plan, cash flow analyses, etc. For example, Japanese “Kaizen” (improvement) activities should be introduced. It is appropriate to invite experts from donor countries.

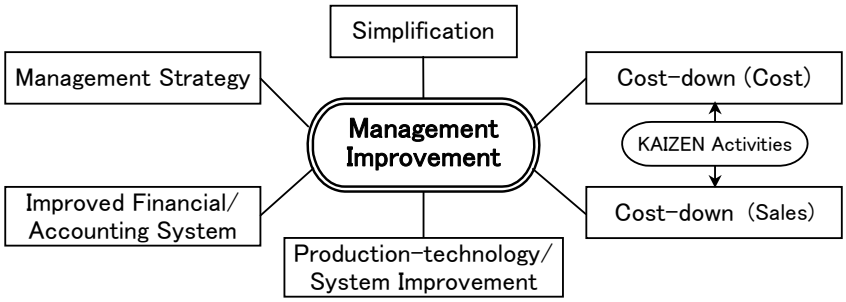



Fig. 8.24 Concept of Management Improvement

**b. Financial Support**

It is not easy to procure capital for mining reconstruction and promotion after its reconstruction from city banks due to their interests, mortgages, guarantees, etc. Mining is process industry and always needs reinvestment. Furthermore, mineral products have strong impacts from the international prices, so it is important to fund operation capitals urgently. In addition, rationalization cost is necessary to decrease man power to the appropriate scale which meets production. Financial supports (loans) are thus necessary to obtain financing easily.

**c. Environmental Measures**

Many mines have environmental issues, but their current real states are not known. In particular, management of waste dumps and tailings dams is insufficient. If mining reconstruction proceed without proper actions being taken against environmental pollution, environmental issues could become a large burden on mining management in the future. The government must implement environmental measures in its responsible extent just before the privatized mines will implement their environmental measures.

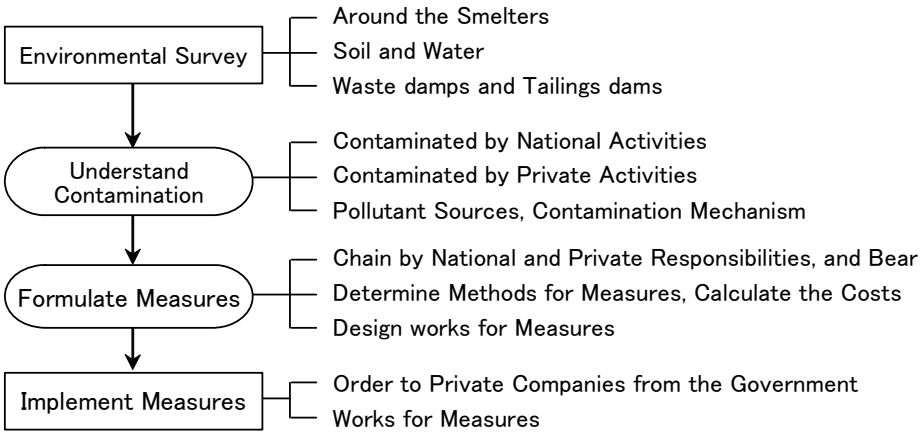



Fig. 8.25 Concept for Implementation Flow of Environmental Measures

**d. Technical Development**

The Serbian government should support the private technical development in the future.

It should noted that the management reconstruction must be done in mining-related survey/engineering companies as well as mining companies. National support for technical development should include the following:

- Establish institutions for national subsidies and grants.
- Implemented by national research organizations.
- Use facilities of national institutes.

**(14) Mining Training Sessions**

Obsolete concepts of management and operation held over from the socialist era still exist in the minds of mine managers, executives, engineers, and other staff. Their cost-awareness is low. The mindsets of people in charge of privatized mines under a market economy need to be updated through local mining training sessions, including mine operation, environmental preservation, cost consciousness, and mining technologies. Instructors can be selected from the experts from Japan or European countries.

- Trends in the mining industry
- Resource economy
- Analyses of market trends
- Economic technology
- Evaluation method for resources
- Exploration technology
- Management of mining environment
- Mining law and mining policies
- Mining finance
- Project financing
- Mining accounting and strategic accounting
- Production management
- International accounting standards for mining
- Mining company strategy
- Cost0reducing methods
- Risk management

**8.6 Institutional Reform Programs**

Detailed measures for the Institutional Reform Programs was studied as well as the Action Program. Summary of these measures is described based on tasks selected by the local surveys, as follows:

**(1) Support Systems for Private Companies**

If Serbian mining companies are nurtured, mining activities will be more virorous, and it will lead to mining promotion. However, this will require official financial support which may be gained from the Mining Fund financed by royalties and taxes. Details are described below (Fig8.26);

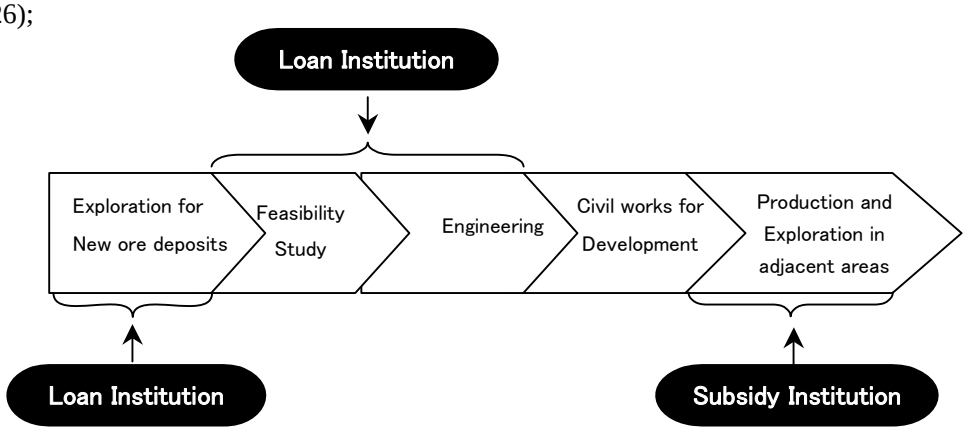



Fig8.26 Support Systems for Private Mining Companies

**a. System for Subsidizing Exploration**

It is difficult to procure financing for exploration activities of mining companies that do not have stable management. Serbian small/medium mines do not have sufficient ore reserves, because little exploration has been carried out since the 1990s (the former Yugoslavia period). Their mine lives are only 3 to 5 years, and there is possibility to stop their production activities. If operations are continued by Serbian companies, this Subsidy System for Exploration might be helpful to activate exploration activities around existing mine sites. Also, it will be liked with stable management to obtain resources for the short/medium term.

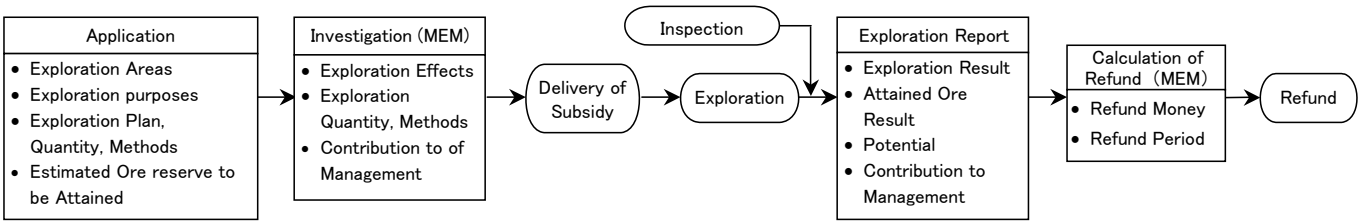



Fig. 8.27 Procedures Flow for Exploration Subsidy Institution

**b. Loan System for Exploration**

It will be used when Serbian mining companies carry out regional exploration. It will activate exploration activities in unexplored areas. It will be supporting system for exploration with large risk. This loan system will be helpful for funding exploration activities to find new ore deposits.

**c. Loan System for Development**

Currently in Serbia, it is not easy to finance mining development. However, when good results of a feasibility study are obtained, financing is not so difficult to procure. Therefore, if there were a loan system for funding feasibility studies and engineering, it would stimulate mining development. The targets would be Serbian mining companies.

**(2) Regional Exploration Institution**

Regional exploration has not been sufficiently undertaken in Serbia since 1990. The country's resource potential is estimated to be comparatively higher by its geological conditions, but there are not data enough to select exploration targets outside of existing mines sites and surrounding areas. Regional exploration financed by the government will activate general exploration activities, and finally lead to development of mines in new districts.

In addition, orders for regional explorations to geological survey companies will help to improve their technological abilities, and foster privatized companies (Fig.8.28 and Table 8.14).

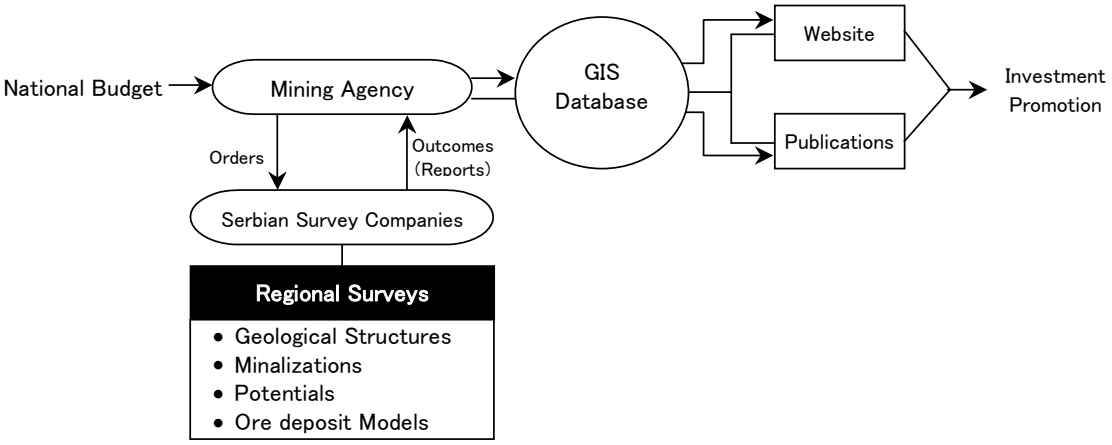



Fig. 8.28 Regional Exploration and Investment Promotion

Table 8.5 Overview of Regional Exploration

| Item | Content |
|---|---|
| Survey extent | 20km×20km （per 1 area） |
| Survey methods | Geological survey （1:10,000 & 1:50,000）<br>Geophysical exploration （meneralized zones）<br>Geochemical exploration （reconnaissance）<br>Structural drilling 500m to 1,000m/hole （1 to 2 hole/area）<br>Remote sensing |
| Analyses | Geological structure<br>Determination of ore deposits potential areas<br>mineralization<br>anomaly areas by geochemical and geophysical exploration<br>ore deposit models |

**(3) Management of the Mining Cadastre**

The mining cadastre of MEM must be improved, as mentioned in (1). Currently its procedures demand time and labors in MEM as well as applicants. Therefore, it is necessary to simplify works in application and the cadastre based on the Mining Law. In other words, the works should be divided into unit processes which enable to be managed by the GIS system (Fig.8.30).

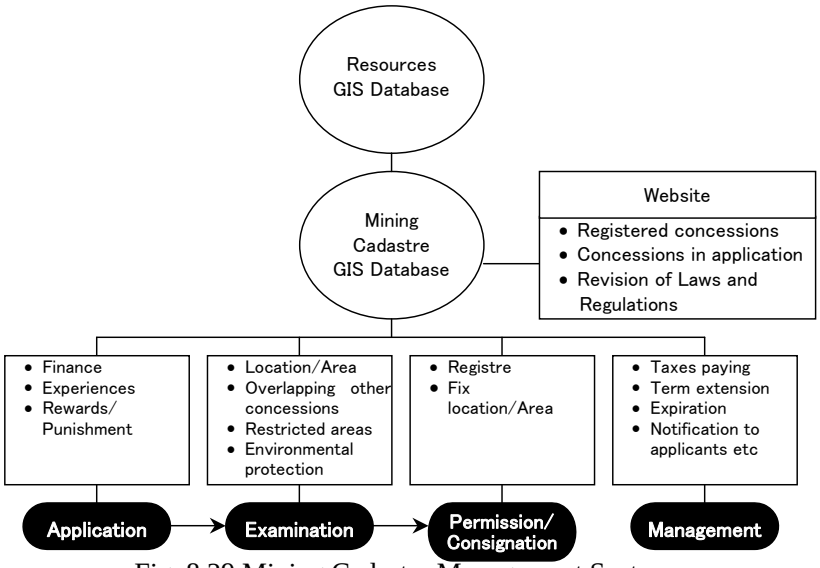



Fig. 8.29 Mining Cadastre Management System

**(4) Strengthening of Legal System**

Serbia's Environmental Law, Mining Law, Investment Law and associated laws should be reviewed comprehensively and systematically, and discrepancies, if any, must be resolved. All of these laws must be functionally effective.

It is also necessary to prepare new legal system including regulations consistent to the new Mining Law. They must include royalties, application for concession, exploration reports, standards for equipment and machines, standards for underground drifts, mine safety, mine safety qualification, mining standards, mining environment protection, mining environmental monitoring, development plan, and others to manage the mining sector efficiently based on the Mining Law.

**(5) Ore Reserve Calculation**

Ore reserves should be calculated by each private company involved, not by the Reserves Verification Commission. In Japan, the calculation method is stipulated by the Japanese Industrial Standards (JIS), and each mine and company selects the calculation method based on the JIS according to characteristics of its ore deposits, then improves it, and creates their own standards and manuals for calculating ore reserves. Under a market economy, ore reserve calculations are the responsibility of each private mine.

**(6) Information system**

Serbian government is constructing information system, and its usage is expanding at the present time. In ministries and agencies, varieties of databases, GIS databases and websites have been developed. The following system developments will be required to improve operational efficiency in the mining sector.

- Strengthening and expanding LAN in the Ministry
- Constructibg a database for documents in the MEM, MEP, relevant organizations and institutes
- Constructing a mining cadastre management system and website
- Expanding the mineral resource GIS database
- Linking between environmental database and mineral resource GIS database
- Usinge GIS database for land conservation

**a.** A diigital archive center which integrates and compiles all geo-science related databases should be established for sharing fundamental spatial data in Serbia.

**b. Expanding of GIS Database for Land Conservation**

In the future, compiling varieties of datasets for geo-science, mining cadastre management, infrastructure, national land use, meteorological data and monitoring data of tailings

dams based on the design, it will be expected to be used for national land conservation system such as natural and humanitarian disasters, and also can be used for regional development. All current monitoring implemented by each organization must be systematized. It will be necessary in the future to analyze all monitoring data and cause for temporal variation of data by networking the database of each organization in order to formulate countermeasures. It will be linked with conservation of the nation's land. In addition, data should be disclosed to the public through the environmental website, to increase the public's understanding of environmental preservation and clear up uneasiness about environmental contamination (Fig.8.32).

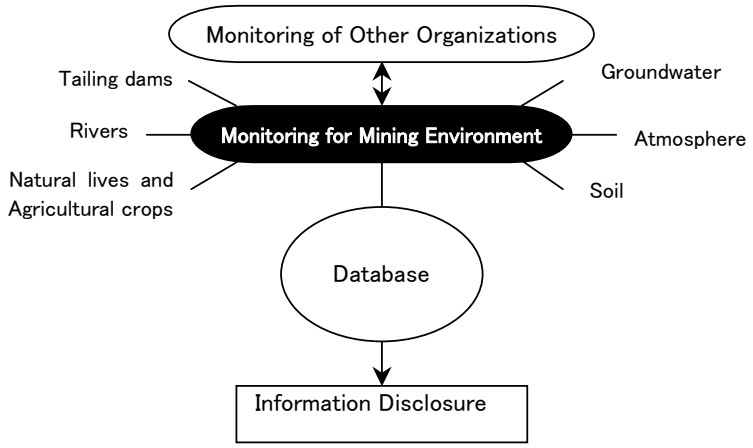



Fig.8.30 Environmental Monitoring and Information Disclosure

**a. Monitoring System**

Mining companies should be required by law to conduct monitoring. In other words, monitoring must be institutionalized based on the Environmental Law and Mining Law.

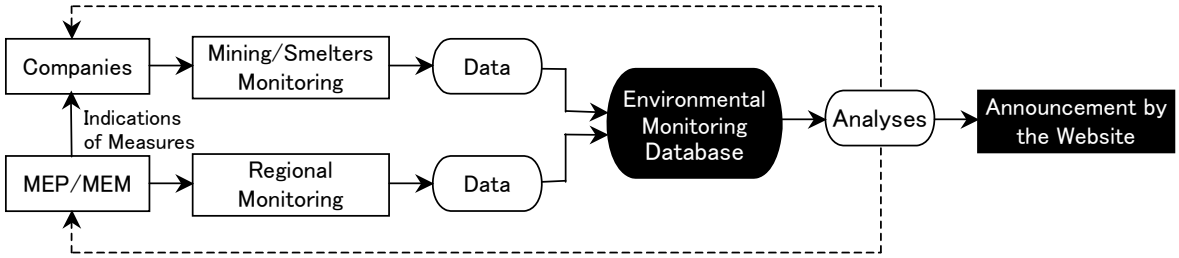



Fig. 8.31 Conceptual Diagram of a Monitoring System for Mining Activities

**b. System for Information Disclosure**

Monitoring data must be disclosed to the public to provide the public with information about impacts of mining activities on the environment. In this system, it will be necessary to determine information content, disclosure method, disclosure time, and the department responsible for information disclosure.

**c. System for Procuring Funding for Procuring Equipment and Facilities for the Monitoring System**

It is likely that privatized mining companies will not have sufficient money due to reconstruction of mine operations. This system will help privatized mines construct a monitoring system rapidly by funding facilities, equipment, computers, etc. Financial source is supposed to be fed by the Mining Fund.

**.d. Survey of Environmental Contamination**

It is necessary to survey the current state of environmental contamination around both active and inactive mines to implement monitoring systematically and effectively. Table 8.15 shows an overview of an environmental survey

Table 8.6 Overview of an Environmental Survey

| Item | Summary |
|---|---|
| Target areas | Around existing and old mines（in extent of 1 to 2km） |
| Survey targets | Soil, rock, rivers, groundwater, vegetation |
| Methods | • Grid sampling of rocks and soils<br>• Sampling of water and plants<br>• Chemical analyses of samples<br>• Satellite images analyses like ASTER |
| Compilation | Stored in the database（resources GIS database） |
| Analyses | Selection of anomalies, environmental analyses |

**(8) Strengthening of MEM Functions**

As MEM manages the sector based on the current Mining Law, its management method dates from the former socialism period. Improving official procedures such as simplifying documentation, methods for making final decisions, sharing information, procedures to escalate, format of meeting minute, etc., is vital for strengthening functionality. Through these activities, the following simplified organizational chart was created. The simplification of the chain-of-command will be linked with functionalizing management of the sector.

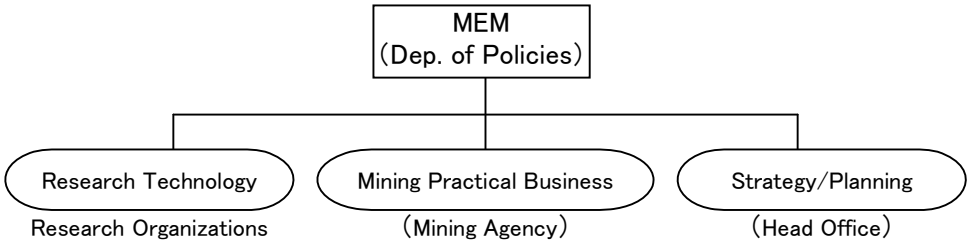



Fig.8.32 Function-enhanced Organization of MEM

It is indispensable to foster staff for more functional administration of MEM.

**a. System for Staff Training**

Staff training will be systematically carried out to manage the mining sector under a market economy. Training for the sector management will be done mainly by field training in advanced mining countries.

**b. System for Inviting Experts**

Experts will be invited to teach mining administration skills and technical information to MEM staff. They will also hold seminars in conjunction with the seminars mentioned in (14).

**c. System for Fostering Human Resources**

Reorganization of MEM and the establishment of the new Mining Agency may cause an excess or deficiency in MEM staff. It is necessary to create a system for training human resources as either new employees, to preparare them to take the place of other employees, and so on.

**(9) Review of the Mining Tax System**

During the 5th year after starting the Master Plan, it will be necessary to review the rates of royalties and taxes related to the mining sector. That is, it will be necessary to reassess their appropriateness based on the trends in market commodities prices, taking account of harmonious balance between the national revenues and the operations of the privatized mining companies.

## Chapter 9 Recommendations

### 9.1 Current State of the Mining Industry and Serbian Mining

#### (1) Global Trend and Structure of the Mining Industry

Mineral products prices have been maintained in high level since 2003. Substantial mineral resources managed by many national governments were released to the free market according to progressed globalization after 1990s. At that time, European and American companies were in a center of the mining industry. However, current situation has been changed. In other words, Russia and China are actively seeking for mineral resources, and BRICs have changed from resource-supplying countries to resource-consuming countries owing to their rapidly progressed industrialization. Serbian people related to the mining industry must understand well this trend and structure of the global mining industry. It should be noted also that economic disparity between the mining companies has been enlarged due to progressed globalization.

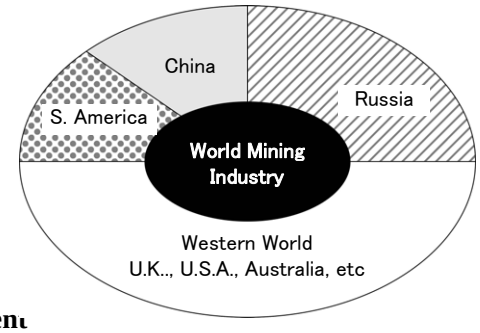



Fig.9.1 Recent Resources Powers

#### (2) Recent Development of Mineral Development

Recent development trend of mineral resources is jumboization of ore deposits to be mined, and also super mass-production due to lowered ore grade such as copper. Therefore, competitiveness of middle/small mines has been weakened. The continuing increase in metals prices is helping small- and medium-size companies to get established. However, if metals prices decline, it is clear that they will have to curtail production or even temporarily or permanently close some mines. It gives importance to prepare the mining laws which are attractive for investors. It is necessary to quickly establish an attractive investment climate.

Accordingly, the mining law itself is a rivalry factor among countries which intend to attract investors. The Serbian mining industry consists of middle and small mines, except the RTB Bor. Therefore, in order to give small and medium privatized mines the competitiveness they need, the national government will have to establish a system for supporting the transition to the private sector.

Most of Serbia’s mines are in the process of being restructured and they are seriously lagging behind the global mining industry. This is due to a lack of competitiveness resulting from the deterioration of equipment and facilities, the persistence of a production management system that dates from the Socialist era, and the delayed introduction of IT, among other reasons. Therefore, while metals prices are still, the Serbian mining industry will have to work very hard to catch up

with the global industry, and efforts will have to be made to enable the Serbian mining industry to thrive in a market economy.

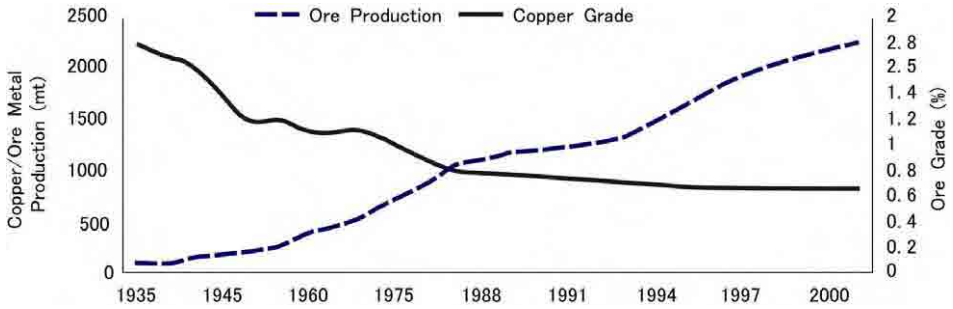



Fig.9.2 Relationship between Copper Ore Production and Ore Grade (source: Raw Material Group)

**(3) Strategy of the International Majors**

Currently in Europe and America, Juniors, exploration companies shown in Fig.9.3, procure capitals from the stock market to carry out exploration activities. When they get good results, they sell them to the international majors. Under this system, neither juniors nor majors take any risk. However, juniors cannot move actively in Serbia under the current Mining Law. Under the present Serbian mining law, junior companies from the EU, North America, etc., are not allowed to play an active role in the country. This is because, among reasons, the acquisition of mining rights is a very complicated process, and it is not easy to transfer mining rights once they are obtained. Therefore, it is indispensable to change the Mining Law to the global standard in order to attract the foreign investment. The following is a list of some of the major strategies:

- Large ore deposits, open pit→ mass production of low grade ore
- Regions adjacent to the market
- Attain promising projects from juniors
- Mines in regions to construct infrastructure or adjacent to those regions
- M&A of good companies
- Enlargement of resources occupation rate (for control of the market)

**(4) Regional Economy**

Trend of reciprocal relation is appearing in the global mining sector based on the regional economy (Fig.9.5). Serbia stands in the good geographical terrain. It has a good location which is easy to build business relation between Europe or Russia. Actually, Russian and European investors have already begun investing in mineral resources business (Fig.9.6) It is necessary to build thus reciprocal relation in resources business based on geographical features.

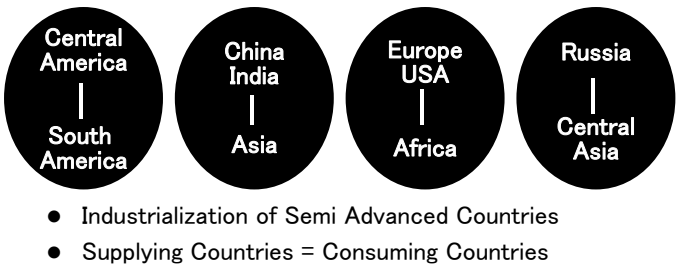



Fig.9.3 Schematic Diagram for Regional Economy in Mining

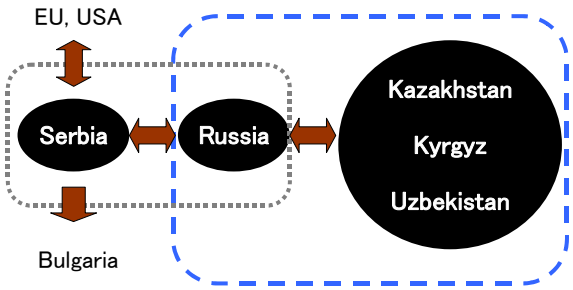



Fig.9.4 Networked Regional Economy between Eastern Europe-Russia-Central Asia

**(5) Serbia's Role in the Mining Sector**

The following are characteristics of the Serbian mining sector:

- Full set of mining technology from exploration to smelting and manufacturing
- Plenty staff in institutes (Mining Institute, Geological Research, CIB)
- High technical level

It is possible for companies without mining technologies and management experience of mining companies to manage mines. This is one of the advantages of investing in Serbia. However, despite this advantage, it probably cannot be satisfactorily exploited because of the mentality of the old system that is still entrenched at mines and smelters. Therefore, it is essential that mines and smelters have skilled personnel and adapt their production systems to a market economy, and work to change attitudes of technicians and workers are involved with production.

## 9.2 National Economic Development Plan and Master Plan

**(1) National Economic Development Plan**

Currently, the Serbian Government is formulating the National Economic Development Plan. Solution of following tasks is necessary to meet membership conditions of the EU.

- Maintain the economic growth.
- Amend regional economic discrepancy.
- Decrease unemployment rate.
- Abolish legacy traces of old institutions.
- Improve the investment climate.

If the unique features of the mining industry could be effectively utilized, it could contribute toward reducing ameliorating regional disparities and reducing unemployment. Mining is a core economic activity in rural areas which can lead to the formation of spin-off businesses and promote employment. Thus, the promotion of the mining industry in such areas can play a direct role in vitalizing local economies and reducing unemployment.

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**(2) Implementation of the Master Plan**

It is necessary for the Master Plan to link with the National Economic Development Plan. MEM and MEP must formulate a 10-year mining promotion plan based on the Master Plan and

implement it under approval of the government. Financing from the national budget or donors is needed to implement measures recommended by the Master Plan. To be more precise, each content will be studied to formulate its detailed program. It is difficult to materialize it without an execution system based on the plan.

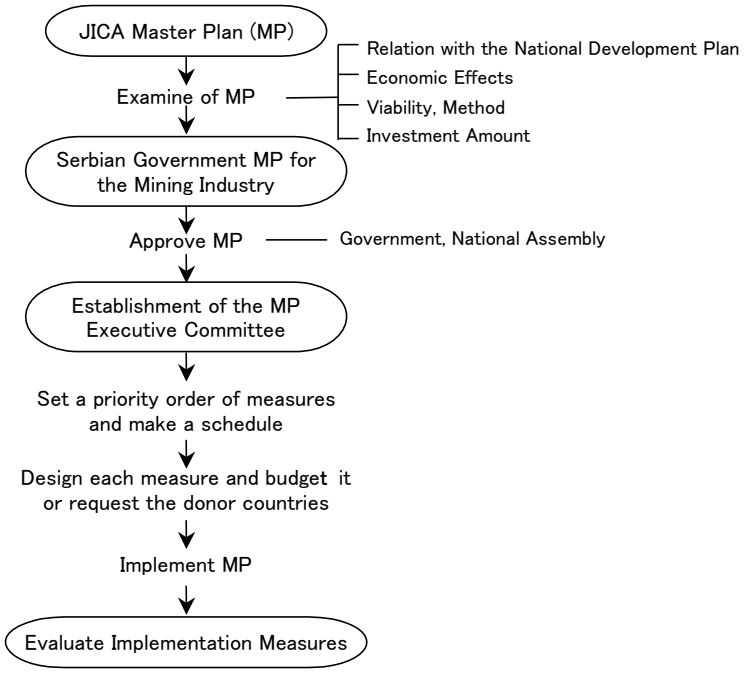


Fig.9.5 Procedure to implement the Master Plan

**(3) Relationship with local communities**

The mining industry can contribute to local communities. If a new ore deposit is developed, it will be linked with local development or local activation.

It appears that local communities still do not have an adequate understanding of mining activities. Compared with the former Yugoslavia era, the mining industry is suffering from a severe depression, and many miners are now unemployed. This may also have an effect on the understanding of information that is released to the public about environmental preservation.

Without the understanding of local communities, it is difficult to sustain mining activities. Therefore, once the Master Plan is completed, it should help to improve communication with local communities during the mining basement construction period (the first 5 years), which is essential for promoting the mining industry.

**9.3 Capacity Building**

**(1) Strengthening of Capacity to Formulate Policies**

There is no department to formulate policies in MEM. The Master Plan describes necessity to establish a department of policies in MEM. Policies are important to manage the mining sector and enhance mining activities. It is necessary to formulate policies from the comprehensive viewpoints such as analyzed information of the global mining sector, issues of the Serbian mining industry, evaluation of the mining sector, medium/long-term viewpoint, environmental protection, production activities, investment state, others.

**(2) Investment Promotion**

The following are indispensable factors for promoting investment in the mining sector:

- The Mining Law should be revised to meet international standards.
- Mining policies can link with profits of the stakeholders such as private companies, regional communities, government organizations, and others, and contribute to the national economy.
- Procedures to obtain concessions should be simple.
- The government and economy should be stable.
- The government organizations related to mining should be functional.
- Taxes and royalties should be fair and transparent.
- Geological information should be compiled to determine easily exploration targets such as geology and ore deposits, and be acquired easily by anyone.
- There should be partners or cooperative companies in Serbia, and human resources should be available.
- Materials should be prepared to assess the investment climate.

**(3) Organizations**

The government organizations related to the mining sector must administrate and manage the whole sector in order to govern the mining sector and activate mining activities. Serbia needs organization to promote mining activities under a market economy:

**9.4 Exploration, Development and Production Activities**

**(1) Resource Potential**

A Regional Survey System must be established to understand domestic resources potential and promote exploration.

**(2) Exploration Technology**

There are full technologies in Serbia, but following technologies are insufficient;

- Remote sensing analyses
- Electromagnetic exploration
- Ore grade management at mine sites

**(3) Mining**

There are full mining technologies in Serbia, and there is no problem in basic technology level. However, following technical improvements will be necessary for privatized mines to survive in the future.

- Complete trackless mining system
- Cut and Fill Method (in middle/small mines)
- Ore grade management in stopes

- Underground transportation system (for miners and ore/materials)

**(4) Ore Processing**

Flotation method is adopted in Serbia, and there is no problem in ore processing. However, improvement of recovery is a task in the future. Therefore, attention should be paid to following points;

- Ore processing based on information of mineral occurrence and mineral processing tests.
- Reason analyses and measures for ore grade difference between plan and result for feed ore and concentrate.

**(5) Smelting**

Smelting in Serbia will require particular emphasis on the following:

- Safety measures, anti-pollution measures, environmental protection measures.
- The use and storage of sulfuric acid.
- Extracting metals from tailings using the SXEW method.
- Making smelters cleaner.

**D. Overseas Joint Geological Surveys**

When Japanese companies conduct required surveys of geological structures when they work with foreign companies to do exploration work, part of the funds needed for the survey (≒ exploration) is provided as a grant.

In this way, the exploration system has been set up to contribute to Japan's national benefit, and the Japanese government is supporting Japanese companies. Even for the subsequent full-scale exploration and development stage, there is a system for financing exploration, and another one for raising exploration capital from debt instruments. Thus, there are systems in place for supporting surveys, exploration and development.

- Today in Serbia, it is essential to establish a system that will vitalize the country's mining industry and provide a steady supply of domestic resources to make an adequate and sustainable contribution to production activities. The systems described above can be applied in Serbia as survey and exploration systems, but both would require Serbian government funding, so it would first be necessary to secure a source of financing such as through a mining industry fund.

## 9.5 Mining Management

### (1) Financial Management System

Figure 9.10 shows a diagram of a financial management system.

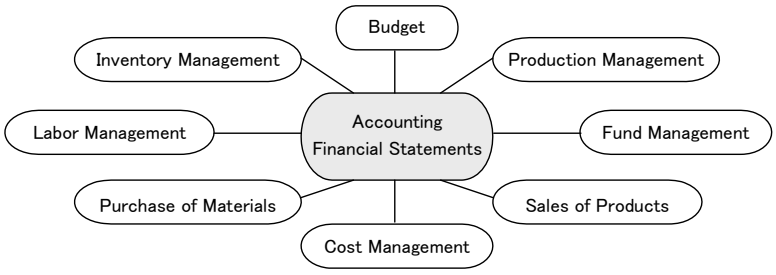


Fig 9.6 One Example of Financial Management

Such a financial management system is being established at many mines. It is possible to make “on time” checks of finances and is very effective for short-term management such as keeping constant track of current inventories, production, and expenditures for capital, production, and storage, among other things.

Thus, the above financial control system would be an integral part of operations, as it would enable the increase of short-term sales, the formulation of cost-reduction strategies, and immediate implementation as a financial management base. It would also be effective for short-, medium- and long-term planning.

**(2) Strategic Accounting**

At the high level of metal prices like present, if an accountant can give concrete indications to each department such as production ore grade, exploration activities, reinvestment and others, and each department can make efforts to achieve these indications, it might lead to the maximum profit and efficient consumption of money. Strategic predicted accounting could thus link with increased profit of the companies and increased revenue of the government according to metal prices.

**(3) Finance**

It is not easy to procure capital for small- and medium-scale mines because of issues with bank interest, collateral, and so on. Although it would also depend on the financial strength of the buyer of a privatized mine, there is also a need to acquire knowledge on finance, methods, organization, and types in a market economy, as well as nurture financial experts who can analyze relations with strategic accounting and financial management.

**(4) Cost reduction**

The Japanese car maker Toyota is always making efforts to cut costs significantly. Its target is a 50% cost reduction, and the entire company works to achieve it. In its efforts to reduce costs, the Japanese mining industry has also introduced the same type of quality control and Kaizen activities that Toyota and others have implemented. It is likely that Serbian mining companies will have to take the same approach as Toyota.

**9.6 Environmental Conservation**

**(1) Monitoring**

Current monitoring system is not insufficient, because it is carried out by various organizations even if they are reportedly moving to put together. There is no measure for pollutant sources, due to lack of analyses. It is necessary to establish a Monitoring Center governing the whole monitoring across the country to prepare measures for pollutant sources.

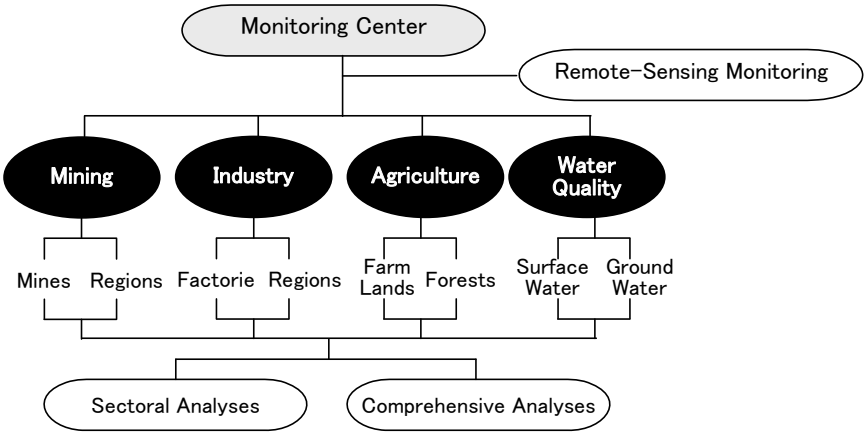

Fig.9.7 A Concept for Monitoring Center

**(2) Measures for Pollutant Sources**

Current measurement of 4 times per year is not sufficient basically to understand the polluted state. And also there is not any autonomous environmental management at each mine. It is necessary to study a new institution that enables each pollutant producer to carry out monitoring autonomously and strengthens environmental management. As its first step, the measuring items should be decreased by limiting them to discharged pollutants, but measuring frequency should be increased.

**(3) Environmental Measures**

Currently an environmental survey is being conducted for RTB Bor by the World Bank. However, any environmental survey has not been conducted for other mines. First of all, it is necessary to implement these environmental surveys to understand the contaminated state around the mines. Even in the RTB Bor, the pollutant sources and loading dose have not been surveyed so far, and priority of countermeasures has not been determined yet. Following item must be studied to formulate countermeasures;

- Survey of pollution load (investigate reducing environmental load through the use of BAT, etc.)
- Decontamination of soil (including river beds)
- Cleaning of polluted air (through comprehensive measures that include replacing equipment)
- Cleaning of polluted water (by installing, increasing, replacing treatment equipment)
- Improving regulations to limit areas of discharge
- Policies for handling slag and tailings
- System for recycling wastewater (to reduce water pollution)
- Replanting, revegetating bare land (to reduce water pollution)
- Investigation of measures for isolating wastes

**(4) Tailings Dams**

In Serbia, it is necessary to first implement detailed investigations and formulate measures

for tailing dams from viewpoints of environment and safety.

**9.7 Unused Resources**

**(1) Possibility to Use the Unused Resources in Serbia**

The unused resources in Serbia are supposed to be as follows;

- Tailings in the tailings dams
- Waste dumps in the mines
- Slag in the Cu smelter (it has been operated with low recovery.), slab in the Zn smelter
- Zn in the smoke from the smelters (recovery from iron net coated by Zn powder)
- Valuable elements like Iridium, etc. in the Zn smelter

It is necessary to study possibilities of their existences, volumes and measures to recover including recycling.

Waste materials that contain metals will likely increase in Serbia. In addition, concepts will also have to be developed for materializing recycling bases (industrial park “eco-towns” in the Balkans in the future.

Table 9.1 Surveys for Unused Resources in Serbia

| Target | Content of the Surveys |
|---|---|
| Tailings Dams | Unused Metals in the tailings, Metal Amounts |
| Waste Dumps | Valuable Metals in Dumps, Dump Amounts, Metal Amounts |
| Slag in the Smelters | Amounts of Cu & Zn in Slag, Slag Amounts, Metal Amounts |
| Zinc in the Dust of the Steel Makers | Accumulation State of Dust from the Electric Furnaces for Steel Making, Amounts of Dust, Zn Grade in Dust |
| Indium | Amount of Indium in Zn-concentrate, Amount of Indium in Zn Mines |

**(2) Investigation on the Tailings dams**

Currently, useful metals included in tailings are being investigated in the 2 tailings dams by this study. Since it is only a qualitative study, a quantitative study will be needed based on the resulta of this study in the future, to understand existing conditions, volume and grade. Finally, an economic evaluation will be also needed. This study includes the laboratory tests for the qualitative evaluation. However, based on this evaluation, a pilot test may be also needed for technical evaluation in the future.

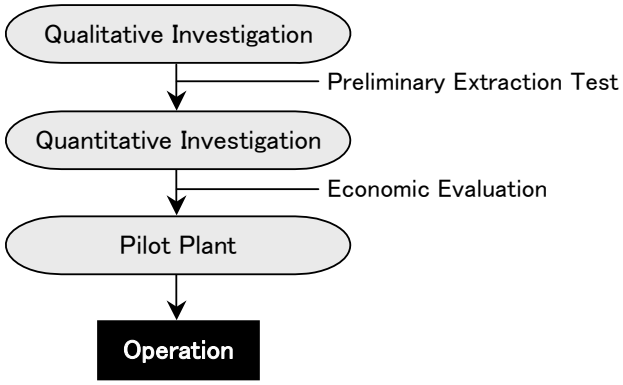


Fig.9.8 Investigation of the Tailings Dam

As mentioned above, the tailings dams that are not in the case study must be also investigated.

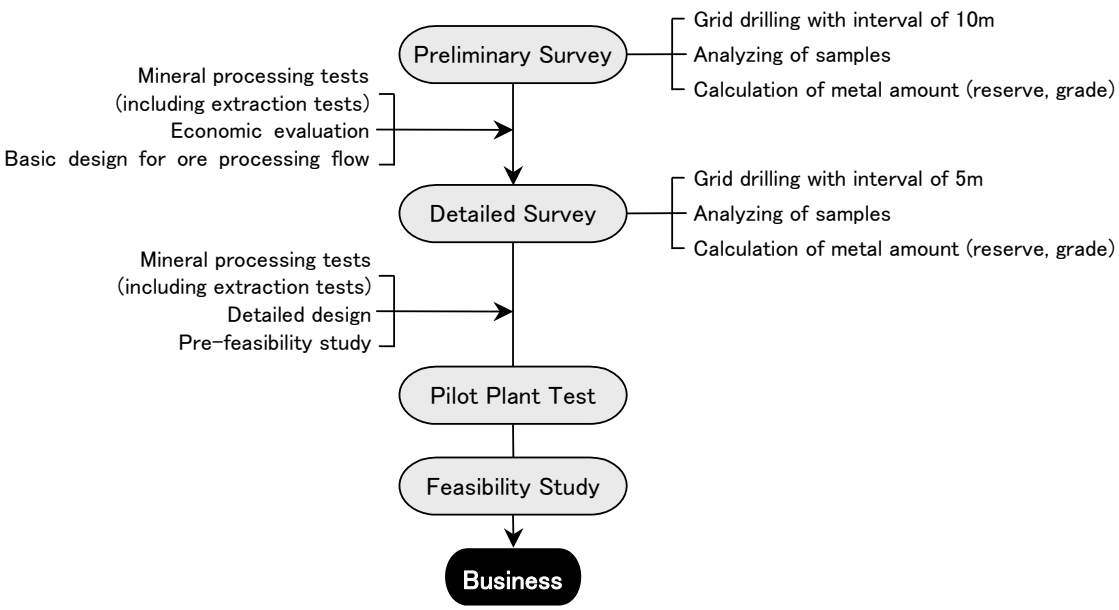

Fig. 9.9 Flow of Recovering Metals from Tailings

## 9.8 Sustainable Development of the Mining Industry

### (1) Conditions for Sustainable Development

The following is a list of conditions necessary for the sustainable development of the mining industry

- Acquisition of reserves and realization of potential that can sustain production over the long term
- Emphasis on environmental preservation
  - Implementation of anti-pollution measures
  - Monitoring
- Establishment of a good rapport with the local communities
- Keeping technicians and engineers
- Quitable mining tax system and mining law (mutual benefits… government, mining companies, local communities)
- Cost competitiveness

### (2) Private sector initiative and changing attitudes

Although privatization is giving the private sector a leading role in mine development, the managers, engineers, workers, etc., who are involved with mining today will likely not change, even if the private sector takes over operations. Mining activities in a market economy are in a fiercely competitive environment and must respond appropriately to changes in mining industry conditions. Even today, people involved in the Serbian mining industry still have attitudes that remain from the Socialist era. Everyone at all levels-- federal, ministerial, research institute, (state-owned) enterprise, and individual levels-- must be instilled with an awareness of costs and competitiveness.

## 9.9 Database

As the Master Plan was taking shape, reports were made of information development and the expansion of the GIS database. If this database can be integrated with databases from each field, then it will be useful not only for the mining sector, but also for geo-science fields, land preservation, and other applications. Regarding future sharing of fundamental spatial information, some current issues and suggested improvements are listed below.

- Information sharing among government organizations is remarkably hampered, because of the government's vertical administrative structure caused by current laws. This can be remedied by promoting personal exchanges and information sharing through the reformation of organic laws
- Conversion of mapping coordinate system from Serbian local system to the world standard system
- The contents of the BRGM's database should be assessed and utilized effectively for projects such as "Metallogenetic and Minerallogenetic Geological Economic Estimation" and the "Strategy for Sustainable Development of Mineral Resources in Serbia".
- Basic geographical information of the MGI should be provided to the general public.
- There should be a clear definition of the role of the newly organized "Mining Agency".
- A new agency should be established for managing and operating digital archives.

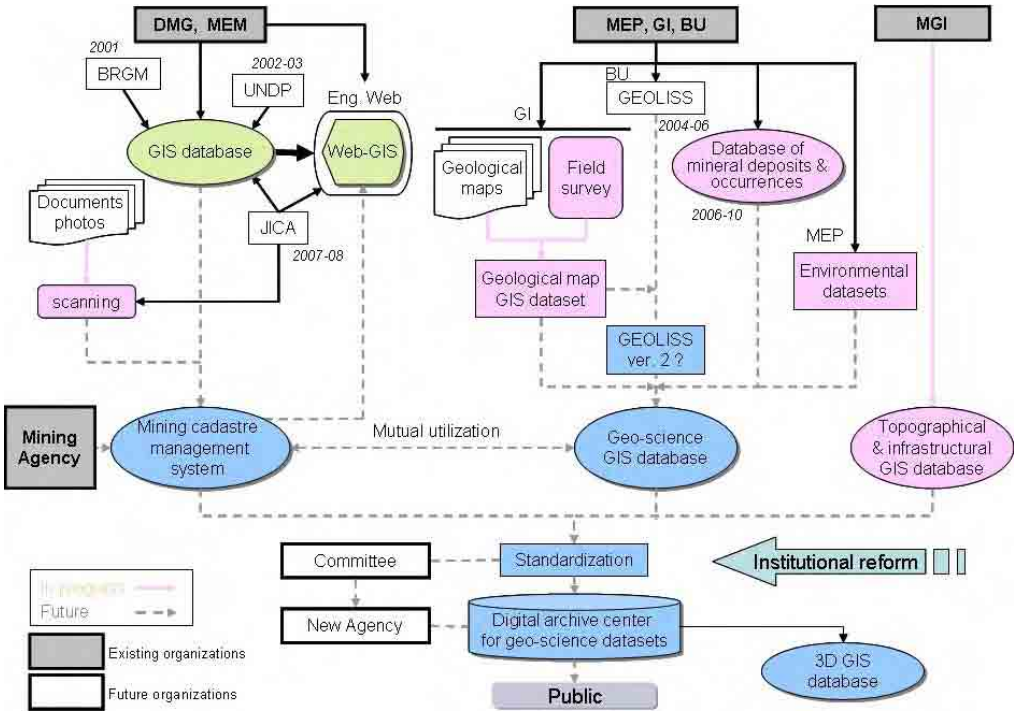


Fig.9.10 Construction and Strategic Flow of Geo-science GIS Databases

### (2) Future expansion of the MEM database system

Considering the current situation of GIS datasets and databases, future needs and usage,

some expansion projects for the coming 5 to 10 years are described below. Here, the three main driving projects, MODEL-A1, A2 and B, are shown based on the present system. MODEL-A1 and A2 are mainly approaches to the expansion of the BRGM's database and existing spatial information, as well as future integration with results from the GEOLISS project. MODEL–B involves the creation of a mining cadastre system including digitizing of the numerous historical mining license documents stored in the archives and the development of a field assistant system using GPS and Portable PC for mining inspection, and an information sharing system with the mining cadastre management system.

Driving projects

| **Database Integration: MODEL-A1** | |
|---|---|
| Contents: | Complete integration of the BRGM's database and MEM's existing spatial datasets through the creation of user-interface and renewal of contents of web-GIS |
| Project style: | A project for short-term dispatch of an expert team |
| Members: | 1) One mining system expert<br>2) Local consultant<br>3) One temporary counterpart of MEM |
| Duration: | One year |
| Budget: | US$100,000 |
| Requirements: | Cooperation & understanding of the MEM |
| **Development of mining cadastre management system: MODEL-B** | |
| Contents: | 1) Create a full-fledged mining cadastre system<br>2) Design and develop a field assistance device for mining inspections<br>3) Entry of historical mining license data (1960-1997) |
| Project style: | Financed by international assistance organizations (JICA, WB,...) |
| Members: | 1) Three experts (two mining system experts and one mining expert)<br>2) Two local consultants (one mining specialist and one IT engineer)<br>3) One counterpart of MEM |
| Duration: | Three years |
| Budget: | US$1,000,000 |
| Requirements: | Results of MEM pilot project conducted in 2006 |
| **Database update: MODEL-A2** | |
| Content: | Data updating by outputs from GEOLISS or other mineral resource database(s) |
| Project style: | Financed by the Serbian government |
| Members: | 1) One mining system expert<br>2) One counterpart from MEP or Belgrade University<br>3) One counterpart from MEM |
| Duration: | One year |
| Budget: | US$200,000 |
| Requirements: | 1) Reform of related laws and regulations (institutional reform)<br>2) Adequate mutual agreement and cooperation from MEM, MEP and MGI<br>3) Disclosure of fundamental geographic information (MGI) |

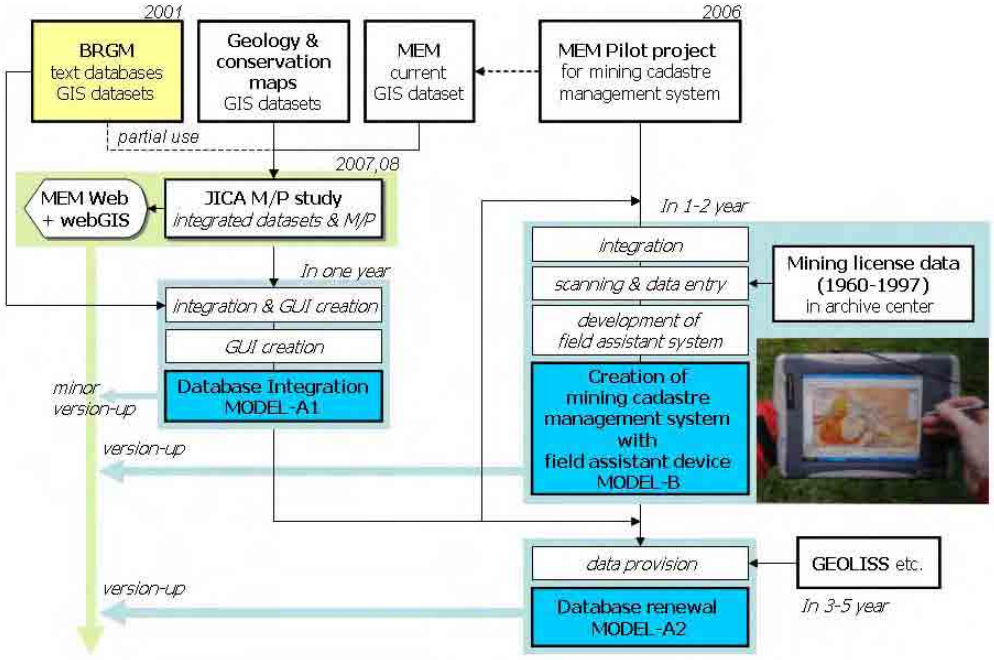


Fig.9.11 Flow of future MEM database

**(3) 3D-GIS database system**

As mentioned above, the creation of geo-science digital datasets is at the stage of two-dimensional digitizing in the geological mapping project based on the GEOLISS project. It will take at least 5 to 10 years to achieve dense coverage of geological and mineral resource information for the entire country. The progress should be accelerated by Serbia itself or with assistance from international assistance organizations to shorten the time to completion. After geological mapping, the next step shall be to develop an approach for three-dimensional GIS database expansion. In this study, we gathered information to investigate approaches for future 3D geological information construction during a visit to the British Geological Survey which has been dealing with such advanced approaches for some time. Based on the survey, general approaches for the construction of 3D geological and mineral resource information are discussed.

Establishing a committee such as a cross-government group is crucial for proceeding with this project. So, it may need institutional change through legal reform. At the same time, it is important to enhance skills and increasing geological engineers especially at the Geological Institute. From a technical point of view, it is also crucial to start this challenging approach as a collaborative project, inviting experts from advanced international institutes or organizations to help maintain international standards for geological information management, and undertake the framework projects effectively. Fortunately, the GEOLISS project, which is designed to standardize geological data, is being conducted in Serbia with an international organization, IUGS, and the key members of the GEOLISS project are making a great contribution toward the development of 3D data structure, designing, and programming. The project should last at least 5 years**.**

**【End of Final Report Summary】**