## 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) in the Ministry of Energy and Mining (MEM) 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, the MEM began converting all mining and geological exploration and exploitation datasets into a digital database through the framework of the CISGEM project. In the same year, a text-based mineral resource database was created with GIS datasets through a project supported by the French Bureau of Geological and Mining Research (BRGM). This was the first step towards construction of a GIS database in the mining section of MEM. In 2002, a capacity building project was created by the United Nations Development Program (UNDP) to implement GIS software and training. Other pilot projects for GIS applications such as web-GIS and a management system for mining rights, have also been started recently.

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. The project has benefited from the knowledge acquired by the BRGM through its scientific research project entitled "GIS Central Europe" as well as from various expert assessment missions to the Balkans during the period 2000 to 2001. The information compiled in the Balkans has been disclosed through a web-base GIS (http://giseurope.brgm.fr/).

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 GeoInstitute (former Geological Institute). The databases comprised information on mineral deposits and districts, which is stored in text-based databases and GIS (originally MapInfo). Opening windows of the mineral deposit and the mining district databases are shown in Figure 5.1. Datasets are stored in three languages: French, English and Spanish.

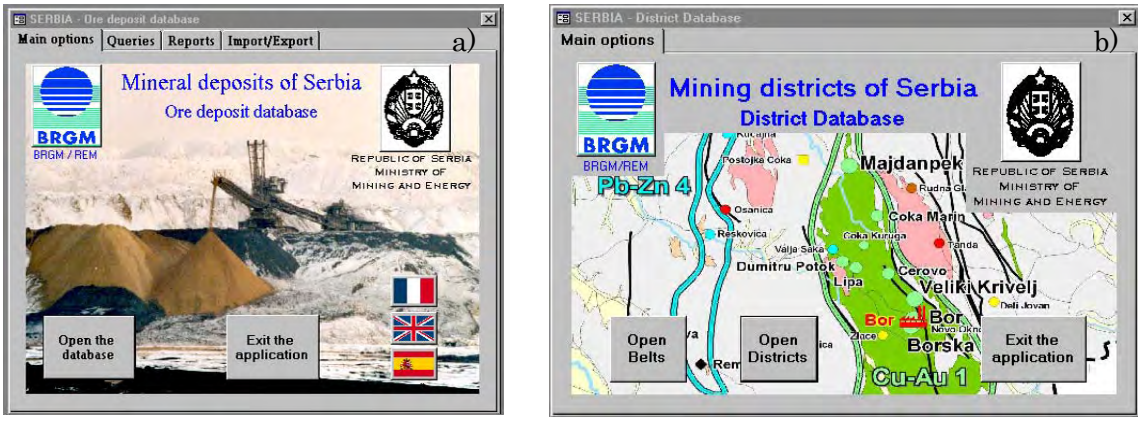



Fig.5.1 Databases Created by BRGM (a) Mineral Deposit Database, (b) Mining District Database

These text-based databases are created and customized based on Microsoft Access, and their general contents are listed in Table 5.2. Table relationships of the mineral deposit and district databases are shown in Fig.5.2. In addition to the tables, 17 reference tables have been prepared for the mineral deposit database and 7 tables for the district database to define the terminology. The structures of the tables for the mineral deposit database and for the mining district database are shown in Appendices I 4(1) and 4(2).

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 |

Besides the text-base databases, the BRGM has compiled GIS-based (MapInfo and ArcGIS) 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 country's main mining districts, are plotted on topographic and simplified geology maps. The spatial datasets are plotted on maps with a projection system of Transverse Mercator, spheroid NAD 27 and ellipsoid Clarke 1866.

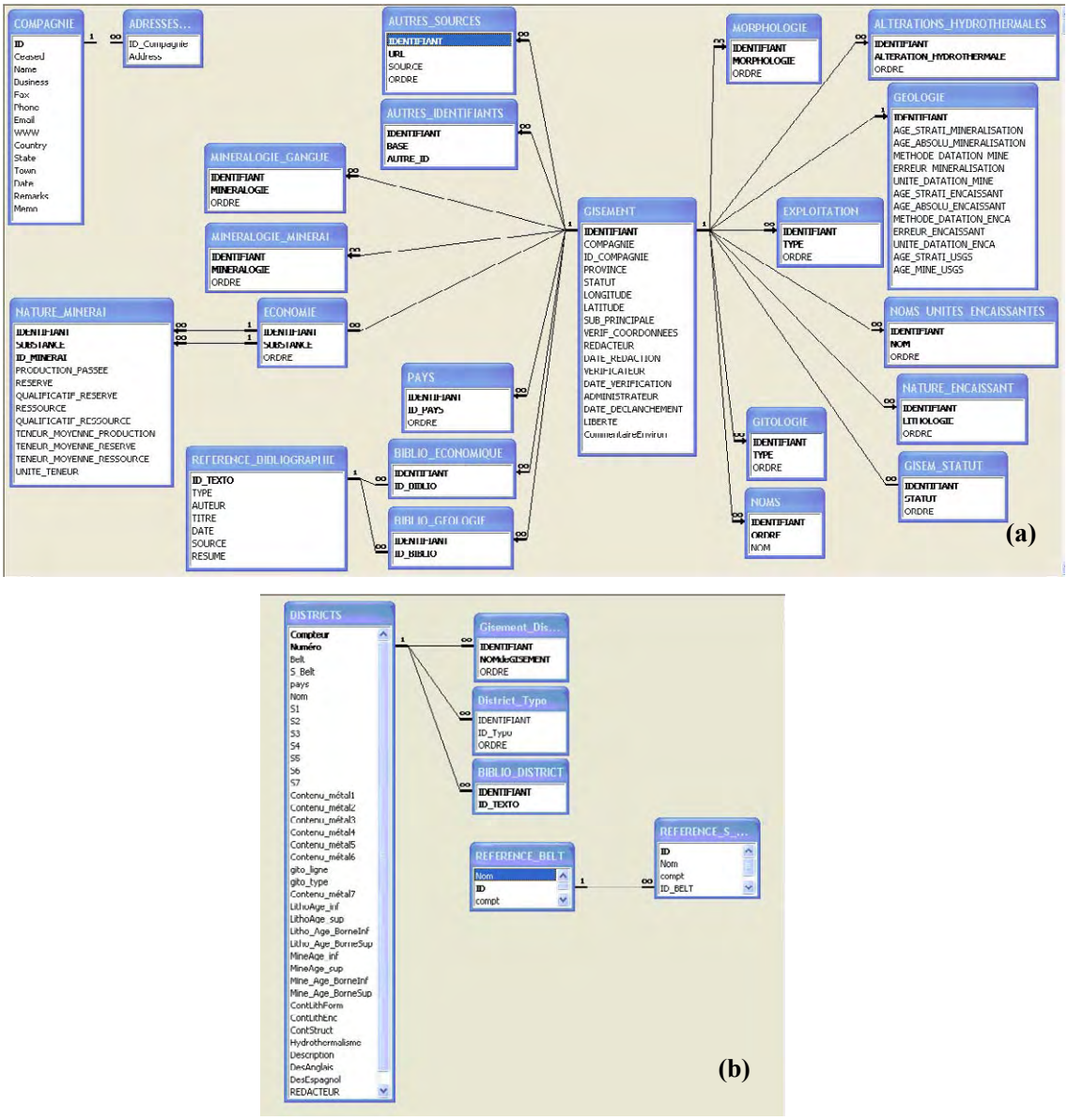



Fig.5.2 Table Relationships in the Databases Created by BRGM

(a) Mineral Deposit Database, (b) Mining District Database

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

① The compiled datasets in the BRGM's databases are not stored in current GIS database of the MEM but they should be integrated.

② Since the stored datasets in the database such as ore reserves and minerals shall be checked, adequate assessment and amendments will be required in subsequent studies.

③ Projection system used in the GIS datasets should be converted to either WGS84, the world standard coordinate system or Gauss-Kruger（datum : Hermannskogel old Yugoslavia）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 and stored in more than 70 layers (Fig.5.3). Although the level of accuracy for the base-maps is not adequate for micro-location planning, it is sufficient and suitable for basic overview of infrastructure related to mineral resources prospects. A set of Digital Elevation Model (DEM) data files by the Shuttle Radar Topography Mission (SRTM) with 90m intervals and Landsat-TM mosaic imagery have already been entered into the database. The satellite datasets comprise only three channels for background images, and are not available for imagery processing for geological exploration. Table 5.4 shows the system management of the GIS database at the MEM-DMG.

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: administrative boundaries, power stations & lines, hydrography, roads, railways, transportation & communication networks, cultural heritage, populated areas, river-networks, contours, economy, toponyms, tourism, vegetation, etc. | Exist (purchased from MGI)<br>More than 70 layers |
| Tailings dam sites | Exist |
| Monitoring data for mining pollution | Exist |
| DEM | Exist (SRTM: 90m intervals) |
| Satellite imagery | Mosaic Landsat TM（3 bands） |

Table 5.4 System Management for the Current Mineral Resources GIS Database at the MEM-DMG

| Item | Status |
|---|---|
| GIS core system | ArcView, ESRI |
| Database management software | Access, Microsoft |
| Web-publishing software for maps, data and metadata | ArcIMS, ESRI |
| Intranet | Networking<br>Stand-alone usage for database and GIS |
| Web GIS server | None |
| Data entry of mining licenses and mineral resource information | Two or three staff members at the MEM |
| Editing of spatial information | One staff member at the MEM |
| Construction and revision of database | Out-sourcing to domestic GIS consultant |

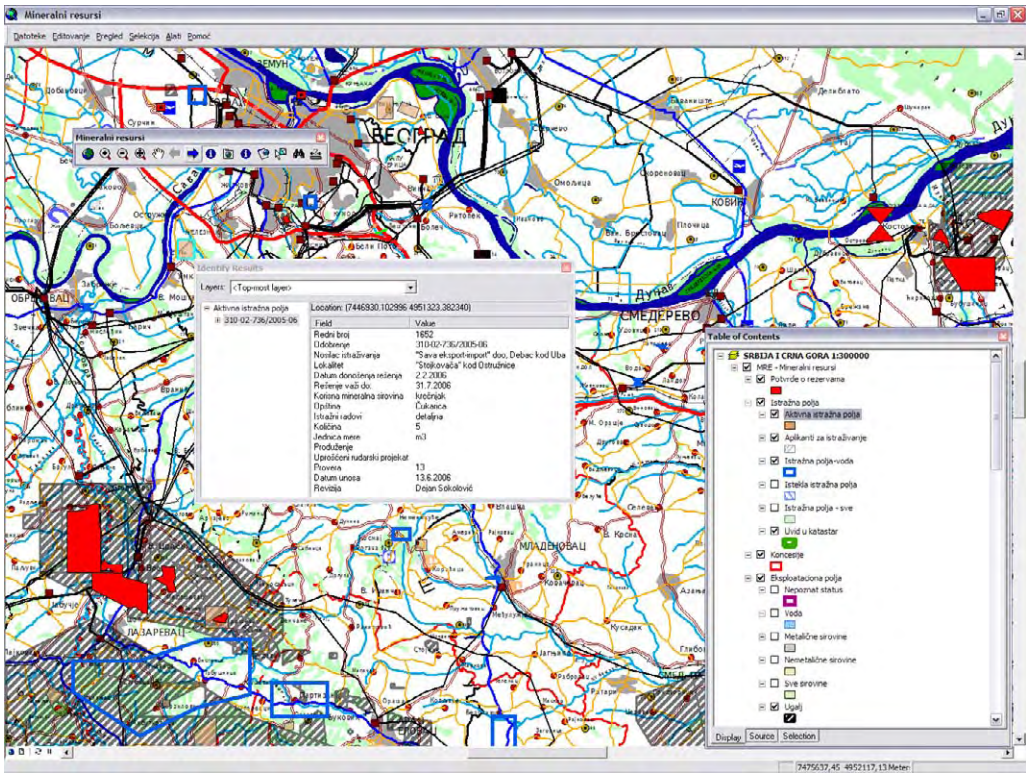



Fig.5.3 A view of the current GIS database at the MEM

## 5.2 MEM Website

### 5.2.1 Former MEM Website

The MEM website (http://www.mem.sr.gov.yu/) provides information on mining-related and energy sector activities in Serbia. Fundamental mining information such as government announcements, mining policies, related laws and regulations, taxes, organizations, active state/private companies, etc., are provided, and 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, for instance, geology, distribution of 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 updating and expansion of the MEM's mining sector website, the MEM and the JICA Study Team agreed to construct an English MEM website. The general contents are listed in Table 5.5. The general concept of the planned English version of the MEM website is shown in Fig.5.4.

Table 5.5 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. |
| 2 | Translation | ・ Translation of the present Serbian pages into English.<br>・ Links to Serbian descriptions of related laws and regulations (shift those links to English translations of laws and regulations as they become available). |
| 3 | Web-GIS | ・ Development of web-GIS for publication disclosure of spatial datasets, such as related maps, from user-oriented point of view.<br>・ The web-GIS site was developed based on the pilot web-GIS by the MEM, adding various kinds of tools and buttons for web-GIS operation, which allow users to interactively draw points and polygons with additional attributes on the top of main map such as topographical and geological maps.<br>・ Locations of GIS datasets on maps were converted on the WGS84 world standard coordinate system.<br>・ A new pop-up window for web-GIS, a web-GIS portal site, accessible from the current web-page, was developed.<br>・ Two web-GIS windows, "Quick web-GIS viewer" and "Full version of web-GIS", are designed.<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 providing user-friendly help windows for web-GIS beginners<br>・ Licensed mining areas are shown in the web-GIS window by points for each area requested from the MEM.<br>・ Domain name of the web-GIS service: www.serbia-mining.info |
| 4 | General instruction for mining activities | Based on discussions with the MEM, user-friendly information about mining laws and related regulations for foreign and domestic companies was included. |
| 5 | JICA report | The JICA final report was presented on the webpage as a third-party evaluation of Serbia mineral potential and the state of mining activity. |
| 6 | Links | Based on the results of the JICA study and related information introduced by the MEM and the MEP, links with other related sites will be added. |
| 7 | Web-server | Lease is effective through February, 2008 |

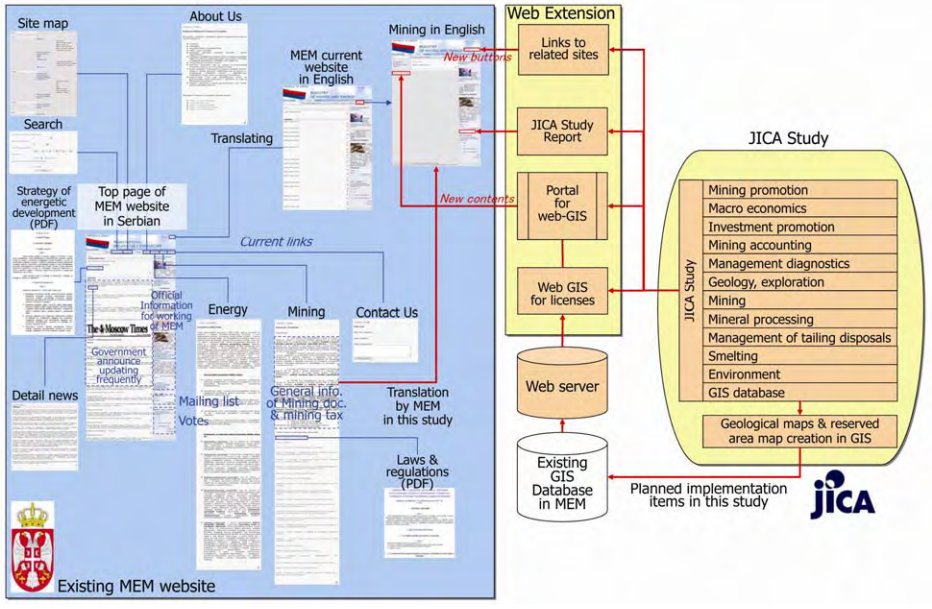



Fig.5.4 General Concept of the Planned MEM English Website

Through this study, the quality and quantity of the web site have been improved dramatically by creating an English version, updating the Serbian version and creating web-GIS. A comparison of the MEM web contents (fundamental items for government mining sites) before and after this study are shown in Table 5.5, with reference to Wada et al. (2006). Here, since there was no English content before this study, I used some Serbian version contents for comparison.

Table 5.6 Development Status of Mining-related Information on the MEM Website

| Item | State of the MEM website before this study | Current situation |
|---|---|---|
| Mining Policy | Existed, but could be confused with unrelated information | Stores it in an appropriate location |
| Mining law and related regulations | Existed, but no appropriate instructions on procedures for users | Groups laws & regulations, and shows laws in English and new guidelines for investors |
| Database of mineral resource information | None | Stores it in "Web-GIS" |
| Existing geological and topographical maps and their procurement methods | None | Stores in "Web-GIS" (1/500,000 geol. maps)<br>Puts some docs for procurement |
| News & government announcements | Existed, but no fresh information | Refreshed in "NEWS" |
| Environmental information | No link to the MSEP site | Links to the MSEP site |
| Mining license areas | None | Provided in "Web-GIS" (dots as areas) |
| Conservation and restricted areas | None | Provided in "Web-GIS" |
| Background information such as infrastructure data | None | Provided in "Web-GIS" |
| Support from international organizations | None | JICA, (BRGM, UNDP, EBRD etc., planning) |
| Reports by third parties | None | Stores the final report & various supplements of this study |
| Links to related organizations | None | Links |
| Address | Existed | Adds a map (planning) |
| Retrieval tool | Existed | Adds new tool in "Web-GIS" |
| Web management | Managed by IT engineers at the MEM<br>Appropriate check flow for content revision and uploading exists | |
| Language | In Serbian (English version was under construction) | In Serbian & English |

A snapshot of newly designed English MEM website is shown in Fig.5.5. The portal website of web-GIS developed in this study is linked on the current MEM website as shown in Fig. 5.6. As information volume stored in web-GIS is huge, it might be a popular apprehension that so-called web-GIS is slow even in broad-band circumstance. We provided two kinds of web-GIS windows in this site, which are a "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. This 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 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. A snapshot of the quick web-GIS viewer is shown in Fig.5.7. 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.5.8. 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 simplify datasets and database structure to maximize retrieval and plotting speed of web-GIS datasets, and this web-GIS has comfortable response circumstances compared with existing web-GIS websites. This website has been updated and improved in the cooperation of a JICA expert and MEM staff members in this study, and web-GIS was opened to the public in January in 2008.

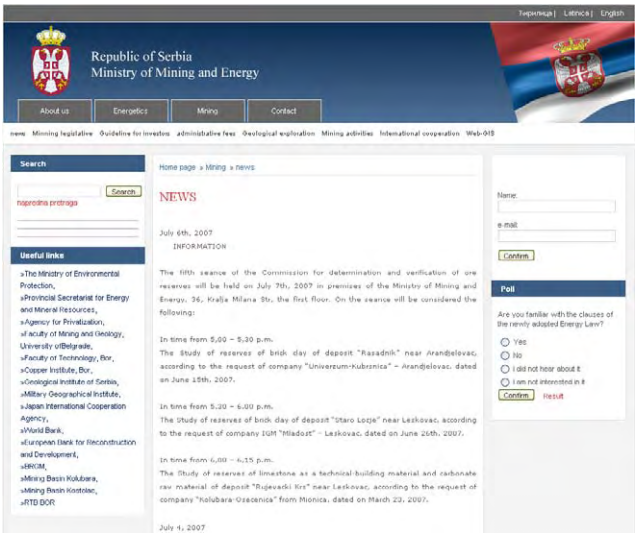



Fig.5.5 Website of MEM-DMG

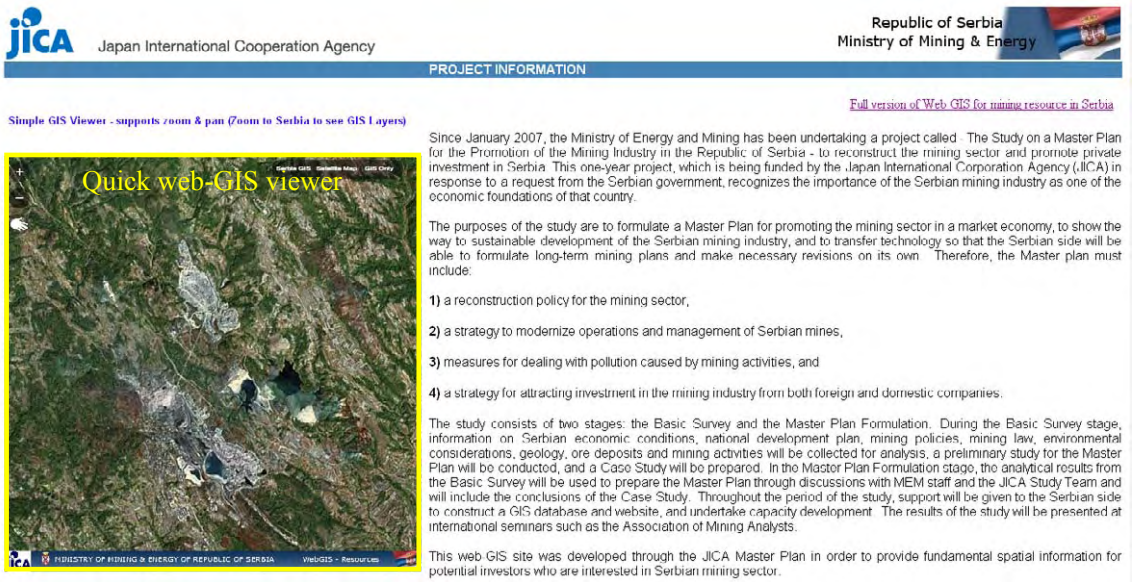



Fig.5.6 Portal Site for Web-GIS

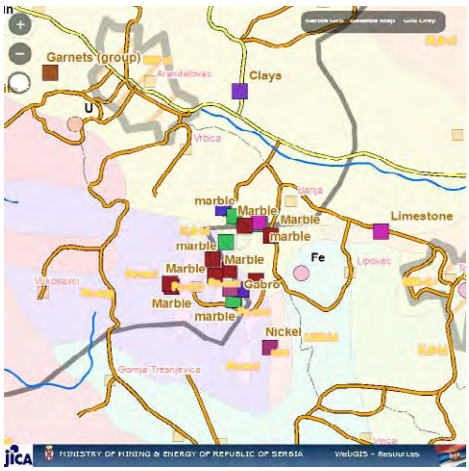



Fig.5.7 Display of Web-GIS by Quick Web-GIS Viewer

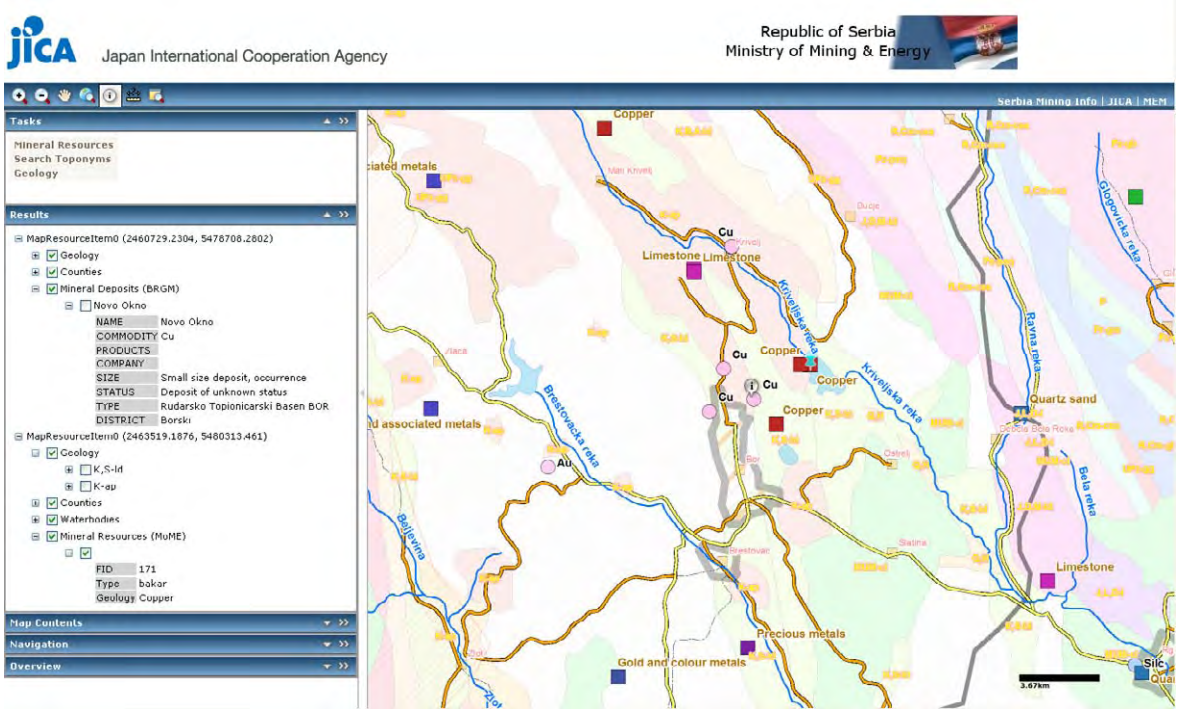



Fig.5.8 Geology, Road Network and Mining Information on the Full Version of Web-GIS Window

### 5.2.3 Web-server for the MEM

Web contents for the MEM are stored at a server of the InfoSky. The contents are supposed to be transferred to a server in Electronic Computing Center or ISP 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 is supposed to be made up to February, 2008, and then will be transferred to a new server which is planed to 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. Probably, almost of all the contents will be transferred the government's servers during the fiscal year of 2008 and will be opened again (Fig. 5.9).

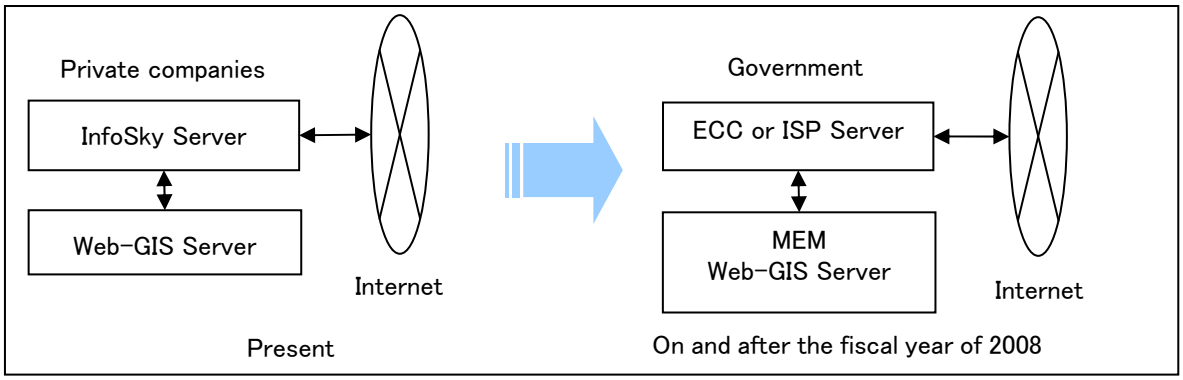



Fig. 5.9 Current and Future Web-Servers

### 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

As the first step toward the construction of a geological information database, the MEP started a three–year project, from 2004 to 2006, to design a database structure for future geo-science information. With financing of 125,000 euros, the Faculty of Mining and Geology of the University of Belgrade completed the project, called "The Geological Information System of Serbia", or GEOLISS. The details are available on the project website (http://www.ekoserb.sr.gov.yu/). Involved with the development of GEOLISS are the Faculty of Geology and Mining of fundamental items for mining sites the University of Belgrade and the Geological Institute, but not the MEM.

The purpose of GEOLISS is to establish an integrated geo-science database including not only geological and mineral resource information, but also hydro-geological and geo-technical information. The project has been carried out through an international project for international geological data exchanges (https://www.seegrid.csiro.au/twiki/bin/view/CGIModel/WebHome) supported by the International Union of Geological Sciences (hereafter, IUGS), which has the world standard of database frames. Table 5.7 provides an overview of the general content. Based on the structure of GEOLISS, the Geological Institute has started to create new 1:50,000 geological maps covering the Uzice, Kladovo, Zajecar, and Prijepolje areas with additional geological field surveys. One example of a GEOLISS operation view is shown in Figure 5.9, and selecting dataset in each theme in a management tool, related information can be seen in the pop-up window.

Table 5.7 Current Situation of Establishing a Geo-science Database Based on GEOLISS

| Items | Contents |
|---|---|
| Objective | Establishing of integrated geo–science information database including not only geology and mineral resources, but also hydro–geological and geo–technical datasets. |
| Stored datasets | ・ Geology, mineral resources, tectonic, boring, geo–technical datasets<br>・ Natural disaster data (landslide, erosion, rock fall), possible to enter, but no data at this moment<br>・ Remote sensing dataset (aerial photos, satellite imagery): Landsat imagery at the Geological Institute<br>・ Topographical data, contours, networks of roads & rivers, infrastructural data: none<br>・ Forestation data: none<br>・ Restricted areas, national parks: none<br>・ Environmental data (water quality, air pollution): no plan<br>・ Mining cadastre datasets: possible, but no data<br>・ Scanned images of referenced academic papers: none |
| Current data volume | ・ Geological Institute: started 1:50,000 Geological map creation (Uzice, Kladovo, Zajecar, Prijepolje areas)<br>・ MEP: two geological maps<br>・ Faculty of the Mining and Geology: two geological maps |
| Database structure | GEOLISS: Geological Information System of Serbia |

| | |
|---|---|
| Plan for integration with the other databases | Datasets of mineral deposits and occurrences metallic and non-metallic mineral resources produced from a project "Prognosis Metallogenetic Geological Economic Estimation of Metallic Mineral Resources and Reserves in Serbia" stated in the next section will be stored in GI |
| Projection & coordinates | Projection : Gauss-Kruger<br>Geographic coordinates : Hermannskogel old Yugoslavia |
| Roles of organizations | MEP: owner, potential user<br>Geological Institute: user<br>Faculty of the Mining and Geology, BU: developer (system design, programming,..), potential user |
| Languages | English and Serbian |
| Utilized software | GIS system: ESRI ArcGIS9.2<br>Database: ESRI ArcSDE<br>DB server: Microsoft SQL Server |
| Related website | http://www.ekoserb.sr.gov.yu/ |

Some of the results can be seen through web-GIS (Fig.5.10) at the GEOLISS site developed at Belgrade University. Though GEOLISS datasets are stored in servers in the MEP, Faculty of Mining and Geology, Belgrade University and Geological Institute, these servers are not connected through LAN at present time.

The GEOLISS has a structure that contains not only geology and mineral resource, and boring datasets, but also natural disaster datasets such as landslides, rock fall and so on. It is also possible to enter other datasets and GEOLISS could become the backbone of geo-science databases in Serbia. 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 Faculty of Geology and Mining of Belgrade University and at the Geological Institute, and proceeding of data-entry and training are very limited in Geological Institute and the Faculty.

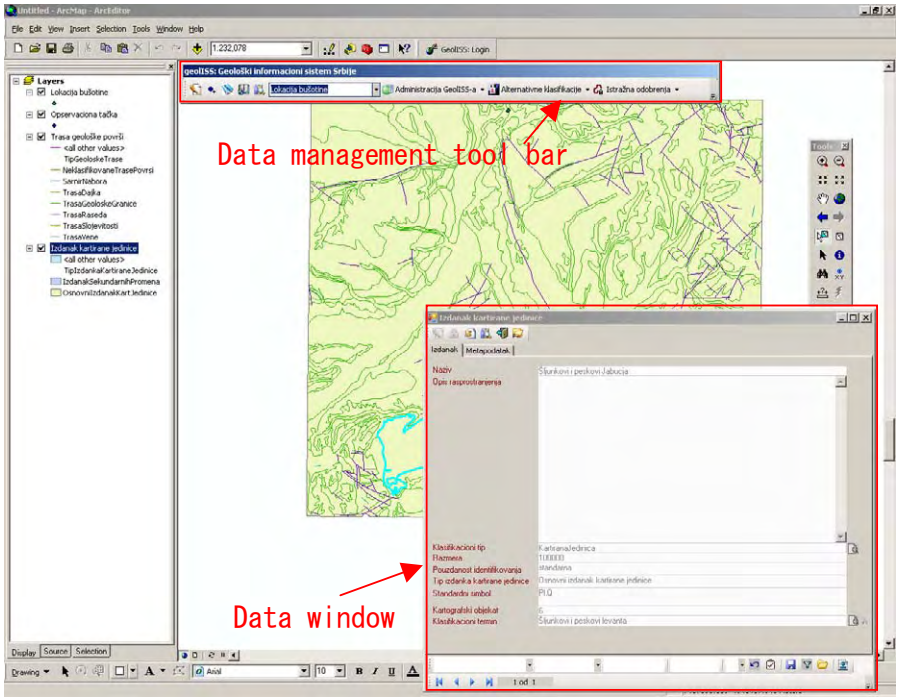



Fig.5.10 Operation Windows in GEOLISS

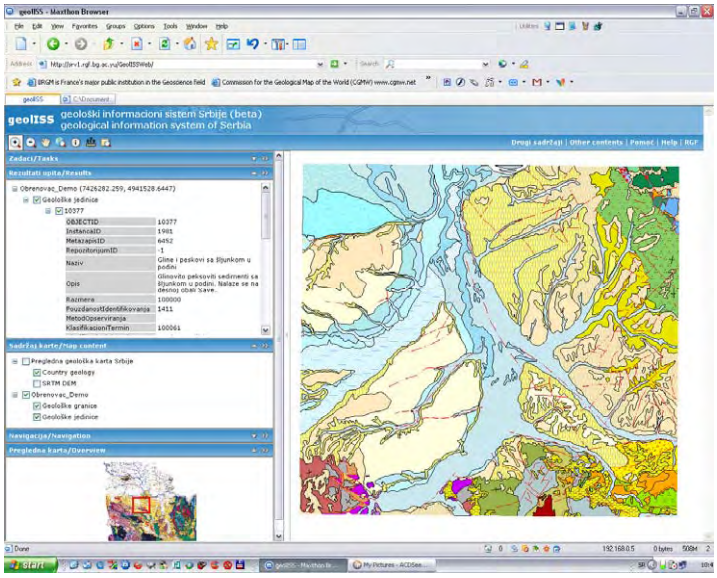



Fig.5.11 Website providing GEOLISS Information

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

The MSEP started two projects; the "Prognosis Metallogenetic Geological Economic Estimation of Metallic Mineral Resources and Reserves in Serbia" project and the "Prognosis Minerallogenetic and Geological Economic Estimation of Non-metallic Mineral Resources and Reserves in Serbia" with approximately 1.75 million euros for 5 years (from 2006 to 2010), in cooperation with the Faculty of Mining & Geology of the University of Belgrade (Prof. Rade Jelenkovic) and the Geological Institute. In these projects, one of the themes is "Database of Mineral Deposits and Occurrences of Metallic and Non-metallic Mineral Resources of Serbia" (Subject 6). Ore deposits and mineral occurrences for metallic (about 900) and non-metallic (about 600) resources will be stored in the database based on GEOLISS's structure. The general features of the database are as follows:

① Preview of geological exploration progress for metallic and nonmetallic materials – done.
② Review and analysis of geological assembly and evolution terrains of Serbia, focusing on ore formations and mineralization.
③ Definition of mineral genetic zones with ore potential areas. Creation of genetic models for mineral deposits.
④ Processing criteria for economic validity of mineral resources and reserves.
⑤ Processing indicators for sustainable development and use of raw minerals.
⑥ Creation of an ore deposit database.
⑦ Creation of a geological exploration development strategy and programs.

For conducting this project, in an annual budget of the MEP in the 2007 fiscal year, about 627 M Dinars, a budget for geological-related matters is appropriately 60 M Dinars, in which only 11 to 12 M Dinars in the fiscal year would be for this project (Table 5.8). Though the cost estimated by the Geological Institute for the project in 2007 is about 30 M Dinars, actual government budget is expected

to be at the same level as last year, and a large budget discrepancy will appear. Database creation will be included in (a) to (c) in the following Table.

Table 5.8 Budgets for the Project (unit：Million Dinars)

| Year | (a) | (b) | (c) | (c) | Government budget | | Estimation based on 2007 plan |
|---|---|---|---|---|---|---|---|
| | Metal | Non-metal | Fossil Fuel | Mineral Genetic | This project | Total in geological section | |
| 2006 | 2.2 | 4.6 | 0.8 | 3.1 | 10.7 | 55 | - |
| 2007 | ? | ? | ? | ? | 11-12? | 60 | 30 |

There are some issues with conducting the project in this calendar year, and it will be necessary to make a downward revision of specifications.

- A shortage of government funding (might be approximately one-third of estimated costs)
- Shortening of the term by delays of tenders and contracts will result in a total working time of only about three months, making it difficult to complete all of tasks planned by the Geological Institute.
- A lack of IT skilled workers for data conversion and creation of spatial datasets

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

This project was financed by the European Bank for Reconstruction and Development (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 Faculty of Mining & Geology of the University of Belgrade, the Geological Institute, and the MEM. It is currently in the final stage of data compilation.

As these projects are fundamental steps towards establishing a database which integrates the most accurate datasets, their final results will provide important and valuable information. Therefore, the MEM also needs to create a partnership with related organizations to advance future cooperative utilization of the database.

## 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. Table 5.9 lists paper-based maps produced by the Geological Institute.

As the Geological Institute is one of the governmental organizations which has started to utilize GIS technology, the technical potential there is very high. The Geological Institute is creating GIS datasets 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 for field surveys. The current state of the GIS database at the Geological Institute is as follows.

- Creating GIS datasets for two 1:100,000 metallogenetic province maps; 1:25,000 maps for one of the areas have already been completed.

- Converting four sheets of 1:50,000 geological maps to GIS datasets based on the GEOLISS structure (map names: Uzice 528-4, Kladovo 434-3, Zajecar 533-1, Prijepolje 578-1).
- Converting 11 sheets of 1:300,000 geological maps.
- Not proceeding with the creation of small-scale geological maps covering all of Serbia.

Table 5.9 Paper-based Geological Map Production by the Geological Institute

| Maps | Scale | Current status |
|---|---|---|
| Geological maps | 1:50,000 | 189 sheets covering all of Serbia, of which only two sheets have been completed:<br>Timocka eruptivna oblast (northeastern part; Bor district), and Surdulicki granodioritski masiv (southeastern part) |
| | | Prijepolje 578-2 in publication (near border with Montenegro) |
| | | Maps for Valjevo 478-4, Zvornik 477-2, Sabac 428-4 are in progress (northwestern area) |
| | 1:100,000 | 65 sheets covering all of Serbia |
| | 1:500,000 | 6 sheets covering the former Yugoslavian territory |
| | 1:2,000,000 | 14 sheets completed (9 sheets published) |
| Mineral deposit map | 1:200,000 | In progress （No published version） |
| Environmental geological maps | 1:2,000,000 | Completed |
| Hydro-geological and hot spring maps | 1:500,000 | Hydro-geological maps and geothermal maps consisting of 6 sheets each |
| Magnetic anomaly maps | 1:500,000 | Internal use |
| Gravity anomaly maps | 1:500,000 | Internal use |

### 5.5 Topographical Maps by the Military Geography Institute

Serbian topographic maps including the Kosovo area produced by the Military Geography Institute (MGI) under the Ministry of Defense and are listed in Table 5.10.

As shown in this table, the local geographic coordinate system has been used for topographical maps, but now a new pilot project for 1:250,000 maps has started to convert to the world standard coordinate system, WGS84. In geodetic surveys in Serbia, GPS measurement technology is widely used now, and numbers of the 1st and 2nd order measurement points in Serbia with Kosovo area are 28 and 900, respectively.

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. In order to promote investment in mining and stimulate economic activity, it will be necessary to reform the law to increase the freedom to utilize fundamental information.

Table 5.10 Current State of Topographical Maps and GIS Management

| Scale | Map Name | No. of Sheets | Projection | Ellipsoid | Current state of GIS datasets |
|---|---|---|---|---|---|
| 1/25,000 | TK25/III | 732 | GK[1] | BS[4] | Completed DEM （25m interval） and TIN datasets based on these maps in 2005. GIS dataset development for the other datasets is in progress. |
| 1/50,000 | TK50/II | 203 | | | Only raster datasets except for GIS datasets of stream networks |
| | KVO50 | 201 | | | Thematic maps (watersheds) |
| 1/100,000 | TK100/II | 61 | | | Only raster data |
| 1/200,000 | TK200/II | 22 | | | Only raster data |
| | VVK200 | 22 | | | Digital navigation maps for the air force |
| 1/250,000 | TK250 | 14 | UTM[2] | WGS84 | GIS datasets only for topographical data, 2 sheets completed; all sheets will be completed by Nov. 2007 |
| | VVK250 | 14 | | | Digital navigation maps for ground type will be completed in 2007 |
| | VVK250 | 14 | | | Digital navigation map for the air force will be completed in 2008 |
| 1/300,000 | PTK300 | 13 | GK[1] | BS[4] | GIS database (14 layers, 69 sub layers) completed, overview of topographical maps |
| | RK300 | 13 | | | Relief chart (3D) |
| 1/500,000 | PTK500 | 2 | LCC[3] | | Only raster data |
| | VVK500 | 4 | | | Raster, for air force navigation |
| | SK500 | 2 | | | Road maps |
| | RK500 | 2 | | | Relief charts (3D) |
| 1/1,000,000 | OGK1000 | 1 | | | GIS datasets (the first GIS datasets at the Institute) |
| 1/1,500,000 | GK1500 | 1 | Polikonusna | BS[4] | Geological charts |
| | RK1500 | 1 | | | Relief charts (3D) |

[1] GK：Gauss-Kruger [2] UTM: Universal Transverse Mercator [3] LCC: Lambert Conformal Conic [4]BS: Bessel 1841

## 5.6 Current IT Utilization at Bor

### 5.6.1 Copper Institute

#### (1) General Information

- The Copper Institute will be a state-owned company soon (permission is at a final stage now).
- There are four major departments for mining activities: Geology Department, Mining Department, Metallurgy Department, and Chemical Control Department.
- There are also an Information System Department and an Industrial Information Department at the Institute which provide IT support for the Institute and RTB Bor, and also provide database-consulting, network design and a variety of IT training courses to the public.
- There are currently about 200 employees of the Institute Main Office.

- There are 5 members in the Industrial Information Department.
- There are 14 university-educated programmers and system engineers.
- There is no geophysical exploration by the Copper Institute and no geophysicists.

**(2) Current State of IT Utilization at the Copper Institute**

The current state of IT utilization in the Copper Institute is summarized in Table 5.11.

Table 5.11 Current state of IT implementation at the Copper Institute

| Item | Installed software/type of PC | Issues/Training/Planning |
|---|---|---|
| LAN/Mining facility control | ・ LAN of 2–3 Mbps is installed in 5 production plants and the main office. Each production plant also has a LAN which is connected to the industrial distributed control system (IDCS). The system is used to control the most important production sites, and monitor various processing parameters (temperature, pressure, flow and so on).<br>・ There are monitoring systems for air pollution and water quality. The monitoring system for air pollution has three stations in Bor city and were established in 2003 (two sites financed by the UNEP and one site by the MEP) and the observed data is checked with process parameters of metallurgy to evaluate the relationship between smelting activities and air pollution. On the other hand, water quality has been monitored manually, with no automated system. | ・ There is currently a lack of modern devices and funding at the Institute, and monitoring and control systems for production plants have been designed and programmed at the Institute using analog devices. |
| Internet | ・ LAN at the Institute is connected to the Internet through a dedicated 128 kbps line via Post Office Internet Provider | – |
| Calculation of ore reserves<br><br>Optimization of mining activity | ・ A Mining Management software, *GEMCOM Surpac* ver.1, was first introduced for block modeling and estimating ore reserves in 1997. The system was upgraded to version 6.1 in May, 2007.<br>・ Two sets of *GEMCOM Surpac* (the latest version 6.1, Canada) are installed with one set for the Mining Department and one for the Geology Department. Operators of *GEMCOM Surpac* are 3 staff members in the Mining Department, 2 in the Geology Department and 2 in the Marketing and Engineering Department.<br>・ 2D Geologic Database Management System, *GDM* (French, BRGM), is also used (to calculate ore reserves, for example).<br>・ The *GEMCOM Surpac* has been used in the Department of Mining to create block models based on drilling and geological information.<br>・ *GEMCOM Whitlle* is also used for mining optimization and "*GEMCOM Minex*", a separate software for stratigraphy deposits, is used spatially for coal deposits.<br>・ *GEMCOM* is accessible to *Microsoft* | ・ The Institute might have a chance to become a distributor of *GEMCOM* products in Serbia.<br>・ The Institute trains not only its own staff members, but also employees RTB Bor and other organizations from all parts of Serbia. |

| | | |
|---|---|---|
| | *Access* and *SQL* databases. | |
| Geological mapping | ・ Geological maps and sections are made using *AutoCAD 2006* based on geological surveys by the Geology Department (5 engineers and 1 technician). The prepared datasets are uploaded to the *GEMCOM Surpac* for block modeling.<br>・ Geological maps with scales of 1:10,000, 1:50,000 (paper-base) and 1:100,000 (as scanned JPG files), are provided by the Geological Institute. These maps are used as base maps.<br>・ There are no crucial needs for GIS in the Institute. | ・ Geological maps from the Geological Institute are provided and staff members have no needs for surface geological mapping.<br>・ There is one GPS in the Geology Department, but more GPS are needed. |
| Database | ・ *Oracle* is used to manage financial reporting including business control. | ・ The Institute is an authorized organization for *Oracle* and Microsoft Products in Serbia. |
| PCs | ・ OS: Windows (UNIX has been used, but it's rare now)<br>・ There are more than 150 PCs at the Institute, and they have been installed and maintained by 6 staff members of the Information System Department. | ・ Some of PCs should be upgraded. |
| Other peripherals | ・ They have A3 size ink-jet color printer in the Information Department.<br>・ There are two A0-size plotters; one in the Mechanical Electricity & Architecture Department and the other in the Marketing & Engineering Department. | ・ An A0-size scanner is now needed in the Geology Department, and will be installed in a few months |

**(3) Assessment and Issues Resolved**

- Copper Institute staff has utilized IT for various fields on their own initiative in spite of the lack of funding.
- 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 around/in the mines and tailing dams
- A fundamental information network has been established and is maintained appropriately.
- 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.
- IT should be incorporated into geological mapping in order to enable more cost-effective exploration, using the full power of mining management software and related applications.
- Continuous upgrading and procurement of basic IT equipment such as PCs and GPS should be made.
- There is a high ability to develop and utilize the database system, which is making a significant contribution to various operations.
- The IT group at the Institute has the potential to expand its IT business not only for mining but also for other fields.
- The Institute provides RTB Bor staff with practical training in IT applications.

### 5.6.2 RTB Bor

**(1) General Information**

- RTB Bor is comprised of the following three companies:
  - ① The Bor Copper mine: RBB located in Bor City
  - ② The Majdanpek Copper mine: RBM located in Majdanpek City (80 km north of Bor city)
  - ③ The Copper Smelter: TIR located in Bor city
- The web site for RBB (http://www.rbb.co.yu/) has been suspended because the web content was moved to a new server at RBB. It is operated by the Data Automation Department.
- Mining equipment procurement has the first priority at RBB at this time, and the replacement of software and PCs has been delayed in spite of the demand for it.

**(2) Current Situation of IT Utilization at RBB Bor**

The information network of RBB Bor, the Copper Institute and related organizations (as of Oct.2007) is shown in Fig.5.12.

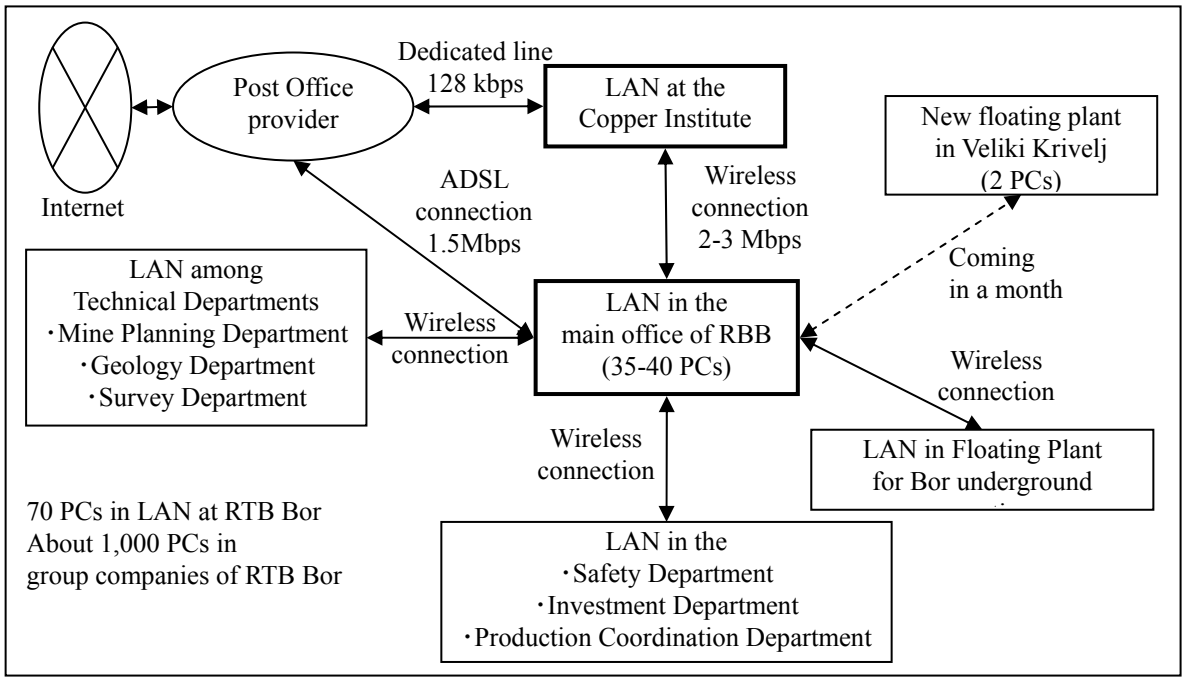



Fig.5.12 Information Network among RBB and Related Companies and the Copper Institute

Table 5.12 Current State IT Implementation at RBB

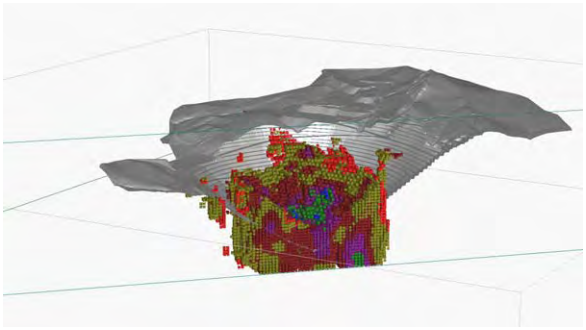
| Item(s) | Installed software/type of PC | Issues/Training/Planning |
|---|---|---|
| Calculation of ore reserves<br><br>Optimization of Mining activity | ・ *GEMCOM Surpac* (version 1.0) has been used for annual planning of exploitation in short-term strategies based on drilling data, lithology models (geology) and block models (long-tem strategy is by the Institute).<br>・ There is only one operator for the system now.<br>・ Block model: 15m x 15m x15m (caused by used machinery's size), 47 levels, 250 rows and 150 columns<br>・ Block models are created based on 90,000 drilling data and 3 levels of underground drifts for exploration.<br>・ Results estimated by the block model are compared with actual drilling data, and adequate fitting with its reality (on a level of +/-5 percent error)<br>・ *GEMCOM Whitlle* is also used for mining optimization | ・ Upgrades of *Surpac*: RTB Bor and the Copper Institute have purchased *GEMCOM Surpac* version 1. However, because of a lack of funding, no upgrading has been done at RTB Bor yet. Requests have been made already, though.<br>・ Training of *Surpac*: Training required for 2 surveyors, 2-3 geologists and 2-3 mining engineers who are potential users.<br>・ Updating of modeling: Because of a lack of manpower for *Surpac* operation, updating of block models has been suspended for two years.<br>・ Currently new block models are being created for the Borska Reka deposit, underground in Bor, and the Cerovo deposit (20km from Bor). |
| Geological maps | ・ Geological maps are hand-drawn based on field survey, and are compared with results of *GEMCOM*.<br>・ Although a package for geological mapping in *GEMCOM* exists at RTB Bor, there are no operators.<br>・ GIS has not been used and there are no requests for geological mapping. | ・ Geological mapping has been done manually, because of limited understanding of GIS capabilities and lack of operators who can use the mapping tool *GEMCOM* |
| Mining facility control | ・ Mining facilities are controlled by a system developed by RBB and the Institute | - |
| Surveying | ・ "Total station" for surveying is being used, and measured data are downloadable to PCs and its datasets are drawn on scanned maps.<br>・ GPS surveying is occasionally made by a survey company in Belgrade. However, it is in only special.<br>・ *AutoCAD* is used for managing data for surveying. | ・ An operations flow from digitizing of survey data to entry of *Surpac* has been established |
| Database | ・ *Oracle* is used for managing all production plants, stock, spare parts and consumption materials for production, and also for accounting. | - |
| Other peripherals | ・ Although peripherals have been installed, there is demand for installing a digitizer | ・ Considering the future usage, an A1-size scanner will be more cost-effective.<br>・ The lack of strong demand for peripherals is due to the limited number of operators of *Surpac* |

**(3) Assessment and Issues Resolved**

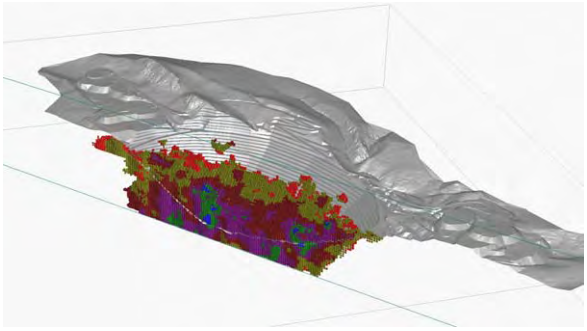
- Block models of each deposit have been made sequentially and used effectively (Fig.5.13).
- Mining management software should be upgraded as soon as possible.
- RBB is greatly reliant on IT technical support from the Copper Institute.
- Digitization of geological data should be also made, and the data should be stored in a mining management system for integrated data management.
- Internal nurturing of operators for the mining management software or recruiting young IT

engineers should be started immediately.

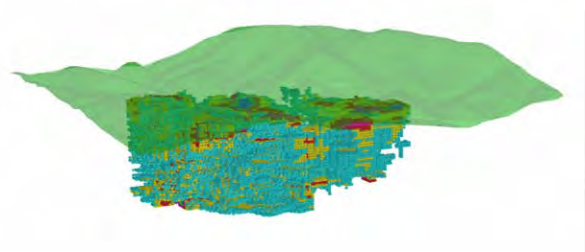
- Purchase of peripherals should be made based on sufficient consideration and planning of future IT usage.



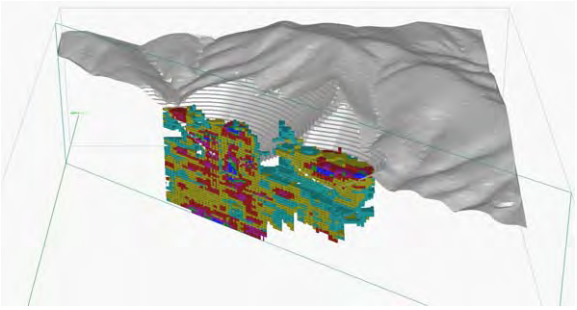
a) A section of block model for the Veliki Krivelj deposit



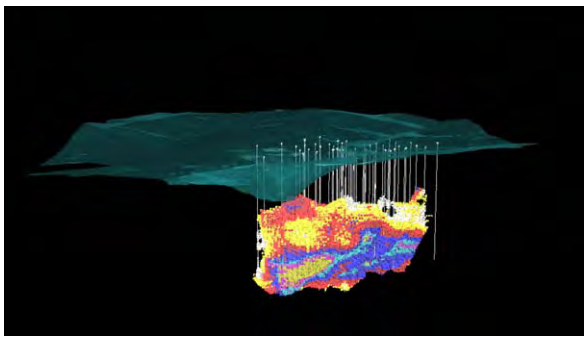
b) Open pit and block model and for the Veliki Krivelj deposit



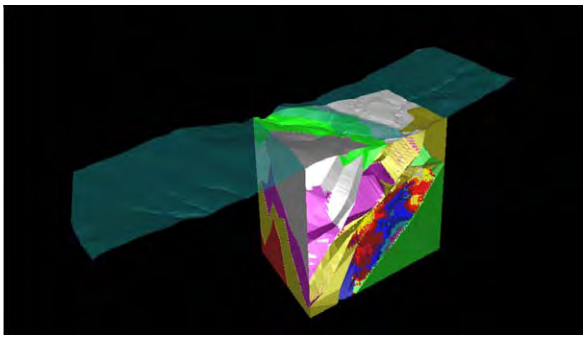
c) Block model for the Cerovo deposit



d) A section of block model for the Cerovo deposit



e) A section of ore reserves and drill hole locations for the Borska Reka deposit



f) Lithology model for the Borska Reka deposit

Fig.5.13 3D Modeling in the RBB

### 5.7 The Seismological Survey of Serbia

In order for mining activity to remain safe, it is crucial to grasp information and risk of natural disaster for acquiring transportation routes of products. Information on seismic disasters and landslides is of particular interest to the Seismological Survey of Serbia. The main missions of Seismological Survey of Serbia are to 1) obtain information on the seismicity of the country through seismic observation, and 2) create seismological risk maps based on the current seismicity and historical seismic activities. The Institution is run by 18 staff members with an annual budget of 25 million Dinars and financed by international support from JICA, NATO, and so on.

In 2006, the Survey acquired the ability to detect micro earthquakes and monitor events with a magnitude of 1.5 or more occurring anywhere in the country. The distribution of hypocenters is managed by the standard GIS software, ArcGIS and MapInfo. For disastrous earthquake occurrence risk maps, "hazard maps of max aspects of intensity" are accessible from the website (http://www.seismo.sr.gov.yu/). These maps have been created based on historical seismic events and soil conditions, and classifying potential of maximum intensities in 12 categories on the Mercalli scale, which may occur in the coming 100 years. However, active fault studies have been not carried out, and there has been no consideration of wide area tectonics for risk map creation.

Landslide damage has been reported in this country, but no specific organizations have been managing such information.

### 5.8 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:

- 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 MEM website.
- Six sheets of 1:500,000 geological maps provided by the Geological Institute were scanned and converted to shape files. Geological unit attribute information was added by the MEM and the JICA expert (Fig.5.14). The geological information was provided for the GIS database and web-GIS creation.
- Index maps for 1:25,000, 1:50,000, and 1:100,000 topographical and geological maps provided by the Geological Institute and the MGI are being converted to shape files with attributes added by MEM staff.
- 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 of Serbia was added to the current GIS database.

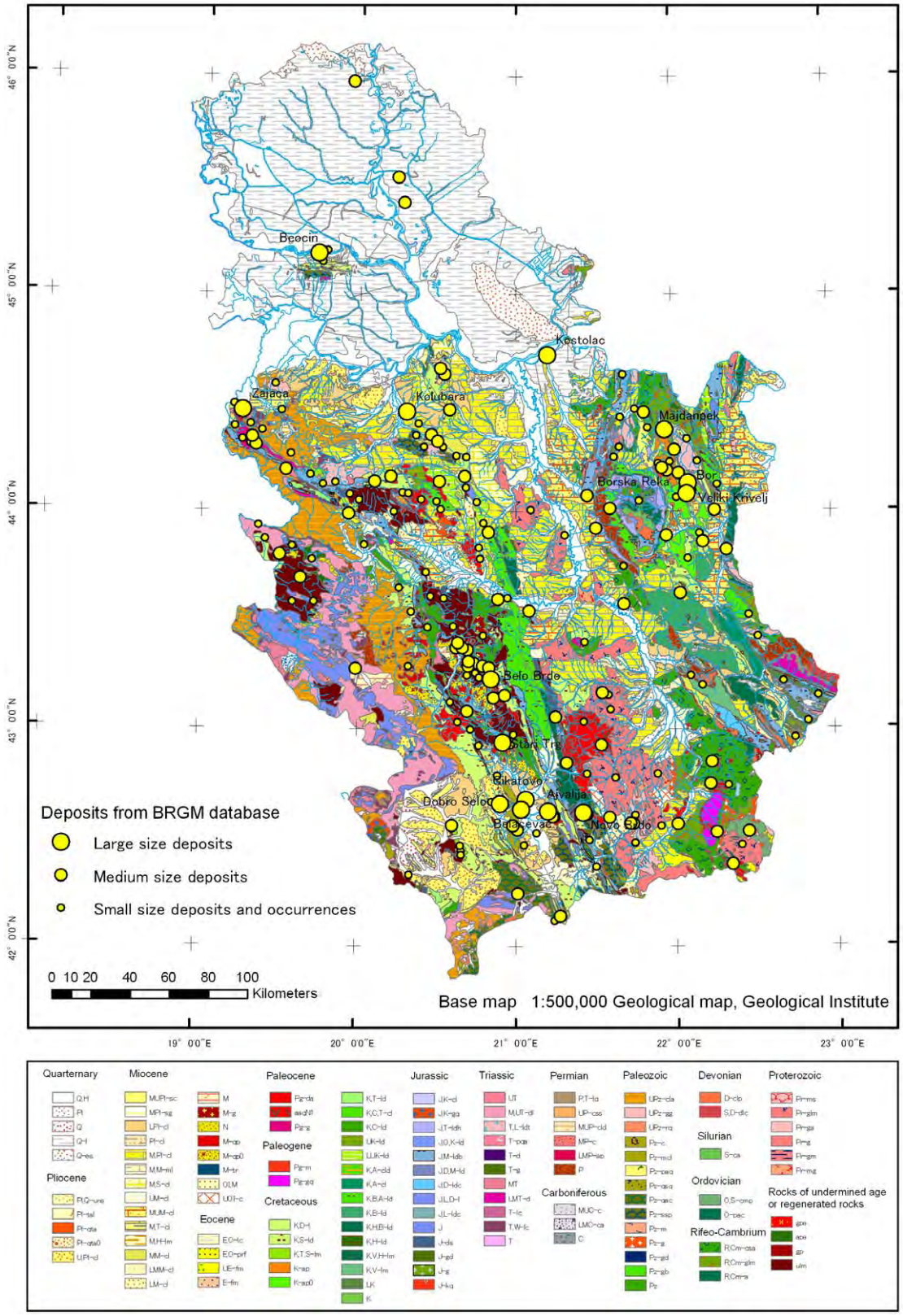



Fig.5.14 Geological Information for GIS Database with Mineral Deposits from the BRGM's Database

### 5.9 Local Consignment and Lease

In this study we made subcontracting agreements and signed leases with local companies to facilitate the development of the website and to assist with GIS operation at the MEM.

PCs and peripherals have been provided to the MEM with leases through the end of February, 2008, as shown in Table 5.13. In response to requests from the MEM, an A1 size printer was provided for a large –sized printout of standard maps, and an A3 size scanner with an automatic feeder was provided to convert various paper-based application documents of more than 10,000 pages for computer-based storage in PDF format. As result, staff of the MEM can use this scanner to quickly scan documents at rate of about 20 pages per minute, and it seems to lead to store application documents related to mining licenses into a database. GIS software is also being provided as a result of discussions with the MEM, as listed in Table 5.14.

Table 5.13 Computers and Peripherals

| | Name | Specifications | set |
|---|---|---|---|
| 1 | Desktop PC | Desktop PC<br>CPU: Core2Duo E6320 1.86GHz, RAM: 2GB, HDD: 400GB, Graphic Card: 512MB, DVD-R+R/RW, Wireless mouse, Display: LCD 21"(ViewSonic) with DVI (Digital Video Interface), OS: Windows-XP | 1 |
| 2 | Laptop PC(1) | TOSHIBA Tecra A8-104<br>Laptop PC, display: 15.4", CPU: Core2Duo T7200 2GHz, Memory: 2GB, HDD:120GB, DVD-RW, OS: Windows-XP | 1 |
| 3 | Laptop PC(2) | TOSHIBA Satellite P200-10C<br>Laptop PC, display: 17", CPU: Core2Duo T7200 2GHz, Memory: 2GB, HDD:250GB, DVD-RW, OS:Windows-XP | 1 |
| 4 | Printer (A3) | HP Business Ink Jet 2800 Powerful A3+<br>Color printer, size: A3, 24ppm, 4800dpi, 150 sheet Input Tray | 1 |
| 5 | Printer (A1) | HP Designjet 130<br>Color printer, 2400 x 120dpi, size: A1 | 1 |
| 6 | Scanner (A3) | EPSON A3 AKENER GT 15000 + ADF<br>Scanner with feeder, size: A3-A5, Duplex/Simplex, ADF only, Load & Eject Capacity 100 sheets, Ultra SCSI+USB | 1 |

Table 5.14 GIS Software

| | Name of software | General specifications | set |
|---|---|---|---|
| 1 | GIS core system<br>ESRI ArcEditor 9.2 | Powerful GIS desktop system for editing and managing geographic data. Includes all the functionality of ArcView and adds a comprehensive set of tools to create, edit, and ensure the quality of data | 1 |
| 2 | Extension software:<br>Spatial Analyst | Extensive tools for comprehensive, raster-based spatial modeling and analysis | 1 |
| 3 | Extension software:<br>3D Analyst | Extensive tools for three dimensional visualization and analysis | 1 |
| 4 | Extension software:<br>Geostatistical Analyst | Extensive tools for spatial data exploration, identification of data anomalies, optimum prediction, evaluation of prediction uncertainty, and surface creation | 1 |

### 5.10 Technology Transfer

The expert has given MEM staff instructions on how to create “shape” files for geological maps and index maps, and how to add attributes to them. The JICA Study Team and the MEM have

agreed to pick up items for training, while confirming progress of GIS operations.

To update the MEM website, the expert instructed the MEM staff members about crucial items such as information disclosure from mining-related government sites and adequate file formats.

### 5.11 Strategic Future Database Construction

In this section, I will discuss the future management of geological and mineral resource information based on the current organizational structure.

#### 5.11.1 MEM－DMG

**(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, as an extension of the CISGEM project, in cooperation with a local consultant (Fig.5.15). 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. In future, ground design for definition of work responsibilities and information sharing shall also be considered from the aspect of management of mining sector information.

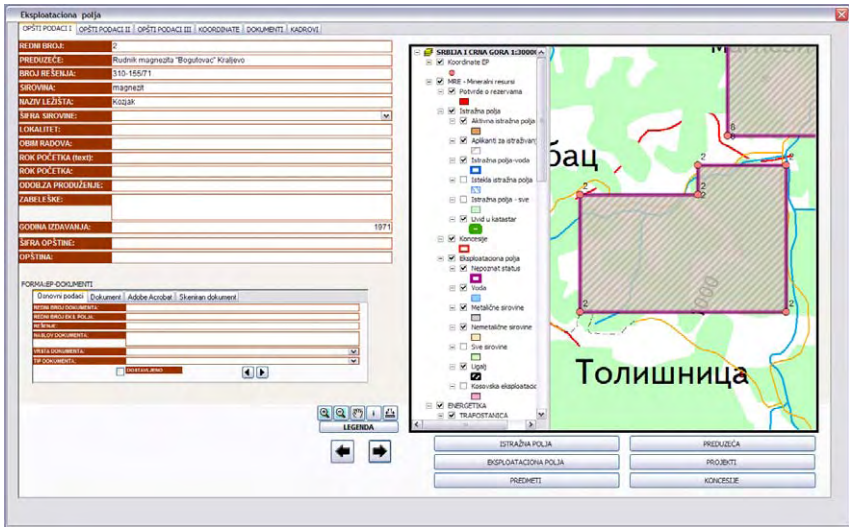



Fig.5.15 A View of the Cadastre Management System Created in the Pilot Project by MEM

**(2) Information Management for Old Mining Licenses**

After the first installation of Microsoft Access for the MEM-DMG in 2001, 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

still stocked in the Central Archives in the Republic of Serbia as paper-documents and paper-maps with standardized references numbers. Thus datasets for 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 stored in the appropriate database, rapidly as possible.

However, a volume of this operation is very huge for the present staff members in the MEM-DMG while doing daily management for mining activities, and it would be difficult to complete the tons of information. Therefore, supports of international organization in JICA or WB expert dispatch or in mini-project might be very effective for this achievement. In this case, it would be possible to complete for text-entry, document scanning, digitizing areas as polygon files and so on by two database experts and local consultants who have enough understanding and knowledge of mining activities in Serbia through one-year project.

### 5.11.2 MEP, GI, BU

The MEP is proceeding to create a geological and mineral resource database (GEOLISS) and GIS-based geological mapping with the Geological Institute and the Faculty of Mining and Geology of the University of Belgrade. The framework will be fundamental geo-science datasets of Serbia which will provide the backbone of an earth science information system through revision of the GEOLISS. The MEP is also managing datasets for water quality monitoring, which shall be integrated for future information disclosure.

### 5.11.3 MGI

Geodetic measurements and topographic maps are made by the MGI. Restrictions have been imposed on their use, not only by the public but also by government organizations, and they have not given status of public property. The current lack of infrastructural information such as topography, road and stream networks, etc., of the geological and mineral resource database shall be ameliorated to achieve one of the most basic missions in a nation, which is providing basic information for mining activity.

## 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.

Environmental laws and regulations are basically grouped as follows. The main laws and regulations are enumerated at the supporting data A in the end of this report.

#### 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. The independent management and voluntary control are expressed as a method of risk management, and minimizing impacts on the environment by adopting BAT (Best Available Technology) is clear. The regulatory values are not clearly defined in the provision, but the law does specify that the government provide the environmental standards and emission norms. The regulatory values are set in individual laws and regulations.

**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.

The person to actually execute the Strategic Environmental Impact Assessment and to describe its report is prescribed clearly that the legal person or the natural person is registered in the registry book, and forms the specialist group composed of experts who have the qualification of the analysis concerning each strategy assessment element. The person in charge of the report author is a specialist with an appropriate university degree, who has the work experience for five years or more in the particular field, and who has already participated in two environmental impact assessment services. Then, it is necessary to consign it to third party's registered agency even in case of the competent authorities. The SEA procedure and the content of the SEA report and the criteria for the evaluation of the SEA reports are provided for in detail. Also, this law is clearly provided the adapt of the public participation system.

**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.

The Ministry for Science and Environmental Protection is able to specify the project that the Ministry admits the necessity for the object of EIA besides the above-mentioned obligated objects. The project developer will submit to the Ministry the application of the decision of the necessity of EIA according to this law. So, there is a problem that the project developer cannot judge if the project is needed the EIA procedure or not.

Moreover, the execution of EIA can be subcontracted out. In that case, the subcontractor must be a corporation or individual listed in the registry book who has experts who have are qualified to work in that particular field. A technical committee that includes an outside specialist is

supposed to be set up and may undertake evaluations of EIA reports and take the approval procedure of the EIA. This law is provided that the public concerned and the local government may submit their opinion.

**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 a actual emission limit values are decided under the inspective organization examinations. A permit with time limit may be authorized, and it will be reviewed twice during the time it is in effect. Moreover, the approved information and conditions are a matter of public record.

A concrete emission standard is like the character that undertakes the examination and is decided.

### 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 is also laws covering waste substance handling.

Environmental standards are provided for by acts of Parliament.

We were informed that laws on air pollution corresponding to laws on water pollution are currently being drafted. Once these new laws are approved and enforced, there will be a uniformity of legal restrictions.

### 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. Measurement methods are provided in considerable detail to ensure reliable measurement data. Details are described in the next paragraph.

### 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. These laws and regulations are inter-related, so it is critical that they mesh with environmental laws and regulations.

Importantly, laws and regulations covering the handling of poisons and dangerous and combustible materials are included in this group.

In the mining field, laws on geological investigations and mining are intricately interlaced with laws covering agricultural land, forest water, public health, water quality, and harmful substances.

### 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).

National organizations, like the Ministry of Environmental Protection and the Hydrometeorology Institute, manage factors like air and water quality which contribute to the quality of the environment in general. Other the hand, city and provincial organizations (for instance, local and autonomous governments, and the Public Health Institute) manage comparitively local environmental issues, such as noise pollution and communal waste.

### 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 5th 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. The majority are organic compounds including agricultural chemicals, and there are few inorganic materials. There are also 20 heavy metals that are closely related to mining. Table 6.1 shows these items. These are considerably different from the types and amounts of restricted materials Japan. Most notably, a bacillus item is included.

Table 6.1 Water Quality Standards

Environment Standard on River of Serbia and Japan (Upper: General item Lower: Harmful substances)

| INDEX | | | Serbia (on river) | | | | | | Japan (on river) | | | | | | Note |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | 1 CLASS | 2 CLASS | 2a CLASS | 2b CLASS | 3 CLASS | 4 CLASS | AA | A | B | C | D | E | |
| Dissolved oxigen | Except underground water and natural lakes | mg/l | 8 | 6 | 6 | 5 | 4 | 3 | 7.5 | 7.5 | 5 | 5 | 2 | 2 | |
| Oxigen concentration | -saturation | % | 90-105 | 75-90 | | | 50-75 | 30-50 | Not provided | | | | | | |
| | -supersaturation | % | | 105-115 | | | 115-125 | 125-130 | | | | | | | |
| Biochemical oxigen demand | Five days, Temperature 20degrees | $mgO_2/l$ | 2 | 4 | 4 | 6 | 7 | 20 | 1 | 2 | 3 | 5 | 8 | 10 | |
| Chemical oxigen demand | $KMnO_4$ | $mgO_2/l$ | 10 | 12 | | | 20 | 40 | | | | | | | |
| Saprobe level by Liebman | Except underground water and natural lakes | | olygosaprobed | mezosaprobed beta-alfa | beta mezosaprobed | mezosaprobed beta-alfa | mazosaprobed alfa-beta | alfa mezosaprobed to plissaprobed | Not provided | | | | | | |
| Level of biological productivity | Only on lakes | | olygotrophy | mild outotrophy | mild outotrophy | | | | Not provided | | | | | | |
| Suspended solid | | mg/l | 10 | 30 | 30 | 40 | 80 | 100 | 25 | 25 | 25 | 50 | 100 | | |
| Dry rest of filtrated water | -for surface water | mg/l | 350 | 1000 | 1000 | 1000 | 1000 | 1500 | Not provided | | | | | | |
| | -for underwater | | 350 | 1000 | 1000 | 1000 | 1500 | - | | | | | | | |
| | | | 800 | 1000 | 1000 | 1000 | 1500 | - | | | | | | | |
| pH | | | 6.8-8.5 | 6.8-8.5 | 6.8-8.5 | 6.5-8.5 | 6.0-9.0 | 6.0-9.0 | 6.5-8.5 | 6.5-8.5 | 6.5-8.5 | 6.5-8.5 | 6.0-8.5 | 6.0-8.5 | |
| Visible sewage | | | no | no | no | no | no | no | Not provided | | | | | | |
| Noticed color | | | no | no | no | no | Low noticed | - | Not provided | | | | | | |
| Noticed smell | | | no | no | no | no | Low noticed | - | Not provided | | | | | | |
| Probable number of colyform microbe | | l | 2000 | 100000 | 6000 | 100000 | 200000 | - | 100 | 1000 | 5000 | | | | MPN/100ml |
| - | -for bathing | | - | 20000 | | | - | - | | | | | | | |
| $NH_4$-N | | mg/l | 1 | 1 | | | 10 | 10 | 10 (as total N) | | | | | | |
| $NO_3$-N | | mg/l | 0.05 | 0.05 | | | 0.5 | 0.5 | | | | | | | |
| Sb | | mg/l | 0.05 | 0.05 | | | 0.05 | 0.05 | Not provided | | | | | | |
| As | | mg/l | 0.05 | 0.05 | | | 0.05 | 0.05 | 0.01 | | | | | | |
| Cu | | mg/l | 0.1 | 0.1 | | | 0.1 | 0.1 | Not provided | | | | | | |
| Ba | | mg/l | 1 | 1 | | | 4 | 4 | Not provided | | | | | | |
| Be | | mg/l | 0.0002 | 0.0002 | | | 0.001 | 0.001 | Not provided | | | | | | |
| V | | mg/l | 0.1 | 0.1 | | | 0.5 | 0.5 | Not provided | | | | | | |
| Fe | | mg/l | 0.3 | 0.3 | | | 1 | 1 | Not provided | | | | | | |
| Hg | | mg/l | 0.001 | 0.001 | | | 0.001 | 0.001 | 0.0005 | | | | | | |
| Cd | | mg/l | 0.005 | 0.005 | | | 0.01 | 0.01 | 0.01 | | | | | | |
| Co | | mg/l | 0.2 | 0.2 | | | 2 | 2 | Not provided | | | | | | |
| Mo | | mg/l | 0.5 | 0.5 | | | 0.5 | 0.5 | Not provided | | | | | | |
| Ni | | mg/l | 0.05 | 0.05 | | | 0.1 | 0.1 | Not provided | | | | | | |
| Pb | | mg/l | 0.05 | 0.05 | | | 0.1 | 0.1 | 0.01 | | | | | | |
| Se | | mg/l | 0.01 | 0.01 | | | 0.01 | 0.01 | 0.01 | | | | | | |
| Ag | | mg/l | 0.01 | 0.01 | | | 0.02 | 0.02 | Not provided | | | | | | |
| Te | | mg/l | 0.01 | 0.01 | | | 0.01 | 0.01 | Not provided | | | | | | |
| Ti | | mg/l | 0.1 | 0.1 | | | 0.1 | 0.1 | Not provided | | | | | | |
| $Cr^{6+}$ | | mg/l | 0.1 | 0.1 | | | 0.1 | 0.1 | 0.05 | | | | | | |
| $Cr^{3+}$ | | mg/l | 0.1 | 0.1 | | | 0.5 | 0.5 | Not provided | | | | | | |
| Zn | | mg/l | 0.2 | 0.2 | | | 1 | 1 | 0.03 | | | | | | |
| CN | | mg/l | 0.1 | 0.1 | | | 0.1 | 0.1 | no | | | | | | |
| Harmful substances are abstracted. | | | | | | | | | | | | | | | |

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).

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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.

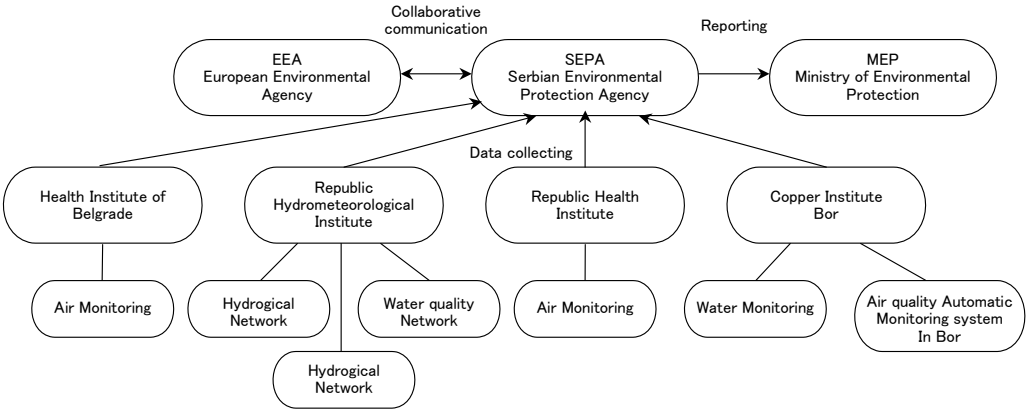



Fig.6.1 Environmental monitor system

Waste disposers are required to request measurement by the registered measuring organization four times per year (every three months), to maintain the measurement results, and to present the results at official inspections. The required measurement data includes a great deal of bacillus analysis in addition to heavy metal measurements. Meteorological monitorings are also required of large enterprises.

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.

The Ministry of Environmental Protection maintains an automatic air quality monitoring network. They hope to set up a similar automatic monitoring network for river water quality. Their plan is monitor at the entrance points into Serbia of the major rivers: the Danube, the Tisa, and the Sava, and also at the outlet of the Danube river, including chemical analysis variables in addition to the standard water quality monitoring parameters (water level, flow velocity, pH, water temperature, EC, DO, turbidity, and ORP).

### 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. The organizational chart is shown in Fig.6.2. 23 staff make up two sections: the environmental status and information systems monitoring section, and the polluter monitoring section.

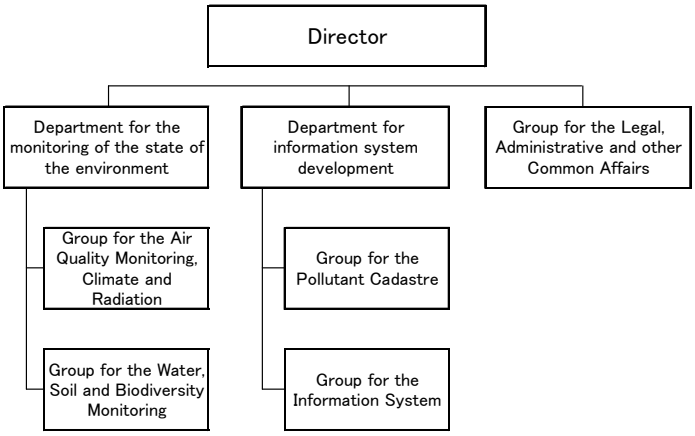



Fig.6.2 Organizational Chart of SEPA

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).

Moreover, SEPA plans to construct an air quality monitoring system. In a previous progress report, the CARDS project (25 stations) was advanced by SEPA. The Serbian Environmental Protection Agency informed us that a restructuring of the CARDS project together with the NIP project (another automatic monitoring system with 17 stations) is in currently progress because of overlaps between monitoring stations and measurement parameters. However, four automatic measurement stations have already been set up in the cities of Smederevo and Bor with capital from the Serbian environmental fund.

### 6.2.2 Hydrometeorology Institute (Hydromet)

The Hydrometeorology Institute is a nationwide research institute organized as shown in Fig.6.3. There are three main sections, related to meteorology, hydrology, and the environment.

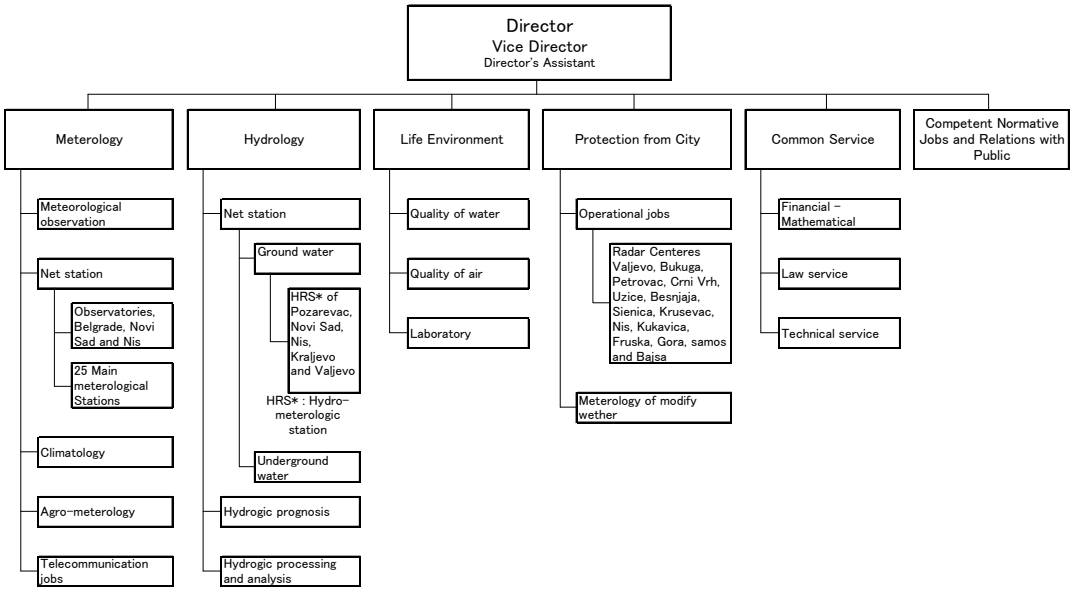



Fig.6.3 Organization Chart of The Hydromet

The Hydrometeorology laboratory has the following water and air quality monitoring networks. Results from these monitoring networks are reported to the Serbian Environmental Protection Agency.

**1) Water Monitoring Network**

The following surface and underground water monitoring networks are in place.

**a) Hydrology Monitoring Network**

A nationwide (including the Kosovo district) hydrology monitoring network with 214

surface water measurement points. This network utilizes snap sampling, and measurements include water flow quantity, (by the water level, with a self-registering water meter or staff rod), water temperature, suspended solids, freezing time. Measurement typically includes a total of 36-63 water quality parameters (see the supporting data B in the end of this report) depending on the measurement location and conditions. The measurement frequency, which varies with the measurement point, is 12-24 times a year. It is executed in accordance with the each annual measurement plan, in which the measurement parameters, intervals, and frequency vary. The measurement points for this monitoring network can be referenced by region or basin on the Hydrometeorology Institute homepage.

The display method (measurement points, measurement parameters, and results) has changed. Beginning with the hydrology monitoring network 2006 measurements, the target water quality category (I-IV) for each measurement point in each basin is displayed. The water quality category is displayed for each measurement parameter (dissolved oxygen, dissolved oxygen saturation rate, coliform bacterium group, spoilage microorganism indicator, BOD5, COD, suspended solids, evaporation residue amount, pH, color, and stench). Overall conditions are evaluated at the same time. Measurement results were summarized in the 2006 annual report on environment conditions.

The number of measurement points for each river in 2006 are as follows (2005 values are shown in parenthesis for reference):

| | | |
|---|---|---|
| • Danube river | 58 points | (51 points) |
| • Zapadna Morava river | 28 points | (44 points) |
| • Juzna Morava river | 25 points | (38 points) |
| • Velika Morava river | 13 points | (16 points) |
| • Sava river | 7 points | (8 points) |
| • Kolubara river | 5 points | (14 points) |
| • Drina river | 8 points | (10 points) |
| • Timok river | 4 points | (9 points) |
| • Beli Drim river | 8 points | (17 points) |
| • Egej river | 2 points | (7 points) |

**b) Water Quality Monitoring Network**

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. (phenols is added in the Ibar river basin, and 8-10 parameters in total are measured). Other water quality parameters are measured twice a month. Measurements are executed in accordance with the annual

measurement plan. The measurement points for this water quality network and its results can be seen on the Hydrometeorology Institute homepage. Past result charts can also be displayed, but do not show all parameters for all periods because of an equipment maintenance problem.

The number of measurement points in each river are as follows:

- Danube river 2 points
- Zapadna Morava river 2 points
- Juzna Morava river 1 point
- Velika Morava river 2 points
- Sava river 2 points
- Kolubara river 1 point
- Tisa river 1 point
- Lim river 1 point

The case that can be compared directly is a little because the number of measurement points is little. But there is a possibility to presume the area of the inflow of polluted water on upstream side of the measurement point by using the change of pH and flowing quantity etc. between the measurement points.

**c) Underground Water Monitoring Network**

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. Moreover, the section of the water level of underground water is measured with 27 sections on 135 measurement points of 4 regions, which are mainly the Morava river and the Tisa river basin. The water quality of underground water measures by 30 parameters (water level, water temperature, temperature, pH, EC and the ions to request chemical composition formula of Kurlov) 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 measurement of the water level and the water quality of underground water by the Hydrometeorology Institute is executed only from a hydrology viewpoint, and the monitoring wells arranged in each aquifer. The pumping up the underground water and supplying water are services of the water bureau of the ministry of agriculture, forestry, and the water management to obtain the drinking water. The monitoring network of the Hydrometeorology Institute is independent.

**d) Monitoring of Other Lakes and Marshes**

The monitoring related to lakes and marshes and the reservoir is executed in all the main lakes and marshes. There is no automatic monitoring network. 36-63 parameters are analyzed by the biannual sample collection and the measurement of precipitation is executed once per year in the

river and the reservoir.

**2) Air Quality Monitoring 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.

**a) Automatic Air Quality Monitoring Network in the Belgrade Region**

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. In every day, each measured results of each measurement point at the day before and a result for a graph of the measurements for the recent week are shown on the homepage of the Hydrometeorology Institute. Also, the comment on the environmental status is put on there.

**b) Nationwide Air Quality Monitoring Network**

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. The analysis with the collection of 24 hour sample is executed in two years (2004 and 2005 year) with 24 measurement points in total, which are consist of 13 points not influenced from an important polluter, 13 points received the influence of pollution from the polluter near the monitoring station and one point specified monitor station for EMEP program promotion in according to the air quality measurement decree that the government adopted. The measurement of the ionizing ray (gamma rays) is executed in a part of them.

**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 (Gradski park, Jugopetrol and Brezonik) and the sample collection and the analysis of the water quality and the soil. The automatic monitoring of the air measures the $SO_2$ density in each 15 minutes, and the Bor copper smelter has changed its operation by the exceed time and density. For the $SO_2$ value during 24 hour and dust, the sample is separately collected and all sample of one month are mixed, and the heavy metal etc. are analyzed at once per month. Besides continuous monitoring point, there are some measurement points of the smoke, the flying particle, and the deposit dust, where the sample is collected by 24 hour sampling equipment. Using the deposit dust sample, measures pH, the dissolved materials, the sulfate ion, the non-dissolved materials, and the inflammable materials, the ash, Pb, Cd, Zn, and the total deposit dust are measured too. The research and investigation related to the water quality and the soil are executed as a special program.

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. The specific pollutants, which are acrolein, formaldehyde, phenol, ammonia, and benzene, are measured at total of 44 measurement points on 19 villages in the area where the production facilities of the specific pollutants exist.

**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, which are the water temperature, the temperature, the color, the stench, pH, EC, the subsidence materials, the suspended solids, the amount of the evaporation residue, the consumption of $KMnO_4$, COD($KMnO_4$, $K_2Cr_2O_7$), BOD5, the dissolved oxygen, the dissolved oxygen saturation rate, ammonia nitrogen, the nitrate nitrogen, the nitrite nitrogen, chlorine, sulfate radical, hydrogen sulfide, fluorine, cyanide, phosphoric acid, Fe, Total Cr, $Cr^{6+}$, $Cr^{3+}$, Ni, Cu, Zn, Pb, Hg, Cd, As, Ba, phenols, anions, tri-chloridie ethane, tri-chloridie ethylene, and 8 kinds of bacteriological. index (the coliform bacterium group, the spoilage microorganism indicator etc.). In case of the Rudnik mine, reaches 43 parameters in total, which are the water temperature, the temperature, the color, the stench, pH, EC, the subsidence materials, the suspended solids, the amount of the evaporation residue, the consumption of $KMnO_4$, COD, BOD5, the dissolved oxygen, the dissolved oxygen saturation rate, ammonia nitrogen, the nitrate nitrogen, the nitrite nitrogen, chlorine, sulfate radical, cyanide, phosphoric acid, Fe, $Cr^{6+}$, $Cr^{3+}$, Ni, Cu, Zn, Pb, Cd, Ca, Mg, Mn, phenols, anions, oil and fats, hardness of water, alkalinity, TOC etc. in little difference with the Grot mine). And the monitoring points are 5 more than the Grot mine. I have 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. Beginning the Ministry of Environmental Protection, the Ministry of Energy Mining and the Ministry of Agriculture, Forestry, and Water management, etc have the inspection sections to work for the obstruction against the deterioration of the environment including safety. How are the services of the inspection section of these each Ministry going?

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 relation between these environmental elements and inspection agent is as below. The organization chart of the inspection section of the ministry of Energy and Mining is shown in Fig.6.4. 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). It is difficult to know directly the matter related to the environment from the section name. Main problems are the destruction of a natural spectacle and the discharge of the spring water (included the pit water) and the soil pollution at exploration and development. 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.

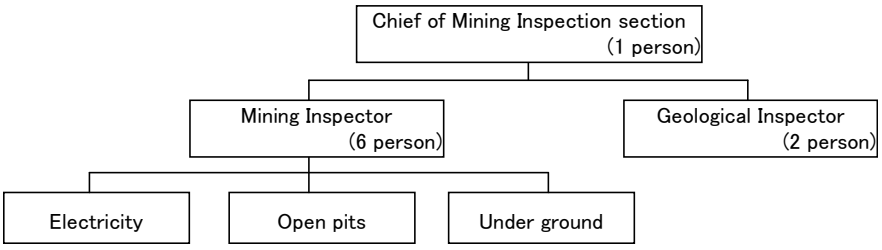



Fig.6.4 Organization Chart of the Inspection Section of the MEM

The organization chart of the inspection section of the Ministry of Environmental Protection is shown in Fig.6.5. The inspection section of the Ministry of Environmental Protection is executing an environmental inspection of whole Serbian land by total 88 persons.

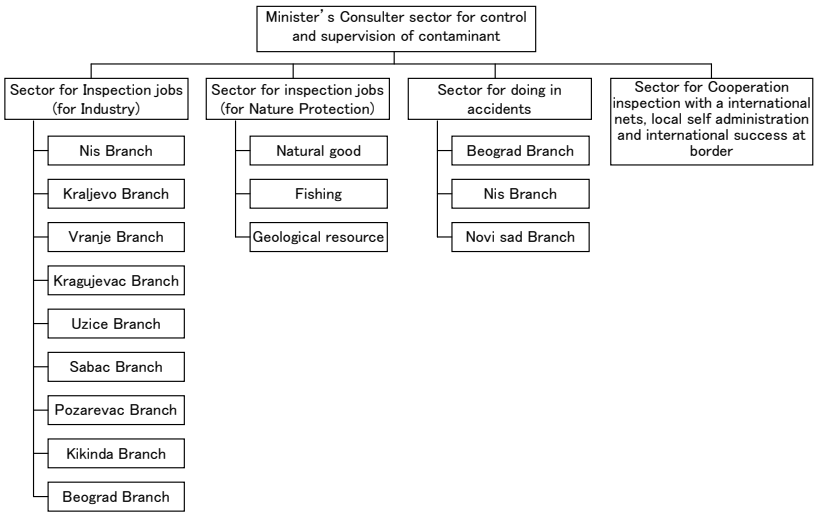



Fig.6.5 Organization Chart of the Inspection Section of the MEP

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.6.6.

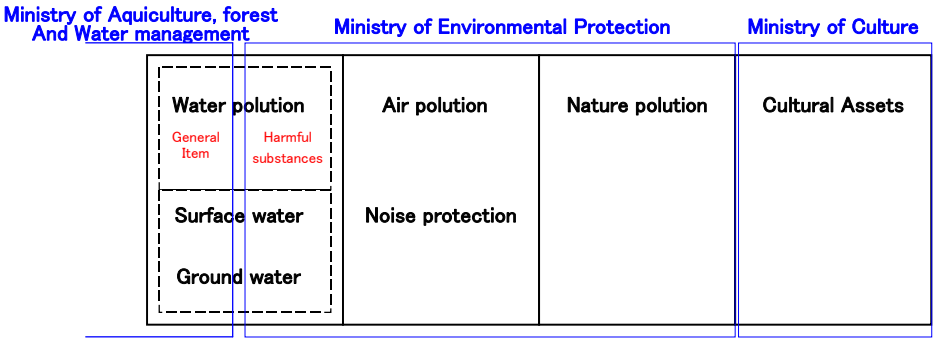



Fig.6.6 Service Segment in each Inspection Section that relates to Environment

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. Details are described later in the paragraph in the Bor mine.

Mining influences especially a lot of environmental parameters, and the source of release includes many things. But, there are relativities between the source and the parameter that influences. For example, the sources that influence the air are a smelting factory with a furnace, a sintering plant, and a sulfuric acid plant. The sources of water pollution are a wastewater of the mine from the waste rock dam and the open pits, and a wastewater from the tailing dam of the floatation plant and the plant of wet metallurgy and the sulfuric acid plants. Especially, the acid discharge becomes a big problem. The soil pollution exists as primary contamination, which is caused directly by the sands and rocks that flows out from the open pit mark, the waste rock storage, and the tailing dam of floatation plant and as a secondary contamination, which the air pollutants and water pollutants cause the secondary contamination.

The environmental status of each mine where the field investigation was done is described as follows.

#### 6.4.1 Grot Mine

The Grot mine is operating. 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.

The mine water of the Grot Mine is pH8.5, and is discharged at a rate of about 60$m^3$/hr. Of this amount, 54$m^3$/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 6$m^3$/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.

Though the wastewater from the other side of the mine did not adversely affect the analytical result of the monitoring, I was told in an interview with the regional environmental inspectors of the Directorate for Environmental Protection that high density heavy metal (Zn 0.93%) had been detected in the bottom sediments of a marsh downstream. Such a high density in the bottom sediments is almost never caused by pit water only. Deterioration of the bottom sediment may have been caused by the erosion of land in the mineralization area, by sand and soil flowed out by rain water, etc., which partially contained ore minerals from the waste rock depositing area where waste rock and mineralized rock ware piled up when the tunnels were excavated. These substances were deposited in the stream and the marsh, especially in the bottom sediments in the marsh.

Because there is no subsidence facility like the tailings pond on the other side, the settling separation of the pollutant cannot be done, and pollution is diffused. The bottom sediments of the marsh will deteriorate more without the treatments of the polluted water and the eroded solid from the mine site, before they enter to the mountain stream out of the mine for instance of setting up the sedimentation pond. Because there is a lake used for drinking water downstream in the Bosilegrad town, it is necessary to determine whether the heavy metal of the bottom sediment is dissoluble matter or not and take immediate measures to mitigate any threat.

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. However, there is no well to measure the water level in the dam body, so it seems that the control of the water level in the dam body relies on experience. 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.

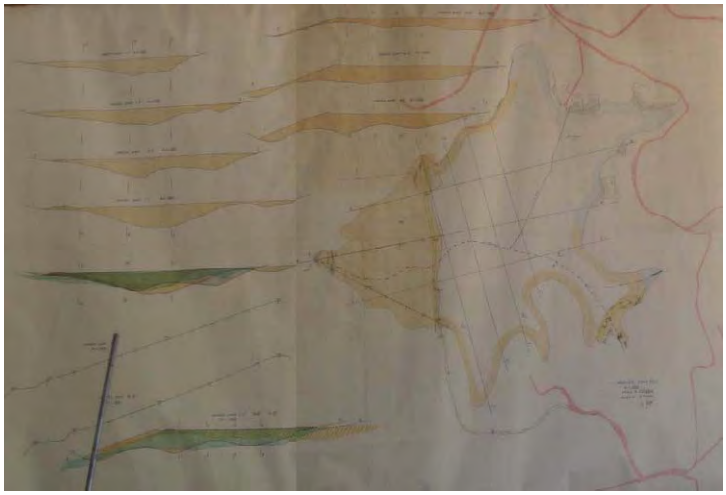


Fig.6.7 Plan and Cross Section of the Tailings Dam of the Grot Mine

Street gutter around the Tailings Dam

Collector Pipe of the Tailings Dam

**6.4.2 Kizevak Mine**

Mine is currently controlled by a bank and is not operating. The material for tender is being prepared to restart operation. The mine has two open-pits. Though water has not entered the pit bottom, 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.

Waste Dump of the Kizevak Mine

There are two tailing dams, a new one and an old one. The old tailing dam is vertical type collector pipe that is enclosed on all sides by an embankment, and exists on one of the banks of the Ibar River. The tailings dam consists of a big part, and a small part, which adjoin one another. Each collecting pipe has partial damage. Since the two tailings dams have not been used for a considerable time, there has been considerable deterioration of the dam body. Although the mine has the replanting plan, the plan has not been carried out due to the lack of funding. There are a few trees and some grass that have spouted spontaneously in the dam body and the pound. So, the use of these plants is considered to be “planting”.

Old tailing dam of the Mine

Old Tailings Dam of the

Erosion of the Dam

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 collector pipe is horizontal. The weir was built at the upstream side of the valley to discourage the upstream side water from entering the pond, and the water was flew to the next valley through canal. A street gutter is set up around the pond so that rain water from outside the pond cannot enter the pond. There is a well to measure the water level in the dam, so it may be possible to keep the dam in a constant state by controlling the water level in the sand of the dam. The dam of Mine is better than the Grot mine because of setting the equipped well. 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.

There was no analysis result of the monitoring. I heard that there was no problem for wastewater and the water quality of the upstream side of the Ibar River was bad. But I cannot judge which is bad.

The Well to measure Water Level in the Dam Body

### 6.4.3 Rudnik Mine

I checked only the tailings dam of Rudnik Mine after returning from the Mine investigation. Rudnik Mine is another small/ medium sized working mine. I heard that Rudnik Mine paid off all its debt this year.

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.

The Tailings Dam of the Rudnik Mine

### 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. However, there has been no analysis.

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.

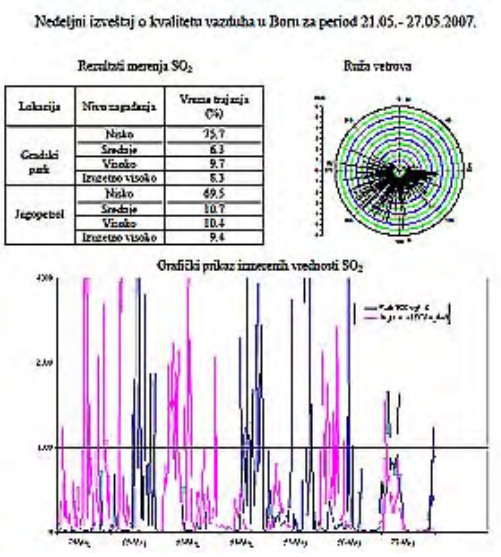
**(1) Air Pollution**

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 two measurement points (Gradski Park and Jugopetrol). These measurements are sent to the Copper Institute of Bor, the Bor city office, and RTB Bor in real time. If two contiguous measurements exceed the high density threshold (2,000μg/$m^3$), the smelter undergoes a partial shutdown. Moreover, these

measurements are publicized in newspapers, on the radio, and on TV. 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.

The $SO_2$ values over 24 hours and dust are measured by a separately collected sample. The samples collected during one month are mixed, then the heavy metals are analyzed. There are 14 measurement points where samples are collected by 24-hour sampling equipment to measure the soot, the dispersion of particles, and the dust fall. Using the dust fall, the pH, the melt quality, the sulfate ion, non-melt quality, and the inflammable, the ash, Pb, Cd, Zn, and the dust fall gross weight are measured.

All dust fall shows acidities, and the soil acidification is advanced. Because average wind direction is northwest and east, the results of measuring points 1 and 2 (because of the influence of the east wind and the short distance) are high. Next, the results of measuring points 3, 4, and 5 (because of the influence of the northwest wind) are in second place. 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.


Nedeljni izveštaj o kvalitetu vazduha u Boru za period 21.05.- 27.05.2007.

Rezultati merenja $SO_2$

| Lokacija | Nivo zagađenja | Vreme trajanja (%) |
|---|---|---|
| Gradski park | Nisko | 75.7 |
| | Srednje | 6.3 |
| | Visoko | 9.7 |
| | Izuzetno visoko | 8.3 |
| Jugopetrol | Nisko | 69.5 |
| | Srednje | 10.7 |
| | Visoko | 10.4 |
| | Izuzetno visoko | 9.4 |

Ruža vetrova

Grafički prikaz izmerenih vrednosti $SO_2$

Fig.6.8 Weekly Report of Air Pollution Status

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.

At the same time, it is also important to execute measures one by one, which can be improved. For example, the desulfurization neutralizing equipment that is currently unused will be reintroduced by changes to the process flow.

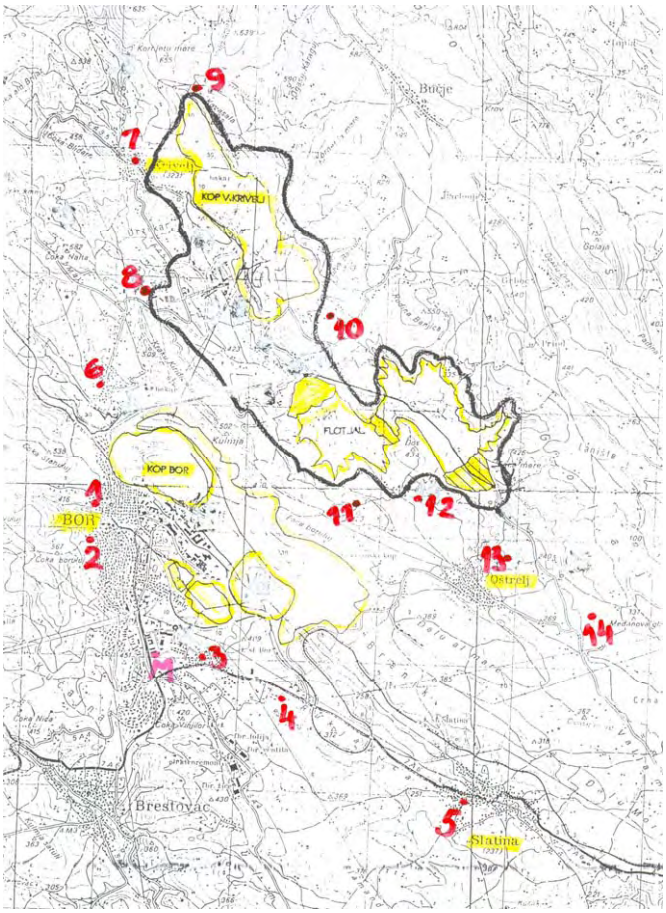



Fig.6.9 Air Pollution Measuring Points

**(2) Soil Pollution**

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 allowance standard (Cd-3 mg/kg, Pb-100 mg/kg, Hg-2 mg/kg, As-25 mg/kg, Ni-50 mg/kg, Cu-100 mg/kg, and Zn-300 mg/kg) is provided. The content of Zn, Ni, Fe, Cd, Hg, and Pb show within a permissible level. It is possible to make a zoning map by the content of Cu and As.

The following three groups are divided from the analysis results of the soil, and the influence level of air pollution can be divided.

・Group1 The district that is the nearest the smelter including Krivelj, Ostrelj, Bucje, Slatina and Bor. The pH of the soil is 3.8-6.83. The content of zinc is partially high. The content of copper exceeds a permissible level with 40%-86% at the investigation point.

The As content exceeds a permissible level with 20%-64% at the investigation point.

・Group2　The district that is the medium zone including Brestovac、Metovnica and Sarbanovac. The pH of the soil is 4.4～6.32 (minimum value is a little high). Though it is different from group 1, the content of Cu and As is within a permissible level.

・Group 3　The district that is the fringe zone including Zlot and Gornjane. The pH of the soil shows acidity but the district that is not shown the air pollution effect.

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.

**(3) Water Pollution**

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.6.11 shows the origin of these wastewaters.

**a) Wastewater from open pit ”Veliki Krivelj”**

Wastewater from the collecting pipe in the pit bottom of the open pit "Veliki Krivelj", and the surface water and wastewater of the underground water origin. The wastewater has a reading of pH4.40 and is pumped up by flow volume 2,333$m^3$/day with densities of $SO_4$ 360mg/l, Cu 127.5mg/l, Fe 0.38mg/l and Zn 3.1mg/l.

**b) Wastewater from ”Saraka” stream** (wastewater is shown in Fig.6.10.)

There is a waste rock deposit from the open pit "Veliki Krivelj" on the upstream of "Saraka" stream, and the oozed water from the waste rock deposit flows into "Saraka" stream. This wastewater is easily influenced by weather, so the flow quantity and density are variable. The

wastewater has a reading of pH4.29 and flows into the Krivelj river 3,802$m^3$/day with densities of $SO_4$ 148mg/l, Cu 101.9mg/l, Fe 34.3mg/l and Zn 1.3mg/l.

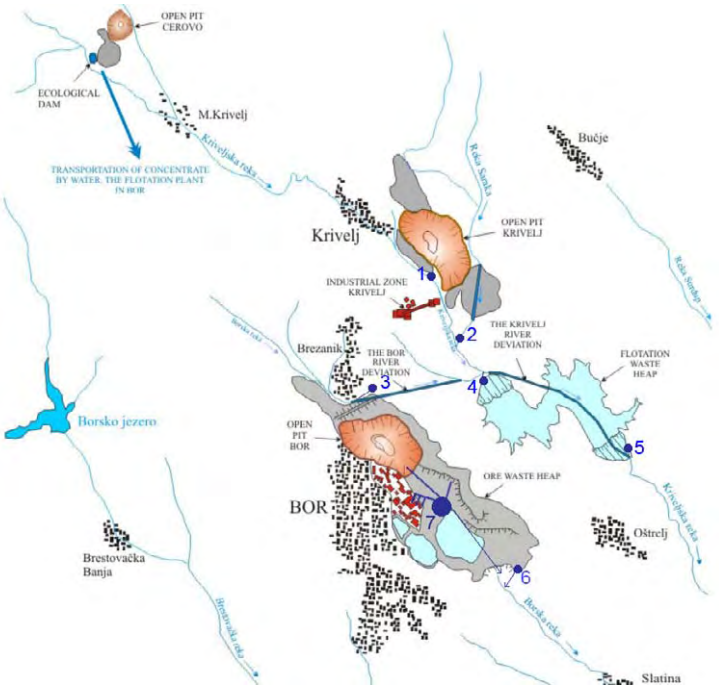



Fig.6.10 Origin Points of Wastewater

**c) Wastewater from open pit "Bor"**

This wastewater is from the open pit "Bor", and flows into the Krivelj river through the changing waterway of the Bor river. The wastewater has a reading of pH2.87 and is pumped up by flow volume 3,599 $m^3$/day with densities of $SO_4$ 247mg/l, Cu 192.1mg/l, Fe 678mg/l and Zn 34.5mg/l.

**d) Wastewater from the pond of Floatation tailing dam " Veliki Krivelj" 1A**

This wastewater is the supernatant water of the pond of the tailing dam of flotation "Veliki Krivelj" 1A and surface water. It flows into the Krivelj river 1,944 $m^3$/day. It varies in pH6.08-8.12. Also, it varies with densities of $SO_4$ 59-730mg/l, Cu 0.07-0.356mg/l, Fe 0.01-4.5mg/l and Zn 0.001-2.612mg/l. Because these wastewaters are from flotation tailing, they should be in the alkali sides originally. However, it is presumed to mix and to treat the water if it frequently becomes acidic. Although the Cu density is low because the Cu forms precipitation in such pH range, the treatment of zinc and Cd becomes insufficient in such pH range. This requires attention.

**e) Wastewater from the pond of Floatation tailing dam" Veliki Krivelj" 3A**

This wastewater is the supernatant water of the pond of the tailing dam of flotation "Veliki Krivelj" 3A. It flows into the Krivelj river 3,024$m^3$/day. It varies in pH4.6-8.24 as well as the wastewater of the pond of 1A. Also, it varies with densities of $SO_4$ 12-701mg/l, Cu 0.02-0.276mg/l, Fe 0.01-2.5mg/l and Zn 0.001-1.95mg/l. Because these wastewaters are from

flotation tailing, they should be on the alkali side originally. However, it is presumed similarly to mix and to treat the water if it frequently becomes acidic. Although the Cu density is low because the Cu forms precipitation in such pH range, the treatment of zinc and Cd becomes insufficient in such pH range. This requires attention.

**f) Wastewater from ”Robule” lake**

"Robule" lake is on the side of the waste rock deposit of the open pit "Bor", the leached water from the waste rock deposit is gathered and formed a lake. A part of the wastewater from smelting and the hydrometallurgy plant has been exhausted near the lake. This wastewater has a reading of pH2.97 and flows into the Bor river 484$m^3$/day. It has densities of $SO_4$ 4145mg/l, Fe 895mg/l, Cu 55mg/l and Zn 26.5mg/l. This wastewater is reddish brown color, and the form of dissolved iron is ferrous (two-valent) iron. This wastewater easily maintains its acidity because the pH decreases when two-valent iron is oxidized to three-valent iron. This wastewater has been exhausted without treatment.

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

This wastewater is a compound of the wastewater from plants including “Bor" open pit, sulfuric acid plant, copper dry smelting plant, and copper hydrometallurgy plant, and flows into the Bor river 2,323$m^3$/day. This wastewater has a reading of pH2.35. It has densities of $SO_4$ 1640mg/l, Cu 54mg/l, Fe 323mg/l, Zn 1.92mg/l, Pb 2.08mg/l, Mn 9.63mg/l and Ni 1.05 mg/l.

The wastewater from the hydrometallurgy plant (7A1) 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 2,874$m^3$/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 1,946$m^3$/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 1,071$m^3$/year. The wastewater of the sulfuric acid plant is sulfuric acid (0.81g/l), Cu (0.041g/l), and the flow volume is 34,944$m^3$/year. These wastewaters have been discharged as imperfect without treatment.

If these data are collected, it becomes as shown in Fig.6.11. 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.

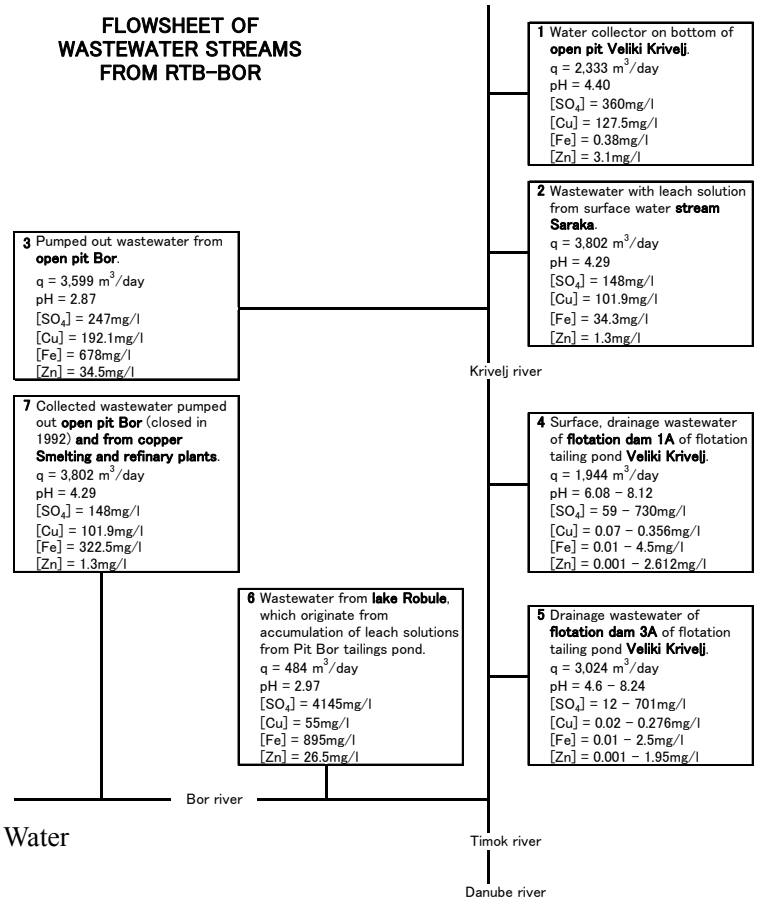



Fig.6.11 Flow of Polluted Water

**(4) Other Environmental Issues**

The tailing dam is structured such that one body was constructed in the exit mouse, the dam body was built up by separated sand. Two tailing dams made the pond a back match, and there is a dam body in both ends. I heard that there are three dam bodies. I did not confirm that. There are a lot of wells to measure the water level in sand of the both dam bodies 1A and 3A. But, many wells cannot measure the water level because of filling slime in the well. Because the dam body started moving before, there is a re-installation plan for the well on the dam body of dam 3A. Only the lowest well in the dam body of dam 1A can measure the water level, then management of the water level in the pond could be controlled with this information and the observation of the collecting pipe set up in the skirt of the dam body. There is not a watering device to prevent the dust generation from the body of the bank of both tailing dams.It should be noted that the heavy metal hydroxide that was separated will dissolve in the pond if the pH in the pond is not kept on the alkali side as much as possible when acid water is introduced into the pond of the tailing dam for neutralization. Also, there is a danger of raising the content of heavy metal of the wastewater oppositely.

Moreover, Tailings dam of Bor has the problem of the crack of the drain pipe set up in bottom of the dam. Therefore, the drain water, which is contained the heavy-metal component, is permeated. Lowering of pH of the pound water has danger of depraving this problem.

Environmental pollution of RTB-Bor is not only 7 sources that were caught now (wastewater from open pit, dressing plant and smelter, supernatant water from the pond of tailing dam) but also acidity ooze water from waste rock deposit near as well as open pit Cerovo, which is flowed into upstream of Krivelj river. Also, erosion of the waste rock deposit and the tailing dam by rainwater and wind occurs. Then, these solids enter the river and cause deterioration of the bottom sediment directly. Though the heavy metal in the wastewater is formed precipitation in water, and subsides in the part where the flow of the river is late. In addition, it pollution will diffuse to the downstream. when the flow volume of the river increases, such as from rain, these subsidences will flow out of the riverbed and downstream. It is a principle to complete treatment in the mine site, and it is advantageous in the process efficiency. At first, it is necessary to investigate the separation of stream water from polluted water.

### 6.4.6 Coal Mine and Cultural Asset(In case of Kostolac Mine)

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.

Moreover, this open-pit coal mine of the Drmno deposit is near the Danube river and the level of the underground water is high, so it needs to pum up it continuously before the deposit develops. After the water level is down, the bench is excavated by the drag line and the coal is mined by excavator. The underground water that is pumped up before the excavation has few impurity, because no oxidation of the deposit is generated. It is used for a surrounding agricultural water. There is few possibility of the underground water contamination.


Roman martial station ruins (red arrow) and open cut of Drmno deposit


Pumping up of underground water

### 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.

The survey result concerning the investigation mines and the case studies are compared according to the environmental elements and the Appendix I, 6 is shown as following.

## (Supporting Data A) Laws and Regulations of Serbia concerning the Environment

The main laws and regulations are as follows. These include laws from the former Yugoslavia age.

- Low on the Environmental Protection
- Low on Strategic Environmental Impact Assesment
- Low on Environmental Impact Assesment
- Low on Integrated Prevention and Pollution Control
- Low on Minning
- Low on the Geological Researches
- Low about Agriculturl Soil
- Low about Forests
- Law on energetic
- Law on tourism
- Low about National Park
- Law on Plant Protection
- Law on the protection at work
- Law on public health protection
- Low on Planning and Constructing
- Low on Water
- Low on Waste Management
- Law on trade on explosive substances
- Law on Explosive Substances, Inflammable Liquids and Gases
- Law on Standardization
- Law on spatial plan of the Republic of Serbia
- Law on Enterprises
- Regulation on Permited Noise Level in Environment
- Regulation on dangerous matters in the water
- Regulation on Handling Waste which has characteristics of hazardous substances
- Regulation on permitted quantity of dangerous and hazardous matters in the soil
- Regulations of the sanitary quality of the drinking water
- Decree on Watercourses classification
- Low about Ministries
- Law on local self-government
- Law on activities of municipalities
- Law on determining certain competencies for autonomous province

- Law on hydro-meteorological affairs of interest for the whole country
- Regulation on detailed conditions which must be fulfilled by professional organisations which perform emissions and imissions measurement
- Regulations on establishing networks and work programs of meteorological stations of interest for the whole country
- Regulation on Trashhold values, imission measuring methods, and criteria for setting-up of measuring points and data evidention
- Regulation on Emission Trashhold Values, Method and Deadlines for measuring, and data collecting
- Regulations on methods and minimum number of wastewater quality testing
- Regulations on methodology for chemical accident risk and environmental pollution assessment preparatory measures and measures for remediation consequences
- Decree on determining organizations that fulfill conditions for measuring noise in the human environment
- Decree on the Establishment of the Air Quality Control Programme in 2004 and 2005
- Water Master Plan of the Republic of Serbia
- Annual Programmes for Construction, Reconstruction and Maintenance of Water Management Facilities and Programmes for Construction, Reconstruction and Maintenance of Water Management Facilities.
- Annual Decree on the water use tax, water protection tax and tax on excavation of construction materials from water bodies.

etc.

## (Supporting Data B)

The measurement items of surface water related to Hydrology Monitoring by the Hydrometeorology Institute are selected 36-63 items from the following items on the measurement program which is planned every year and is executed.

Flow rate (water level, flow volume), Temperature (water, air), Sensory examination items (appearance, stench, color), Particle items (degree of clearness, turbidity, suspended solids, [subsidence materials, evaporation residue]), Oxygen items (dissolved oxygen, dissolved oxygen saturation rate), Carbonate and acid degree-alkalinity (alkalinity, water hardness, carbon dioxide, carbonate, hydrogen carbonate, calcium carbonate), Electrochemical items (pH, EC, Total dissolved natrium chloride), Nitrogen items (ammonia nitrogen, the nitrate nitrogen, the nitrite nitrogen, organic nitrogen, total nitrogen), Nutrient items (phosphoric phosphorus, total dissolved phosphorus, total phosphorus), silicate (dissolved silicate), Cation of inorganic element (Na, K, Ca,

Mg), Anion of inorganic element (Cl, $SO_4$, CN, S), Macro elemental metal (Fe, Mn, dissolved Fe, dissolved Mn), Micro elemental metal (Zn, Cu, total Cr, $Cr^{6+}$, Pb, Cd, Hg, Ni, dissolved Zn, dissolved Cu, dissolved Cr, dissolved $Cr^{6+}$, dissolved Pb, dissolved Cd, dissolved Hg, dissolved Ni), Semimetal and nonmetal (As, dissolved As), Organic items (BOD5, COD-$KMnO_4$, COD- $K_2Cr_2O_7$, TOC, anion surfactant, total petroleum hydrocarbon, polycyclic aromatic hydrocarbon (furuoraten, benz(b) furuoraten, benz(k)furuoraten, benz(a)pairen, benz(ghi)perylene, indino(1,2,3-cd) pairen), Phenols, PCBs(PCB28, PCB52, PCB101, PCB138, PCB153, PCB180, PCB194), Tannin, Absorption materials at 254nmUV, Organic chlorine insecticide ( $\alpha$ -HCH, $\beta$ -HCH, $\gamma$ -HCH, hexachlorobenzene, heptachlor, heptachlor epoxide, apurin, endrin, DDE, dieldrin, p,p'-DDD, p,p'-DDT, o,p'-DDT, methoxychlor), Herbicide (atrazine、simazine、propazine), Radioactivity index (total beta dose), Bio-indicator (pollution class index by Pantle-Buck method, chlorophyl a), Bacteriological index (coliform bacteria group, spoilage microorganism indicator)

**Measurement Items of Underground Water Monitoring Network**

30 measurement items of the underground water quality which the Hydrometeorology Institute executes are water level, water temperature, temperature, pH, EC and the ions to request chemical composition formula of Kurlov and Geochemical diagram of underground water. Those are decided independently from a hydrology viewpoint.

Formula of the water chemical composition (Kurlov) is shown as following.

FORMULA OF THE WATER CHEMICAL COMPOSITION
(Kurlov)

$$CO^{2}_{0.03}\ M_{0.72}\ \frac{HCO^{3}_{80}\ SO^{4}_{14}}{Ca_{56}\ Na{+}K_{23}\ Mg_{21}}\ T_{15.4}$$

Note: $CO_2$ (g/l); M (g/l); T (°C);
Anions and cations (% ekv.).