No.

The Study on Geological Mapping and Mineral Information Service Project for Promotion of Mining Industry in the Republic of Zambia

Final Report

July 2009

JAPAN INTERNATIONAL COOPERATION AGENCY

INDUSTRIAL DEVELOPMENT DEPARTMENT

IDD
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09-041

PREFACE

In response to a request from the Government of Republic of Zambia, the Government of Japan decided to conduct the Study on Geological Mapping and Mineral Information Service Project for Promotion of Mining Industry in the Republic of Zambia, and the Study was implemented by the Japan International Cooperation Agency (JICA).

JICA selected and dispatched a study team headed by Mr.Masaharu Marutani of Mitsui Mineral Development Engineering Co., Ltd.(MINDECO), and consist of MINDECO and Nikko Exploration and Development Co.,Ltd. to Zambia between Jan. 2007 and June.2009.

The team held discussions with the officials concerned of the Government of Zambia and conducted field surveys at the study area. Upon returning to Japan, the team conducted further studies and prepared this final report.

I hope that this report will contribute to further sustainable development of mining sector in Zambia with investment promotion and to the enhancement of friendly relationship between our two countries.

Finally, I wish to express my sincere appreciation to the officials concerned of the Government of Zambia for their close cooperation extended to the study.

July 2009

Seiichi Nagatsuka
Deputy Vice President
Japan International Cooperation Agency

Seiichi NAGATSUKA
Vice President
Japan International Cooperation Agency

Letter of Transmittal

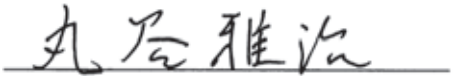
It is with great pleasure that we submit to you this final report on the Study on Geological Mapping and Mineral Information Service Project for Promotion of the Mining Industry in the Republic of Zambia.

Under contract with your organization, this study was carried out by Mitsui Mineral Development Engineering Co. Ltd. (MINDECO) for 30 months, from January 2007 to July 2009. This report is an overview of the study, which was conducted to provide and organize information about the geology and mineral resources of Zambia in order to attract more investment in that country's mining sector. To help achieve this goal, the results of the study will be publicly released, both in Zambia and in other countries, and the capacity development of the Geological Survey Department, an agency of the Ministry of Mines and Minerals Development, will be enhanced.

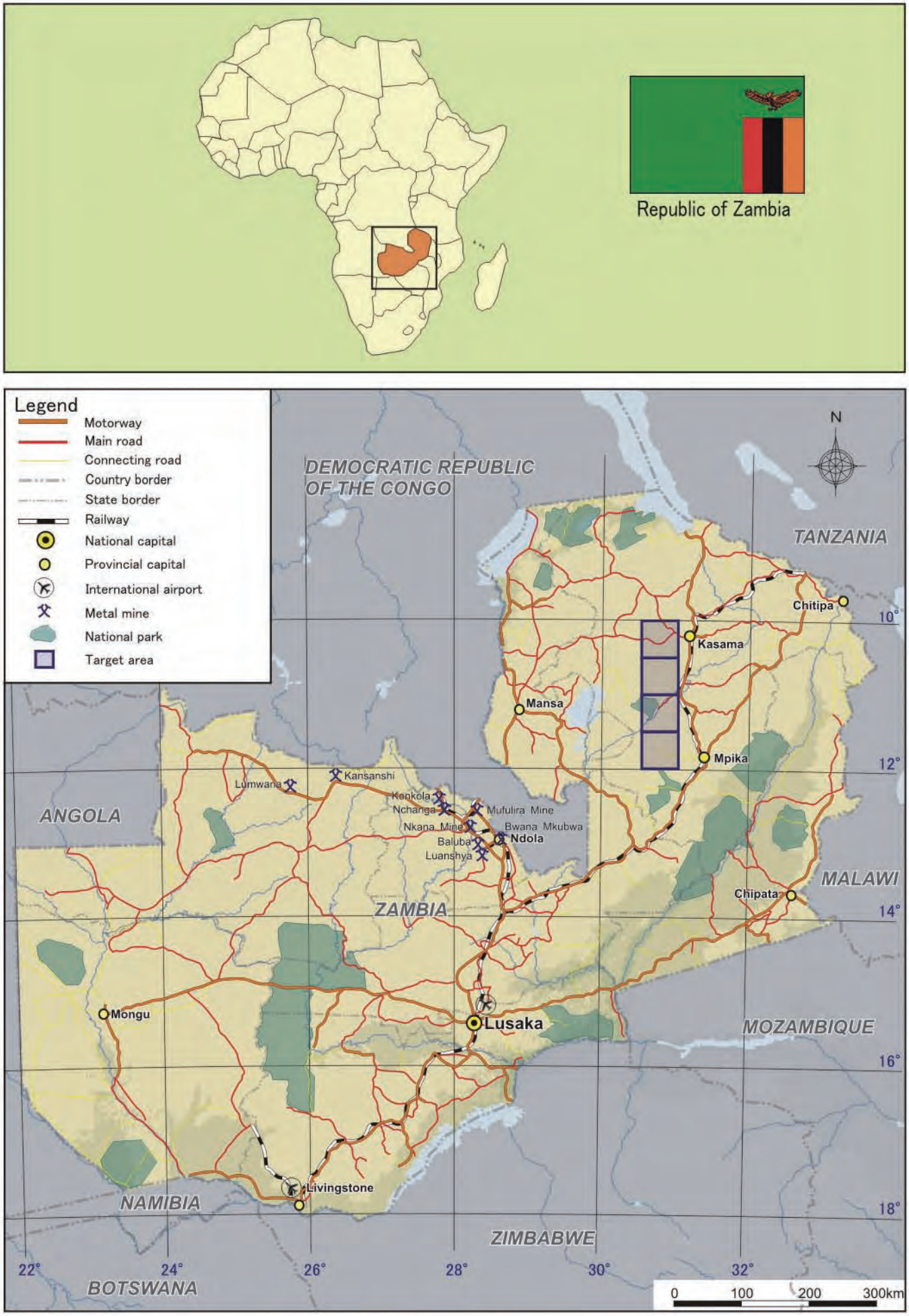
The ultimate goal of this study is to provide information on the geology and mineral resources of Zambia to promote investment in that country's mining sector. Even after the completion of the study, we would like to encourage the Geological Survey Department to continue to address investment promotion. For this purpose, during the study we undertook a series of collaborative tasks with our GSD counterparts such as conducting geological field surveys and creating geological and mineral resource maps. It is our hope that the GSD will be able to sufficiently apply the results of capacity development derived from this study to its future work.

In closing, we would like to express our sincere gratitude to your organization, the Japanese Ministry of Foreign Affairs, and the Japanese Ministry of Economy, Trade and Industry for yours and their support and guidance with this project. We would also like to thank all related organizations such as the Zambian Government, the Ministry of Mines and Minerals Development, and the Geological Survey Department, as well as the Japanese Embassy in Zambia and the JICA Zambia Office for their assistance and support in carrying out this study.

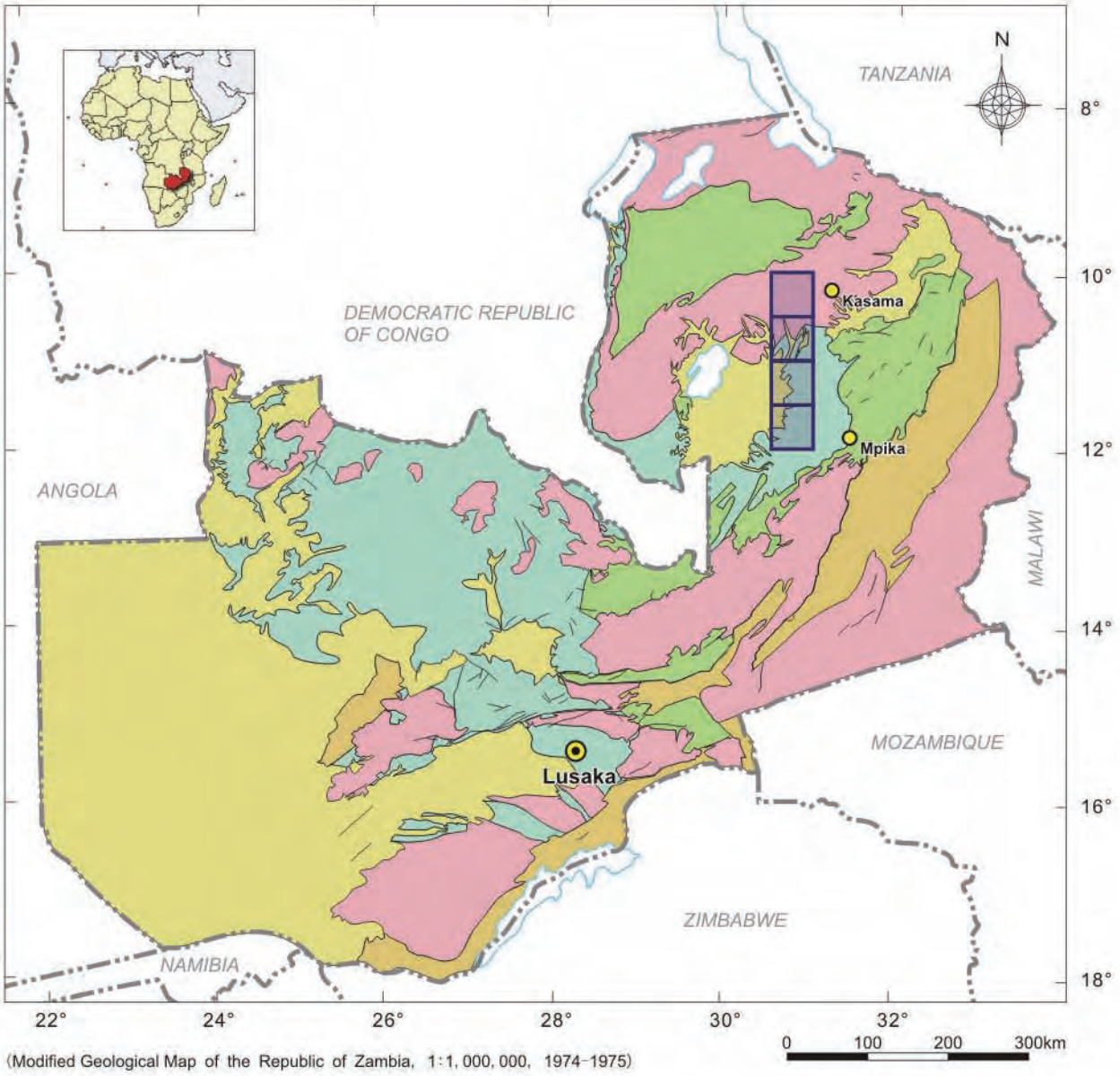
July 2009



Masaharu Marutani
Team Leader
Study on Geological Mapping and
Mineral Information Service Project
for Promotion of the Mining Industry
in the Republic of Zambia



Location of Zambia

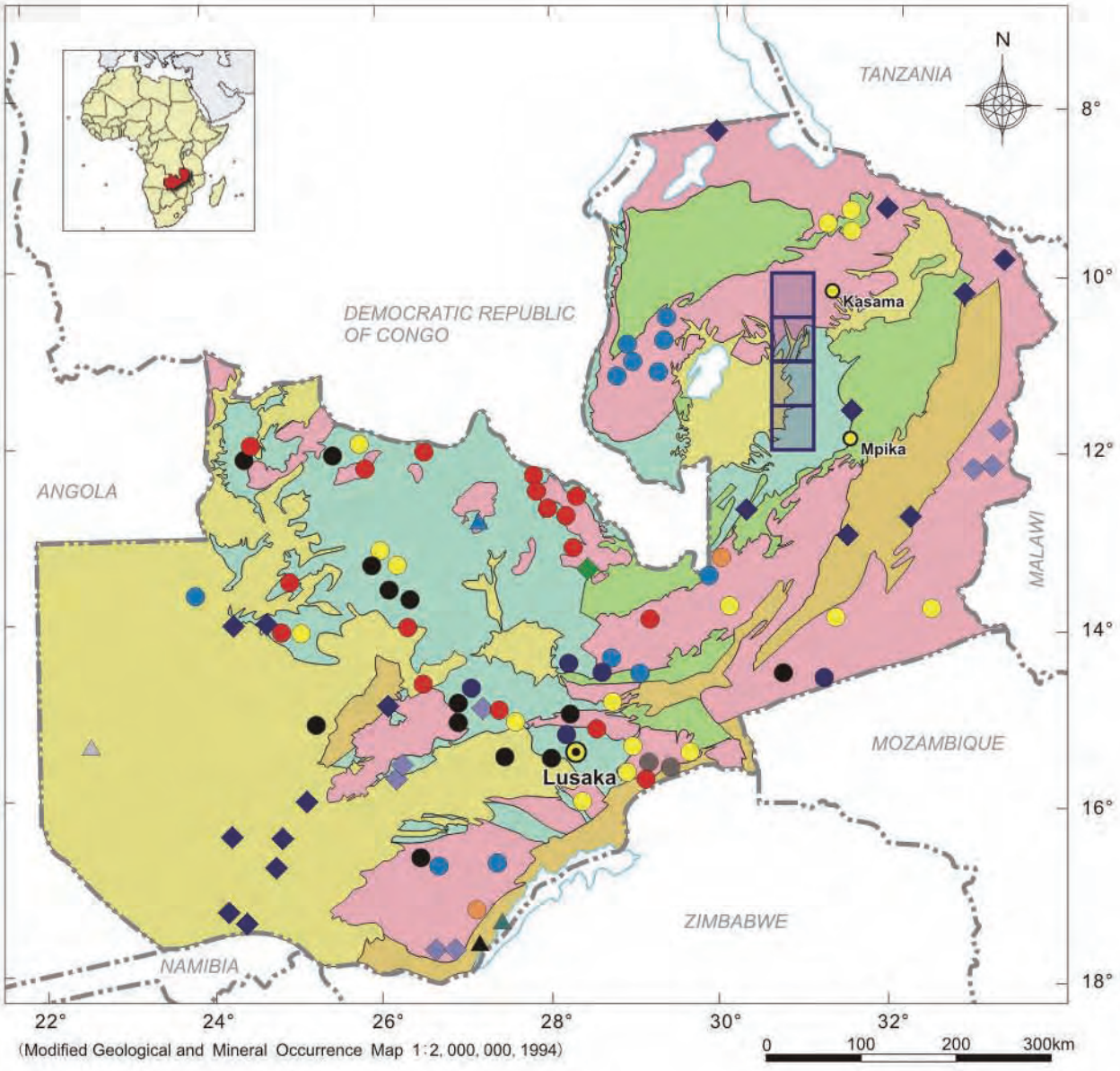


(Modified Geological Map of the Republic of Zambia, 1:1,000,000, 1974-1975)

GEOLOGY LEGEND

Post Karoo	Tertiary to Recent continental clastic sediments
Karoo Supergroup	Upper Carboniferous to Jurassic continental clastic sediments and volcanics
Upper Proterozoic to Cambrian	Metamorphosed pelites, psammites and carbonates of the Katanga Surpergroup
Middle Proterozoic	Metamorphosed pelites and psammites of the Muva Surpergroup
Lower Proterozoic	Basement gneiss complex including Archean lithologies
Lake	Fault
Target area	

Geology of Zambia



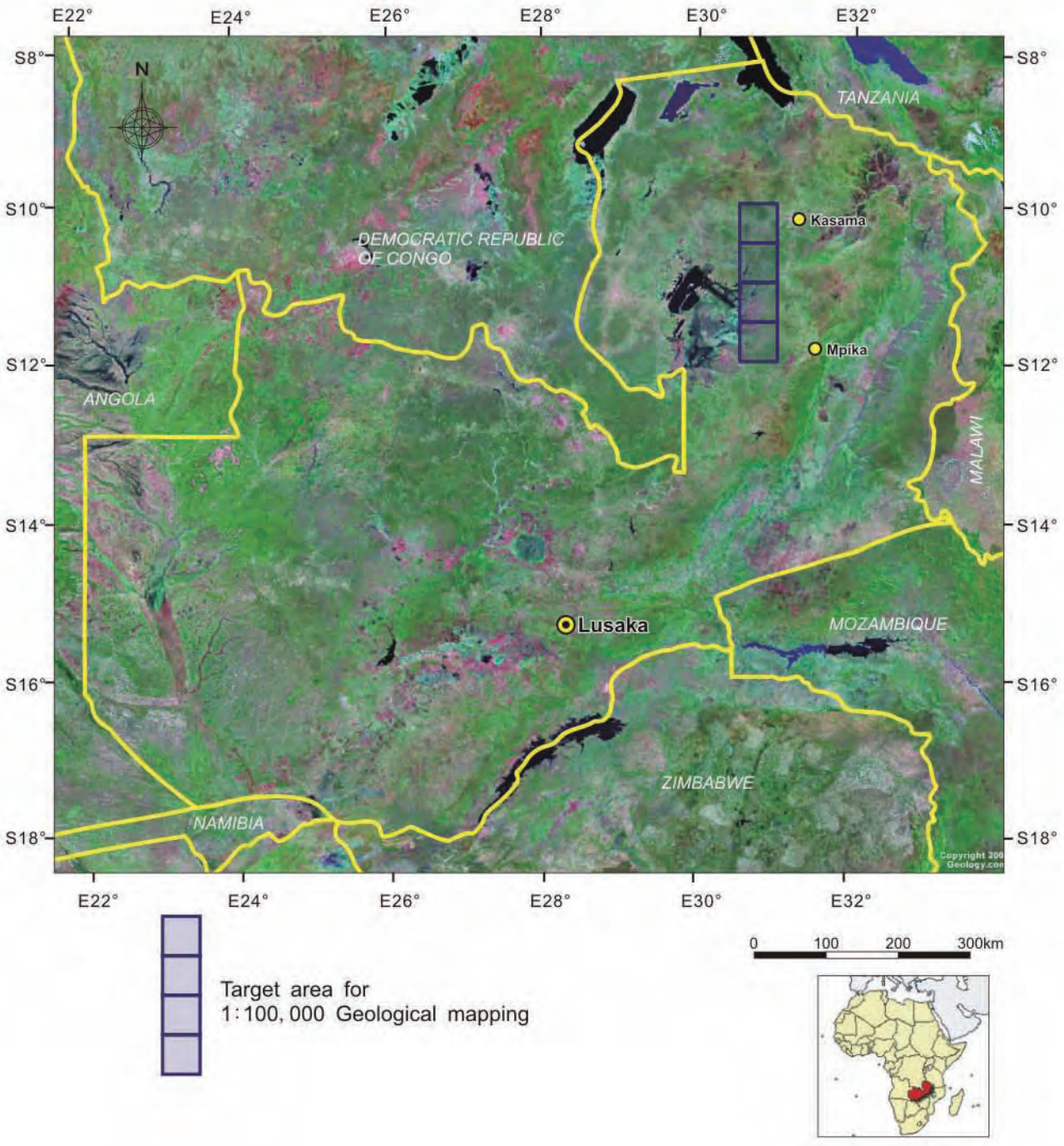
(Modified Geological and Mineral Occurrence Map 1:2, 000, 000, 1994)

LEGEND

Post Karoo	Tertiary to Recent continental clastic sediments
Karoo Supergroup	Upper Carboniferous to Jurassic continental clastic sediments and volcanics
Upper Proterozoic to Cambrian	Metamorphosed pelites, psammites and carbonates of the Katanga Surpergroup
Middle Proterozoic	Metamorphosed pelites and psammites of the Muva Surpergroup
Lower Proterozoic	Basement gneiss complex including Archean lithologies
Lake	
Target area	

Copper/Cobalt	Aquamarine
Gold	Emerald
Lead Zinc	Diamond
Nickel	Coal
Tin	Oil,Gas
Manganese	Uranium
Iron	

Distribution of Mineral Deposits and Occurrences in Zambia



Landsat Image of Zambia

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Geological Mapping and Mineral Information Service Project
For Promotion of Mining Industry in the Republic of Zambia
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List of Abbreviation

Abbreviation	English
AIST	National Institute of Advanced Science and Technology
ASTER	Advanced Spaceborn Thermal Emission Reflection Radiometer
BGS	British Geological Survey
C/P	Counterpart
CAD	Computer Aided Design
CMZ	Chamber of Mines of Zambia
DB	Database
EBZ	Export Board of Zambia
EPMA	Electron Probe MicroAnalyzer
ERIPTA	Economic Recovery and Investment Project Technical Assistance
EU	European Union
FOB	Free on Board
Ga	Giga-annum
GDP	Gross Domestic Product
GIS	Geographical Information System
GPS	Global Positioning System
GSD	Geological Survey Department
HRA	Human Resources and Administration
ICP-AES	Inductively Coupled Plasma - Atomic Emission Spectrometry
ICP-MS	Inductively Coupled Plasma - Mass Spectrometry
INDABA	INDABA
IPPA	Investment Promotion and Protection Agreement
JOGMEC	Japan Oil, Gas and Metals National Corporation
LAN	Local Area Network
M/M	Minutes of Meeting
Ma	Mega-annum
MDD	Mining Development Department
MFEZ	Multi-Facility Economic Zones
MIGA	Multilateral Investment Guarantee Agency
MMMD	Ministry of Mines and Mineral Development
MSD	Mines Safety Department
MSDP	Mining Sector Diversification Programme
NASA	National Aeronautics and Space Administration
NTMS	Non-traditional Mining Sectors
PDAC	Prospectors and Developers Association of Canada
PGE	Platinum Group Elements
S/W	Scope of Work
SADC	Southern African Development Community
SEDB	Small Enterprises Development Board
SEED	Support to Economic Expansion and Diversification
SHRIMP	Sensitive High Resolution Ion Microprobe
SRTM/DEM	Shuttle Rader Topographic Mission - Digital Elevation Model

List of Abbreviation

Abbreviation	English
UAE	United Arab Emirates
UTM	Universal Transverse Mercator
WGS84	World Geodetic System 1984 Datum
ZAMCOM	Zambian Institute Mass Communication
ZAWA	Zambia Wildlife Authority
ZCCM	Zambia Consolidated Copper Mines
ZDA	Zambia Development Agency
ZESCO	Zambia Electricity Supply Corporation
ZIC	Zambia Investment Centre
ZPA	Zambia Privatisation Agency

Chapter 1 Overview of the Study

1.1 Background of the Study

Zambia is rich in mineral resources such as copper and cobalt, and mining is one of its most important industries. Mining has a major impact on the country's economy, as seen in the 1990s when the price of copper was depressed and the Zambia Consolidated Copper Mines (ZCCM) went into decline, leading to economic stagnation. However, with the privatization of ZCCM in 2000 and the rapid rise of copper prices that began in 2003, the mining sector has been revitalized, with copper mines being reopened and new copper mines being developed.

But Zambia has more than just copper and cobalt – it also has very high potential for such minerals as lead, zinc, gold, and nickel. In terms of providing steady employment and acquiring hard currency, the mining sector is quite important in Zambia, and its development should make a significant contribution toward reducing poverty in that country.

From the late 1950s to the 1970s, geological surveys were conducted with assistance from the United Kingdom, and in the 1990s they were conducted with assistance from the EU, World Bank, and others. As a result of these surveys, 1:100,000 geological maps were compiled, covering 58% of the country. However, no detailed surveys have been made of the remaining 42%, so it is not possible at this time to evaluate the mineral potential of the latter area.

Information on Zambian mineral resources is being managed by the Geological Survey Department (hereafter GSD) of the Ministry of Mines and Mineral Development (hereafter MMMD). However, because of GSD's limited capacity, there is no integrated management of data obtained from geological, geochemical, and physical surveys, and there is no system that can provide effective administrative services. In order to promote mine development through private sector investments, GSD will have to take a leading role in facilitating private investments and developing and disclosing necessary information on mineral resources.

Against this backdrop, the Zambian Government requested the Government of Japan to implement the "Study on Geological Mapping and Mineral Information Service Project for the Promotion of the Mining Industry" in 2005. In response to this request, the Japan International Cooperation Agency (hereafter JICA) signed a scope of work agreement for the study with MMMD in December, 2006.

1.2 Purposes of the Study

The main purposes of the present study are to promote investment in the Zambian mining sector by developing information related to the geology and mineral resources of Zambia and disclosing it

inside and outside the country, and to enhance the capacity of GSD, which plays a leading role in mineral resources development. At the same time, the study is designed to transfer technology to GSD for conducting geological and mineral resource surveys. Specifically, this entails the following:

1) Revising the existing 1:1,000,000 geological and mineral resource maps and explanations for the entire country.
2) Compiling 1:100,000 geological maps and explanations of target areas from the results of field geological surveys and analysis and interpretation of satellite and other images.
3) Revising and developing the GIS database for mineral resource development.
4) Transmitting mineral resource information through domestic and international seminars.
5) Nurturing human resources at GSD to support the above activities.

1.3. Target Area of Study

The target area for the study is the entire country of Zambia. However, the target of the 1:100,000 geological map compilation ("geological survey areas") will be 4 districts in Northern Province of Zambia located between 10º and 12ºS and 30º 30'and 31º E.

1.4 Method and Content of Study

This survey was divided into 3 phases: Phase A, involving preparation for the compilation of geological maps; Phase B, involving the actual compilation of geological maps; and Phase C, involving the development of resource information for promoting investment.

In Phase A (preparation for the compilation of geological maps), there was a review of geological and mineral resource information, and preparations of revisions were made to 1:1,000,000 geological and mineral resource maps. At the same time, field geological surveys, satellite image analyses and image interpretation were conducted in geological survey areas, and preparations were made to compile 1:100,000 geological maps.

In Phase B (compilation of geological maps), revisions of 1:1,000,000 geological and mineral resource maps and explanations continued, field geological surveys were conducted in geological survey areas, 1:100,000 geological maps in the northern 2 districts were compiled. Hereafter, a GIS database, including the obtained geological and analytical data, will be revised and developed.

In Phase C (development of resource information for promoting investment), the 1:1,000,000 geological and mineral resource maps and explanations, and the 1:100,000 geological maps in the southern 2 districts and explanations will be completed, and a series of geological maps will be

prepared. The study results will be presented and information on Zambian mineral resources will be provided at investment promotion seminars in Zambia and Japan, and at international events such as the INDABA exposition in South Africa and the PDAC convention in Canada, in order to promote investment.

The samples collected during the field surveys over the course of the 3 phases will be subjected to chemical analyses. The results will be statistically interpreted to enhance the capacity of and transfer analysis technology to the counterparts. These samples will also be subjected to mineral tests and used as materials for constructing deposit models.

It should be noted here that even after the study has been completed, capacity will be further developed through on-the-job training, seminars, and personal instruction so that the GSD will be able to continue to compile geological maps and develop resource information. The main items of the survey will be as follows:

Phase A: Preparations for Compiling Geological Maps

- Understanding the current state of the mining sector in Zambia and reviewing existing geological and mineral resource information
- Revising existing 1:1,000,000 geological and mineral resource maps and explanations
- Undertaking preliminary field geological surveys in the geological survey areas for compiling 1:100,000 geological maps
- Analyzing satellite images and interpreting other images of the geological survey areas

Phase B: Compilation of Geological Maps

- Undertaking field surveys, compiling 1:100,000 geological maps and explanations
- Undertaking chemical analyses of samples taken during field surveys, conducting mineral tests
- Revising and developing a GIS database related to mineral resource development, including geological and analytical data obtained from geological surveys

Phase C: Development of Resource Information for Promoting Investment

- Completing 1:1,000,000 geological and mineral resource maps and explanations
- Completing 1:100,000 geological maps and explanations
- Presenting research results in investment promotion seminars in Zambia and Japan, and at international events such as INDABA and PDAC
- Nurturing human resources who can continue the above tasks even after the present survey has ended.

1.5 Site Study

(1) Implementation of the Study

- The first site study was carried out from 24 February to 8 March, 2007 (13 days), the first part of the second study lasted from 10 June to 6 July, 2007 (27 days), the second part of the second study – from 8 August to 29 November, 2007 (114 days). The third study was conducted from 29 June to 25 November, 2008 (150 days), the fourth study was undertaken from 6 January to 15 February, 2009 (41 days). The fifth study lasted from 26 February to 7 March, 2009 (10 days). The sixth study was implemented from 25 May to 4 June, 2009 (11days). The JICA study team completed the site study as scheduled.
- One senior staff member joined the team from the National Institute of Advanced Science and Technology (AIST) in the second (2) site study.

(2) Study Team Members

The assignments and study periods for each member were as follows (Table 1.5.1):

Table 1.5.1 List of Team Members

Name	Assignment	First Site Study	Second Study (part 1)	Second Study (part 2)
Marutani, Masaharu	Leader/ Investment promotion	24.2.2007 to 8.3.2007	10.6.2007 to 3.7.2007	14.8.2007 to 6.9.2007 7.11.2007 to 26.11.2007
Hirose, Kazuyo	Geology A	24.2.2007 to 8.3.2007	10.6.2007 to 6.7.2007	8.8.2007 to 29.11.2007
Inoue, Toshio	Geology B	24.2.2007 to 8.3.2007	10.6.2007 to 6.7.2007	8.8.2007 to 29.11.2007
Watanabe, Hidehisa	GIS database	–	10.6.2007 to 29.6.2007	19.8.2007 to 25.9.2007
Fujii, Noboru	Coordinator	–	12.6.2007 to 27.6.2007	–

Name	Assignment	Third Site Study	Fourth Site Study	Fifth Site Study	Sixth Site Study
Marutani, Masaharu	Leader/ Investment promotion	29.6.2008 to 31.7.2008 13.9.2008 to 15.11.2008	15.1.2009 to 15.2.2009	–	25.5.2009 to 4.6.2009
Tsushima, Norio	Geology A	29.6.2008 to 15.11.2008	13.1.2009 to 15.2.2009	–	–
Takebe, Akimitsu	Geology B	29.6.2008 to 15.11.2008	13.1.2009 to 15.2.2009	26.2.2009 to 7.3.2009	25.5.2009 to 4.6.2009
Watanabe, Hidehisa	GIS database	29.6.2008 to 25.7.2008 6.11.2008 to 25.11.2008	6.1.2009 to 30.1.2009	–	–

Management supervisor

Name	Assignment	Second Study (part 2)	Sixth Site Study
Ehara, Yushiki	Planning/Coordination	18.11.2007 to 25.11.2007	25.5.2009 to 2.6.2009
Watanabe, Yasushi	Geological Survey Plan	18.11.2007 to 25.11.2007	–

(3) Minutes from Meetings with the Zambian Side

The Japanese Team had three meetings with the Steering Committee, which represented the Zambian side in the "Study on Geological Mapping and Mineral Information Service Project for the Promotion of the Mining Industry in the Republic of Zambia", and reached agreements on the following (minutes presented in Appendix I-1, I-2 and I-3):

a. The First Steering Committee meeting (5 March, 2007)

- The contents of the Inception Report and study schedule;
- Overview of domestic and international seminars;
- Approval of the Inception Report

b. The Second Steering Committee meeting (9 July, 2008)

- Confirmation and adoption of the minutes of the First Steering Committee meeting
- Summary of the Interim Report, and approval of the Report
- Results of field program in 2007
- Project program in 2008 and Investment promotion programs

c. The Third Steering Committee meeting (29 January, 2009)

- Summary of the Draft Final Report, and approval of the Report with comments of the Zambian side.
- Further investment promotion programs

(4) Organization of the Workshop and Lecture

A workshop was held for the purpose of technology transfer, with the following schedule:

- Database, GIS and Remote Sensing Workshop (Appendix I-4)

  23 August, 2007 at the Conference room of ZAMCOM

  - The GIS database expert and remote sensing expert from the Team explained about the basics of the database and vector data type. The experts also talked about the principles of remote sensing and gave some examples of remote sensing analysis, and provided technical instruction. In attendance were a total of 20 participants from GSD.
- Special lecture on apatite: a possible source of rare earth elements (Appendix I-5)

  20 November 2007 at the Conference room of the GSD

  - Dr. Y. Watanabe of the Geological Survey of Japan, AIST, explained about the demand for rare earth elements in the world, several types of deposits from which rare earth elements are extracted and the possibility for rare earth production from apatite. In attendance were a total of 10 participants from GSD.
- Practical Workshop of GIS and GPS (Appendix I-6)

  10 July, 2008 at the Conference room of ZAMCOM

  - The GIS database expert and two senior geologists from the Team explained about the

basics of GIS, and showed how to create a geological map with Arcview, and digitize a geological map with TNT Mips, and talked about the GPS data processing method and gave some examples of geological field surveys. In attendance were a total of 13 participants from GSD.

- Seminar on Geological Mapping (Appendix I-7)

  11 November, 2008 at the Conference room of ZAMCOM

  - Two senior geologists from the Team and a geologist from the GSD explained about the results of the geological field survey, the analytical results of the geochemical survey and comprehensive analysis, and presented four new sheets of 1:100,000 geological maps. There were 16 participants from the GSD in attendance.

- Draft Final Seminar (Appendix I-8)

  27 January, 2009 at the Amalila conference room of the Taj Pamodzi Hotel

  - The results of this study were presented by the leader, two senior geologists and a GIS expert from the Team, together with a senior geologist from the GSD. They presented a summary of the study, the results of the geologic dating, the analytical results of the geochemical survey, the GIS database, and comprehensive analysis. A total of 39 participants including 16 participants from the GSD and 4 participants from MMMD headquarters were in attendance. The seminar deepened their understanding of the role and results of the study.

(5) International Seminar

- Seminar for Promoting Investment in Zambia (Appendix I-9)

  16 December, 2008 at the Toyo Conference Room of the Japan Oil, Gas and Metals National Corporation (JOGMEC)

  - In order to give potential Japanese investors a good understanding of the investment climate and mineral resources potential of the Zambian mining sector, an investment seminar was held in Tokyo under the auspices of the Zambian Embassy, JICA, and JOGMEC. The Zambian government was represented by the Director and a senior officer of the ZDA, and the Director and two senior officers of the GSD. There were a total of 60 participants, including representatives of leading Japanese trading companies, major banks and mining companies, and governmental mining related organizations and institutes.

- Mining INDABA (Appendix I-10)

  9 February to 12 February, 2009 at the Cape Town International Convention Centre

  - At Mining INDABA 2009, the Team set up a Zambian display booth to explain about the investment climate in the mining sector and the mineral resources potential for international investors, and to promote investment in exploration in Zambia.

Representatives included the Director and a senior geologist from GSD, a senior privatization officer from ZDA, and the Team Leader and two senior geologists from the Team. A total of 300 people from mining, exploration, banking, and investment companies visited the Zambian booth.

- PDAC (Appendix I-10)

  1 March to 4 March, 2009 at the Metro Toronto Convention Centre

  - At PDAC 2009, the Team also set up a Zambian booth to explain about the investment climate in the mining sector and mineral resources potential for international investors, and to promote investment in exploration in Zambia. The Representatives included the Director and a chief geologist from GSD, and a senior geologist from the Team. A total of 200 people from mining, exploration, banking, and investment companies visited the Zambian booth.

- Investment Seminar in Zambia

  During the 6th site survey, a seminar will be set up in late May, 2009.

  - The Team Leader and a senior geologist will represent the Team at the Copperbelt Mining, Agricultural and Commercial Show in Kitwe city in Copperbelt province, and will explain about the results of the study to people from mining and exploration companies at the MMMD booth.

1.6 Geological Field Surveys

In order to define the method and implementation plan for the geological field surveys, a preliminary survey was conducted in the target area in Northern Province during the first site study (Table 1.6.1).

Table 1.6.1 Geological Field Surveys

Fiscal Year	Study Period	Survey Area	Survey Type	Members		Survey Schedule
				Japanese	Zambian	
The 1st year	First site study period	North 1 area	Preliminary	Marutani, Hirose, Inoue	Dokowe	2. 3.2007 to 4.3.2007
The 2nd year	Second site study (part 1) period	North 2 areas	Reconnaissance	Hirose, Inoue, Fujii	Dokowe, Mwale, Mwila	20. 6.2007 to 26. 6.2007
		South 2 areas	Reconnaissance	Hirose, inoue, Fujii	Dokowe, Mwale, Mwila	27. 6.2007 to 2. 7.2007
	Second site study (part 2) period	North 2 areas	Geological survey	Hirose, Inoue	Dokowe, Banda Mwale, Kasumba	27. 8.2007 to 9. 11. 2007
The 3rd year	Third site study period	South 2 areas	Geological survey	Takebe, Tsushima	Dokowe, Chibesakunda	15. 7.2008 to 12.9.2008
		North 2 areas	Geological survey	Takebe, Tsushima	Chibesakunda	12. 9.2008 to 25.9.2008

Based on the implementation plan, reconnaissance geological surveys were carried out in four target areas during the first part of the second site study. In the second part of the second site study, 1:100,000 scale geological field surveys were implemented in two northern survey areas. In the third site study, 1:100,000 scale geological field surveys were carried out in two southern survey areas. The survey group was composed of JICA study team members and counterparts from GSD. Several technologies for survey methods and drawing of route maps were transferred to the counterparts through the geological field surveys.

1.7 Steering Committee

The Members of the Steering Committee, consisting of representatives of GSD, MDD and MSD, are shown in Table 1.7.1.

Table 1.7.1 Members of the Steering Committee

	Name	Title, Organization
Chairman	Mr. Kennedy Liyungu	Director, Geological Survey Department
Member	Mr. Charles Dindiwe	Chief Mining Engineer, Mineral development Department
Member	Mr. B. Chewe	Ag. Snr Inspector of Explosives, Mines Safety Department

1.8 Nurturing human resources

1.8.1 Skill levels of the counterpart (C/P) members at the beginning of this study

1) Field geological survey techniques

- Listings of items for geological field surveys were not uniform because the lack of a standard form.
- The counterparts' ability to use handy GPS receivers in field surveys was mainly restricted to the positioning function. They did not have sufficient know-how to effectively incorporate GPS measurement results into GIS.

2) Editing of geological maps

- Although C/Ps had learned basic methods for using GIS software, they had not achieved a level that was sufficient for creating publishable maps (lack of experience).

3) GIS database

- The registered mineral resource database was not sufficiently understood by the GSD database engineer.
- Two-thirds of registered mineral occurrences data had a significant lack of supplementary information (ex. coordinate data)
- In data searches, there were difficulties in finding the data that were being sought (problems with the data output format)

4) Providing information on Zambia's resources

- GSD personnel had no experience in providing information to investors at international conferences, etc.
- GSD personnel had insufficient experience in discussing pertinent topics with investors.

1.8.2 Technology transfers made through the study and their results

The following technology transfers were conducted through the site study for the purpose of improving C/Ps' skill levels mentioned above.

- Technology transfer through the Practical Workshop
- Technology transfer through geological field surveys
- Technology transfer through field data processing and reporting
- Assistance with the Seminar for Promoting Investment in Zambia (Tokyo) geared toward Japanese investors
- Assistance with promotional activities at international conferences (INDABA, PDAC)
- Assistance with providing information at a domestic seminar in Zambia (Copperbelt Show)
- Technology transfer for revising the GIS database

The details of transfers and their results are described below.

(1) Technology transfer through the Practical Workshop

a) GIS Course for Geologists

"Geology A" of the study team made the following presentation about GIS software, using Arcview as an example.

- Basics of GIS

Explanations were given about the definition of GIS and specific examples, data format of GIS, and projective methods.

- Creation of a geological map using Arcview

Explanation about the procedure for using GIS to create a geological map from field survey data.

- Applications of GIS to geological surveys

Explanations were given about importing previous geological information and field survey results, and conducting data analyses using GIS software.

- Practical training

In addition to lectures, counterpart engineers got practical experience by receiving hands-on software training on actual PCs at the GSD.

b) Methods for processing GPS data in the outdoor (field) survey

Geology B Team Members gave a presentation about methods for using a handy GPS receiver.

- There was an explanation about how coordinate data for the planned survey points, the plan for taking samples, etc., were uploaded into a GPS receiver and the procedure by which the data were used for field navigation.
- There was a presentation about the method for downloading GPS data into a PC.

The presenter explained about downloading point coordinates, reconnaissance survey route data, etc., obtained with a GPS receiver into a PC, while keeping in mind the incorporation of field survey data into GIS

- Demonstration

GPS was operated in an actual setting outside the presentation hall, and a demonstration was given of how data were processed in a PC.

c) Overview of TNT Mips and Methods for Use

The GIS Database Team made the following presentation on GIS software, using TNT Mips as an example.

- Method for displaying spatial information

The Team explained about the basics of TNT Mips, method for installing software, creating a data structure, and method for displaying spatial information with TNT Mips.

- Digitization of geological maps

The Team explained the procedure required for creating digital geological maps, including inputting geological map data using TNT Mips, assigning coordinates, and creating vector data.

(2) Technology transfer in the geological field survey

The following types of technology transfers were made during the field survey in Northern Province

- Effective field study planning

Every day, road and topographical information, locations of rivers that might be obstacles, etc., were extracted from satellite image data, and plans for an effective survey route for the next day were formulated based on the estimated distribution of outcrops. Technology transfer was made regarding the procedure.

- Methods for using GPS

Technology transfer was also made regarding methods for uploading next-day survey plans onto GPS and downloading acquired coordinate data into a PC.

- Introduction of outcrop lists, sheets for taking samples for geochemical surveys

Technology transfer involved introducing formatted outcrop lists and sheets for taking samples for geochemical surveys and methods for systematically acquiring and arranging geological

observation information.

- Methods for managing sample IDs

  In order to prevent discrepancies in sampling, technology was transferred for serializing sample IDs, and a ticket system was introduced (in which sample IDs are entered on the list sheet beforehand and inserted as a ticket into the sample bag when the sample is collected; this can prevent unintentional redundancy of numbers, mistakes in transfer, etc.

3. Technical transfer for collecting and processing field geological survey data

- Here, the technology transfer involved creating route maps, compiling data, and creating geological maps.
- A cooperative effort was made to prepare survey reports and create an instruction manual for geological maps

(4) Assistance with the Seminar for Promoting Investment in Zambia (Tokyo)

The seminar held in Tokyo was attended by one representative each from GSD and ZDA, who gave presentations on the investment climate in the Zambian mining sector and the country's mineral resource potential. This seminar produced the following results:

- It demonstrated that Japanese companies are highly interested in the Zambian mining sector: more than 60 representatives from Japanese trading companies, banks, mining companies, and government organizations attended the seminar.
- Through the presentations, Japanese participants were able to get more than a general overview of Zambia—for example, they learned much about the country's strengths, such as political and social stability, and a highly accommodating attitude toward attracting investment.
- Reference materials distributed to attendees included the Zambian Mining Journal Supplement and an investment promotion CD.
- Discussions with attendees provided the counterparts with a clear understanding of the information that Japanese companies require (such as specific conditions, infrastructure, etc.).

The seminar provided a way for the Zambian side and Japanese companies to begin directly exchanging information.

(5) Support for providing information at international conferences (INDABA, PDAC)

By engaging in discussions with investors at INDABA, PDAC and collecting information from related government organizations from other countries, the participating counterparts were able to

obtain the following perspectives

- They became aware of the importance of continuously providing information for promoting investment
- They became aware of the specific types of information that investors demand.
- They became aware that providing opportunities for junior companies, major companies and finance organizations to get together is very effective for promoting the development of the Zambian mining industry.
- Visitors to the booth were given a copy of the Zambian Mining Journal Supplement and attendees were given an investment promotion CD. There was also disclosure of the results of the present development survey.

(6) Assistance at a domestic seminar in Zambia (Copperbelt Show)

There was a booth with exhibits at the Copperbelt Show held in Kitwe, which provided the following results:

- In addition to mining and investment companies, the booth attracted visitors from related Japanese companies. This was an excellent opportunity to present visitors with the results of the present development study.
- This was also an opportunity to introduce the revisions made to the 1:1,000,000 geological and mineral resource maps to people involved with the Mopani Mine, the Konkola Mine, and the mining association.

An explanation of the results of the present survey could be made directly to Deputy Minister Beene of the Ministry of Mines and Minerals Development. Due to the success of the Mining Journal Zambia Supplement, the Deputy Minister expressed the desire to have a revised edition published at the next opportunity.

(7) Technology transfer related to the GIS database structure

The following results were obtained by transferring database structure technology to the people in charge of the GSD database:

- Problem points related to the quality of the data stored in the mineral resources database (such as missing data, errors such as overlapping, etc.) were discussed so that everyone at GSD would be aware of them.
- Regarding data reliability, conditions were created to encourage discussion within GSD.
- The counterparts learned that GIS is a tool for displaying and evaluating simple data, and they were able understand how important the data in GIS is. As a result, the GSD side recognized the need to continuously maintain, update, and ensure the quality of GIS data.
- Counterparts were also able to learn about methods for acquiring GIS data, etc., owned by other organizations.

- By changing the format of the data registered in GIS, it became possible to make flexible searches and evaluations.

1.8.3 Important points for future improvement

1) Geological surveys

- Use of PCs and GPS in geological field surveys and processing data in the field.
- Acquiring practical experience for processing survey results, such as converting geological study data to GIS
- Thoroughness in entering data on outcrop and sampling sheets
- Accumulation of practical experience with methods for using GPS equipment (ex data uploading to GPS receivers)
- Enhancing skills for using GIS software

2) Creating geological maps

- Enhancing skills for creating diagrams, etc., for printed manuscripts using software programs such as GIS and CAD.

3) GIS database

- Learning how to reevaluate the contents of the mineral resource database (discovering and fixing data errors, continuous maintenance and management of the database, etc.) and techniques for ensuring their quality.
- At the present time, it is not clear who exactly is in charge of or responsible for managing geological information. In order to meticulously ensure the quality of the data, there must be a clear understanding of who is in charge/responsible for this information (constructing a management system).

4) Provision of information on Zambia's resources

Please refer to the following section for suggestions for promoting investment in Zambia' mining sector, including the provision of resource information

1.9 Suggestions for promoting investment

The following is a recommendation for ways to promote investment in the Zambian mining sector:

(1) Building an exploration report system

Every quarter, the Zambian government, through the MDD of the MMMD, releases reports on the amount of copper, cobalt, etc., that was produced in active mines. However, there is still insufficient effort being made to report on the activities of mines, exploration companies, etc., operating under

the Mining Law, such as yearly length of boring, amount of tunnels and shafts, proven reserves and grade, and the amount of money invested in exploration. For the government, it is difficult to get basic statistical values for exploration work and a clear understanding of the amount of proven reserves broken down by mineral type. These basic statistical values provide objective criteria for judging the ability of the government's mining policies to improve the lives of the citizens, and are also basic values that will have an effect on future revenue generation (tax collection) in national long-term development plans and elsewhere. In the future, it will be necessary to construct and meticulously manage and operate a system for reporting on the amount of exploration work.

(2) Provision of investor-oriented information on a regular basis

- Although various methods and media may be used for providing and conveying mining information to the outside, those which are feasible for the Zambian government are listed below. We believe that it will be important for the MMMD (especially GSD) to form a close working relationship with ZDA to address this issue.
- The latest information about the Zambian mining sector should be provided to investors through such media as web sites, e-mail and periodicals.
- Regular updating of web site

The GSD web site that is currently accessible to the public should be updated regularly to provide the latest information. In addition to information that is already available to the public on the web site, large amounts of the following types of information should also be provided:

- Latest information on exploration projects in Zambia
- Legal system, mining law, tax system (especially royalties)
- Changes, etc., in procedures for acquiring concessions
- Infrastructure information

- Public release of maps showing the state of concession acquisition

Maps should be publicly released on the web site and in other media so that investors can quickly gain an understanding of the state of concession acquisition in Zambia

  - Synopses (available areas, etc.): Should be provided free of charge
  - Detailed information: Provided for a fee

- Introduction of supporting companies related to the Zambian mining sector

Information should be made available about mining-related companies that provide necessary support services for resource development in Zambia, such as mining consultants (geological surveys, physical prospecting, boring, etc.), engineering companies, infrastructure survey companies, law firms (for advice on procedures related to direct investment), and so on, and help

junior and major mining companies that are involved with examining development proposals, exploration and development, to access these supporting companies.

- Promoting exploration activities by junior exploration companies

Junior exploration companies conduct surveys at or near the grass roots level and take on the riskiest part of global resource development. By being listed on stock exchanges in Canada, Australia, New Zealand, etc., these companies can procure exploration funds, which are essentially "risk capital", from ordinary investors. If the results of exploration work are successful and a junior company discovers an excellent deposit, it can sell its rights to a mining company, and the junior company and its investors can reap capital gains. The mining company can proceed to the construction and operational stages for this via such means as feasibility studies. Therefore, getting junior exploration companies as involved as possible in exploration activities is important for promoting mining investment.

To promote exploration, the exploration reporting system described earlier will be used to provide information on the activities of junior exploration companies that are conducting exploration work in Zambia, and will be closely tied to providing junior exploration companies with the information that they need. In addition, it will also be able to link to information geared toward junior exploration company investors (mining companies, etc.) from the GSD web site, and act as a portal to the GSD, providing access to quarterly and annual reports. For investors visiting GSD to gather information, the system can provide an introduction to junior exploration companies. By providing such information, this system will be helping to support exploration work and identify issues in exploration and development.

Chapter 2 Current Investment Climate and Situation of the Mining Industry

2. 1 Overview

The current Zambian mining policy was implemented in 1995. Although mining administration has been centralized into the Ministry of Mines and Minerals Development, its performance is still lackluster due to a shortage of manpower. Efforts should be made to attract foreign investment using provisions of the Mines and Minerals Act and the Investment Act. Management of mineral resources data is systemized, but its update, addition and utilization are issues to be addressed in the future. Nurturing of human resources is another task that should be done to promote the mining sector.

Mining activities in Zambia mainly involve foreign-owned enterprises extracting copper from mines that were privatized by ZCCM. Exploration is implemented by foreign companies with copper-gold and copper-nickel as targets. However, mineral potential has not been evaluated in many regions because there is lack of basic geological information such as geological maps. This in turn hinders further exploration. Zambian mining law is more competitive than that of neighboring countries in terms of mining rights, license areas and royalties.

2.2 Role of the Mining Sector

The 2007 GDP of Zambia was US$11 billion. The annual GDP growth rate is 6.2%. The main industries of Zambia include farming, mining, manufacturing, construction, tourism, and services, and their respective shares of the 2007 GDP were 13%, 8%, 10%, 11%, 3% and 52% (Fig. 2.2.1).

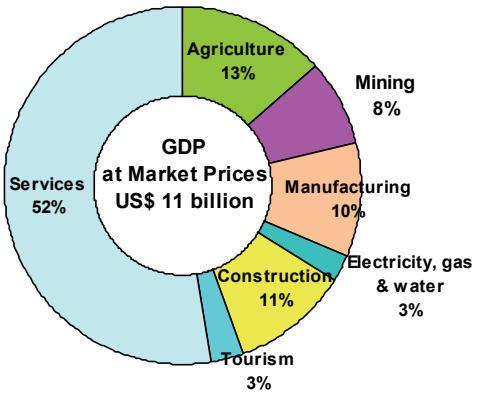

Fig. 2.2.1 Zambian GDP by Economic Activity

(Source: MIF Statistical Appendix 2007)

Since 2006, Zambian trade has been in a surplus, with exports surpassing imports. This is largely the result of increased prices of Zambia's main export minerals such as copper and cobalt in recent years (Fig. 2.2.2). Imports include machinery, petroleum, vehicles, electronic equipment, and iron and steel.

The make-up of Zambia's trading partners for exports and imports is vastly different. Partners for exports include European countries such as the UK and Switzerland which are the destination for 45% of Zambia's exports, followed by countries such as South Africa and Congo of the Southern African Development Community (SADC), which receive 18% of Zambia's exports. South Africa is the source of 46% of Zambia's imports, followed by other SADC countries (11%) such as Zimbabwe and Tanzania, and UAE (10%) (Fig. 2.2.3).

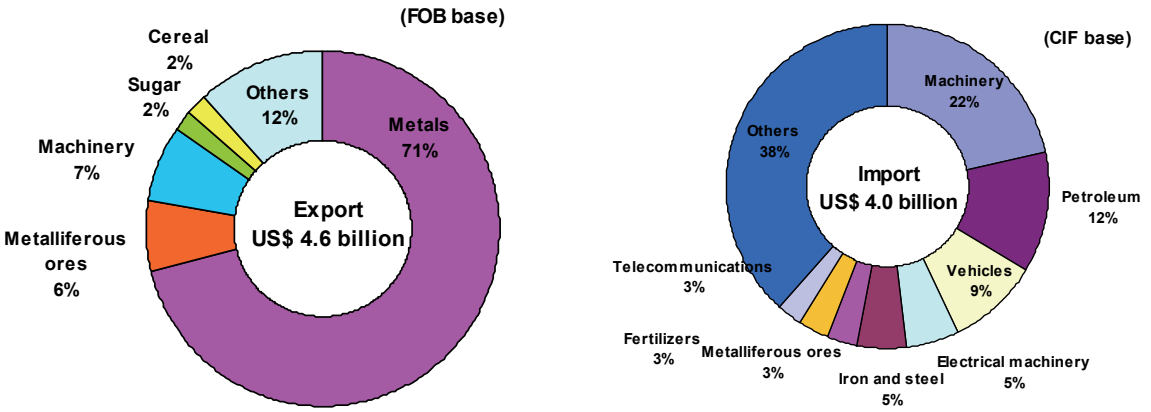

Fig. 2.2.2 Zambia's Exports and Imports by Commodity (2007)

(Source: Zambian Central Statistical Office)

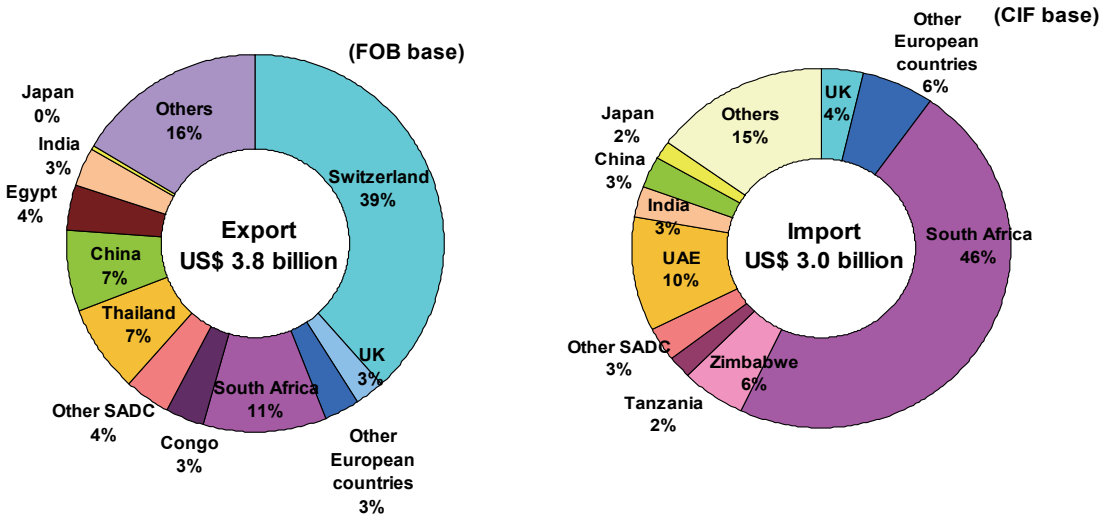

Fig. 2.2.3 Zambia's Exports and Imports by Country (2006)

(Source: Zambian Central Statistical Office)

Zambian trade with Japan is at a surplus for Zambia. Specifically, in 2007 Zambia's exports to Japan totaled 14.8 billion yen (125 million US dollars), while its imports from Japan totaled 3 billion yen (25 million US dollars). Furthermore, in value terms more than 90% of Zambia's exports to Japan are mine products such as cobalt, electrical copper, crude copper, and copper concentrates. In contrast, more than 70% of Japan's exports to Zambia are in the form of used automobiles and other vehicles, with used telephone equipment, and construction equipment such as bulldozers making up much of the remainder (Fig. 2.2.4).

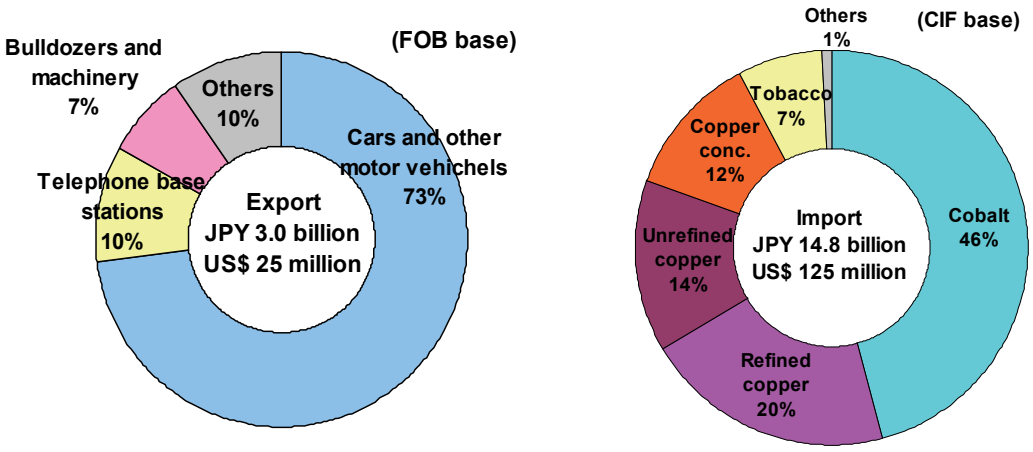

Fig. 2.2.4 Trade between Japan and Zambia (2007)

(Source: Trade Statistics of Japan)

Table 2.2.1 shows statistical information on the main non-ferrous metals that Japan imports from Zambia. In 2007, Japan imported 12,763t of cobalt ingots (mattes, etc.), of which 988t were supplied by Zambia. Zambia is the 5th largest supplier of cobalt to Japan, behind Finland (4,575t), Australia (2,695t), Canada (1997t), and Norway (1,134t).

In 2007, Japan imported a total of 20,735t of crude copper, of which 2,553t was imported from Zambia. Zambia is the 4th largest supplier of crude copper to Japan, behind the Philippines (7,487t)、Indonesia (5,008t) and Chile (3,038t). In the same year, Japan imported 102,273t of electrical copper, of which 3,600t came from Zambia. Zambia is the 6th largest supplier of electrical copper to Japan, behind Chile (44,924t), Indonesia (16,830t), Peru (11,643t), the Republic of Korea (10,900t), and the Philippines (4,727). Additionally, Japan imported 8,000t of copper concentrates from Zambia.

Table 2.2.1 Japanese Imports of Non-ferrous Metals from Zambia

(Trade Statistics of Japan, 2007)

	Imported from Zambia (A)	Total imported to Japan (B)	Percentage (A)/(B)	Rank	Imported amount (million ¥)	Imported amount (million US$)
Cobalt mattes and others (t)	988	12,763	7.7%	5	6,688	56
Unrefined copper (t)	2,353	20,735	11.3%	4	2,093	18
Refined copper (t)	3,600	102,273	3.5%	6	3,022	25
Copper concentrate (Kt)	8	5,051	0.2%	12	1,748	15
				Total	**13,551**	**114**

2.3 Mining Policy

The key objectives of the Government's Mining Policy, published in 1995, are as follows:

- To make the private sector the principal producer and exporter of mineral products through the establishment of a privatization programme.
- To promote the private sector initiative in the development of new mines in order to increase and diversify mineral and mineral-based products and exports.
- To promote the development of a small-scale mining industry.
- To promote the development of gemstone mining and facilitate market liberalization.
- To promote the exploration and exploitation of industrial minerals and energy minerals and to encourage the establishment of a ferrous metal industry.
- To reduce the danger of ecological damage arising from mining operations as well as potential damage to the health of workers and local residents from air, water, and soil pollution.
- To promote the local processing of raw minerals into finished products for added value.

The policy is aimed in particular at encouraging private investment in exploration and in the development of new mines. In addition to returning the major copper mines to the private sector, thus encouraging cost-effective management and greater exploitation of the enormous copper resources, the policy seeks to direct attention to the exploitation of the very diverse range of metalliferous deposits, industrial minerals, gemstones, and energy resources that exist in Zambia.

2.4 Mining Administration

Mining administration is under the jurisdiction of the Ministry of Mines and Mineral Development (MMMD), which consists of a Geological Survey Department (GSD), Mines Development Department (MDD), Mines Safety Department (MSD) and Human Resource and Administration (HRA) (Fig.3.4.1).

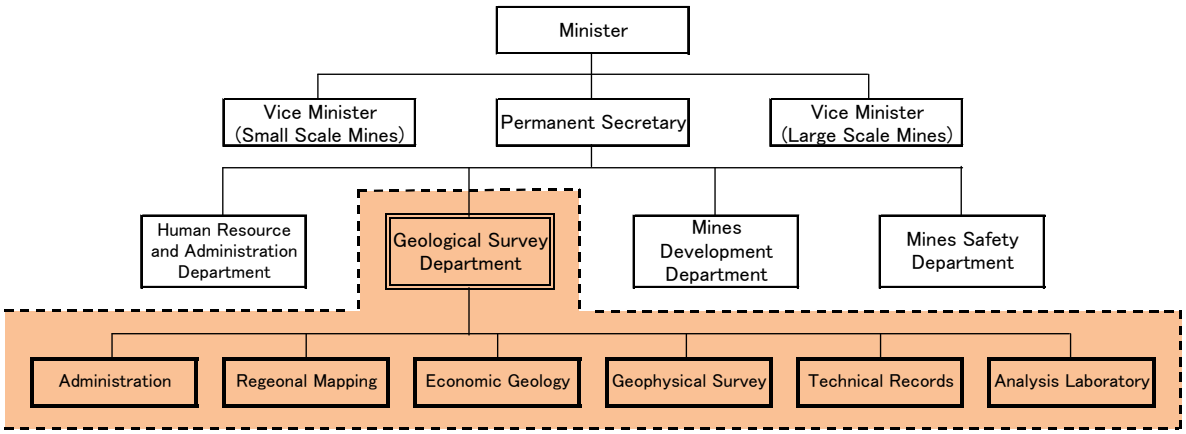

Fig. 2.4.1 Organization Chart of MMMD and GSD

MMMD is responsible for all activities of the mining sector, including implementation of improvements based on the mining policies adopted in 1995 by the government.

The primary roles of GSD are to provide geological, geophysical, and geochemical data on a country-wide basis, to prospect on behalf of the Government, to act as a national depository of all information relating to the geology of Zambia, and to provide support and advisory services to the public. The Department also administers prospecting licenses, mineral processing license, geological and mining consultancy and mineral laboratory permits.

Key responsibilities for MDD are the issuance of all mining licenses, together with mining operations to ensure that development is in line with approved programmes of operations and in accordance with the Mines and Minerals Act. The Department also issues Gemstone Sales Certificates.

MSD is divided into four technical sections - Mining, Explosives, Machinery and Environment - which enforce the relevant legislative and statutory instruments, formulate new legislation and regulations, evaluate all aspects of safety in mining operations, and offer technical advice and training in their respective fields. Roles of individual departments are indicated in Table 2.4.1.

Table 2.4.1 Roles of MMMD

Institution	Roles
Ministry Mines and Mineral Development	- Sector Leadership - Mining Policy formulation and guidance - Mobilize funds and other resources - Overall responsibility for human resources - Investment promotion
Geological Survey Department	- Geological mapping of the country - Enforcement of Mines and Minerals Act - Provide geo-science information to local and foreign investors (e.g. mineralogical, geochemical, geophysical, etc.) - Geo-analysis of samples (analytical services)
Mines Development Department	- Mining registry - Survey of Ministry Rights - Provide extension services to the Miners through the regional mining bureaus - Licensing - Enforcement of Mines and Minerals Act
Mines Safety Department	- Enforcement of Mining Safety Regulations on all operating mines. - Enforcement of the Explosives Act - Licensing of handlers of explosives - Issuance of manufacturing and blasting licenses

(Source: MMMD Homepage)

The budget for the MMMD has been growing year-by-year; for example, the budget for 2007, at 42.2 billion Kwacha (about 11.7 million US dollars), is roughly triple the 2006 budget (Table 2.4.2).

Much of this increase is going to fund disaster prevention associated with the activation of mining operations and field surveys associated with oil exploration and amendment of the Mines and Minerals Development Act.

Table 2.4.2 Actual Expenditures and Budget of MMMD

	2004 (Results)	2005 (Results)	2006 (Results)	2007 (Results)	2008 (Approved Estimates)
Headquarters (million ZK)	4,434	6,320	3,792	5,055	12,554
GSD (million ZK)	2,250	3,091	4,474	11,332	17,124
MDD (million ZK)	968	1,905	2,699	3,088	7,570
MSD (million ZK)	1,318	3,865	2,062	3,471	4,944
Ministry Total (million ZK)	8,970	15,181	13,027	22,946	42,192
Exchange rate (ZK/$)	4,782	4,516	3,603	4,053	3,600
Total（thousand US$）	1,875	3,362	3,616	5,661	11,720

(Source: HRA)

2.5 Geological Survey Department (GSD)

The GSD was established in 1950, and is currently comprised of the following six units: Administration, Regional Mapping, Economic Geology, Geophysical Survey, Technical Records, and the Analysis Laboratory (Fig.2.3.1). There are around 50 employees, including 12 geological engineers, 1 geophysical exploration specialist, and 2 chemical engineers.

The roles of the GSD are to 1) advise the MMMD about geological and mineral resource matters, 2) produce geological and mineral resource maps covering the entire country, 3) supervise the activities of exploration companies, 4) manage all geology and mineral resources-related information, provide information to domestic and international investors, and promote investment in the mining sector, 5) conduct chemical analyses of samples, and 6) provide a wide range of geology-related services.

The GSD budget for 2008 is 17 billion Kwachas (4.8 million US dollars). In 2008, the sum of 12 billion Kwachas (about 3.5 million US dollars) was added to the normal operating budget of 5 billion Kwachas (about 1.3 million US dollars) to pay for special petroleum surveys. This increase more than trebled the normal operating budget. The special petroleum surveys are being treated as a temporary outlay. About 40% of normal operating expenses are used to pay salaries and wages, 20% is used for office maintenance, and the remaining 40% is used for work related to surveys and studies (such as travel expenses, vehicle maintenance, fuel, supplies, etc.). However, there is not a steady source of survey funding.

GSD is equipped with a chemical analysis laboratory and a metallurgical laboratory, but the equipment and apparatuses have become so old and decrepit that they are nearly all unusable. Furthermore, GSD has no boring machine. In 2007, extra money was received from the government for the petroleum surveys, and this money was used to purchase several new 4WD vehicles and

other equipment.

2.6 Mining Legislation

2.6.1 Mines and Minerals Development Act

In line with the Mining Policy, the Government of Zambia enacted new legislation in 2008 - the Mines and Minerals Development Act No.7 of 2008 - which greatly simplifies licensing procedures, places minimum reasonable constraints on prospecting and mining activities, and creates a very favorable investment environment. A framework for responsible development has also been created through the publication of the Environmental Protection and Pollution Control Regulations in 1997.

Legislation has provided the following basic assurances for foreign investors:

- Secure title to mining rights
- Economic stability
- Retention of foreign exchange (currency)
- Right to market mine products
- Right to assign (trade) mining rights
- Freedom to conduct commercial operations

The cadastral unit of MDD consists of concession maps, and a mining company ledger system. Investors can do 'one-stop shopping' for exploration rights, mining rights, and so on. All investors are guaranteed technical and legal safety with mining rights, and the procedure for obtaining mining rights is being simplified. Both mining and exploration companies can own 100% of rights they have received. Fees for approving and renewing (annually) exploration rights and mining rights are reasonable, making investment in this sector more attractive.

For all minerals except petroleum, Zambian law divides rights that can be given for prospecting and development into 7 categories (Appendix II-1, II-2 and II-3).

Initial large-scale prospecting licenses are granted for a 2-year period, and can be renewed twice, each time for two years. Furthermore, the Ministry can extend these licenses for another year at its discretion, meaning that it is possible to have a total of 7 years of prospecting licenses. The upper limit of each prospecting license is 1,000 km^2 and a cumulative of 5,000 km^2. The area must be reduced by 50% each time a prospecting license is renewed.

In the case of large-scale mining license, licenses can be issued to mine operators for 25 years of operations and exploration. If reserves are expected to last longer than that, it may be possible to

renew these licenses for another 25 years. The upper limit of a mining license is 250 km^2. In addition to excavation and investment plans, plans must also be submitted for environmental preservation and for employing Zambian citizens in mining-related operations.

Small-scale prospecting permits cover a maximum area of 10km^2 and are only good for one 2-year period (no renewals allowed). Small-scale mining licenses are for a maximum of 400 hectares. They are good for 10 years, but may not be renewed.

Gemstone licenses are divided into small scale and large scale. The large scale licences are greater than 4 km^2 up to maximum of 250 km^2. While a small scale gemstone license up to maximum of 4 km^2. Both gemstone licenses are granted for a 10-year period, but they may be renewed every 10 years thereafter. Artisan mining rights are issued to local residents and cover a maximum of 6.6 hectares. They are good for 2 years but may not be renewed.

The following is a brief list of some of the features of mining law in Zambia:

- Mining licenses are issued according to the scale of the operation (large-scale and small-scale).
- There are 3 types of large-scale operations: large-scale prospecting licenses, large-scale mining licenses and large-scale gemstone licenses. For small-scale operations, there are 4 types of licences: small-scale prospecting permits, small-scale mining licenses, small-scale gemstone licenses, and artisan mining rights.
- Mining licenses are not classified by the type(s) of mineral(s).
- Large-scale prospecting licenses are normally for a maximum of 6 years.
- Large-scale mining licenses are issued for 25-year periods, and may be renewed.
- Mining license can be transferred.

On the other hand, while they are not mining rights in Zambia, reconnaissance permits can be granted to conduct reconnaissance. Such permits make it possible to enter an area that is not covered by mining rights, and conduct preliminary surveys of mineral occurrence areas through physical surveys, geochemical surveys, photogeology and/or surface reconnaissance, and/or conduct aerial surveys. Permits are valid for 90 days.

2.6.2 Investment Law

Investments in Zambia are regulated by the Zambia Development Act No. 11 of 2006 (the ZDA Act). The ZDA Act offers a wide range of incentives in the form of tax incentives, non-fiscal incentives, exemptions & concessions for companies. The Act provides for investment thresholds that investors

have to meet to qualify for fiscal and non-fiscal incentives. There are five categories of investors who can be considered under the ZDA Act.

The first is that of investors who invest not less than US$ 10 million in an identified sector or product. This category of investors is entitled to negotiation with the Government for additional incentives other than those they might already qualify for under the ZDA Act.

The second category is that of investors who invest not less than US$500,000 in the Multi Facility Economic Zones (MFEZ) and /or in a sector or product provided for as a priority sector or product under the ZDA Act. This category, in addition to being entitled to the general incentives, is entitled to the following incentives:

- Zero percent tax rate on dividends for 5 years from year of first declaration of dividends.
- Zero percent tax on profits for 5 years from the first year profits are made. For year 6 to 8, only 50 percent of profits are taxable and years 9 and 10, only 75 percent of profits are taxable.
- Zero percent import duty rate on raw materials, capital goods, machinery including trucks and specialised motor vehicles for five years.
- Deferment of VAT on machinery and equipment including trucks and specialised motor vehicles.

The third category of investors relates to investors who are designated as micro or small enterprises under the ZDA Act. Like the second category, this category is also, in addition to the applicable general incentives, entitled to the following incentives:

- For an enterprise in an urban area the income shall be exempt from tax for the first three (3) years.
- For an enterprise in a rural area the income shall be exempt from tax for the first five (5) years.

The fourth category is that of investors who invest less than US $500,000 in a sector or product provided for as a priority sector or product under the ZDA Act. This category is only entitled to general incentives.

The fifth and last category is that of investors who invest any amount in a sector or product not provided for as a priority sector or product under the act. This category of investors is also only entitled to general incentives provided under the various pieces of legislation.

General incentives are incentives available to investors investing in various sectors of the economy. These incentives are provided for under the pieces of legislation falling under the Zambia Revenue Authority, namely the Customs and Excise Act, Income Tax Act and Value Added Tax Act.

The ZDA provides facilitation services to its clients. In this regard, the ZDA facilitates registered investors to:

- Acquire land;
- Obtain water, electric power, transport, and communication services and facilities required for their investments;
- Regularize their immigration status;
- Acquire other licences required to operate a business in any particular sector; and
- Access any other after care assistance that may be required.

Investors who invest in Zambia enjoy the following guarantees:

- Free repatriation of profits & dividends without restriction
- Business cannot be compulsorily acquired by Government, except by act of parliament in extreme circumstances
- Protection against non-commercial risks, as Zambia is a signatory of multilateral investment guarantee agency (MIGA and Africa trade Insurance Agency).
- Impartial forum for resolving disputes
- Investors can enter into Investment Promotion and Protection Agreements (IPPA) with the Government.

2.6.3 Tax Regime

Zambia has a favorable tax regime for mining. Corporate tax is set at 25% of profits, while manufacturing companies are taxed at a rate of 35% of profits. There is a complete exemption from customs duty at the exploration stage. All mining equipment and machinery imported for mining purposes can be exempted from customs duty throughout the life of a project. Companies that do not show a profit during the exploitation (mining) stage have 10-year carry forward losses for tax purposes. Furthermore, there is a favorable tax regime for exports.

Royalties were calculated at 0.6% of net back value of mineral products. In the Law, "net back value" means the market value of minerals free-on-board at the point of export from Zambia or, in the case of consumption within Zambia, less the cost of smelting and refining or other processing costs, and the cost of transport, including insurance and handling charges, from the mining area to the point of export or delivery within Zambia.

However, given the steep increases in the prices of copper and cobalt in recent years, the corporate tax on these mine products rose from 25% to 30% in April 2008, and royalties rose from 0.6% to 3.0%. These trends in the tax rate are occurring against a backdrop of rising prices and rising profits for mining companies, but because the Zambian royalty rate of 0.6% was noticeably lower than the world standard of 2.5%, opinion polls showed that the portion of these profits that was being returned to this resource country was not sufficient.

The tax regime for mining activities in Zambia compares favorably with other mining countries, including other African countries (Appendix II-4). Accordingly, Zambia's tax regime and tax rates are internationally competitive.

2.7 Current Status of Mining Activities

The Zambian mining sector has been recovering sharply with the recently rising price of metals in the international market spurred by increased demand for metals in Asia, especially China.

In the 1970's, copper production in Zambia reached its peak (700,000 tonnes in 1972). Subsequently, falling copper metal prices caused annual production to drop to 200,000 tons in the late 1990's. The privatization of Zambia Consolidated Copper Mine (ZCCM) began in 1996, and foreign capital flowed in from investors such as Glencore (Switzerland) and First Quantum Minerals (FQM, Canada - Australia). Consequently, copper production has increased since 2000, reaching a level of 570,000 tons in 2007 (Table 2.7.1).

Table 2.7.1 Production of Copper and Cobalt at Major Mines in Zambia

Company	Mine	Commodity	Unit	2002	2003	2004	2005	2006	2007
Konkola copper mines plc	Nchanga	Copper	tons	174,413	144,816	135,420	94,422	118,578	154,304
		Cobalt	tons	2,039	1,157	210	19	–	
	Konkola	Copper	tons	47,597	50,347	43,552	45,358	18,901	
	Other	Copper	tons	–	–	12,712	23,824	4,299	
Mopani copper mines pls	Nkana	Copper	tons	97,966	134,391	56,459	61,918	60,234	162,530
		Cobalt	tons	1,786	2,045	2,128	1,777	1,437	1,788
	Mufulira	Copper	tons	–	–	78,093	70,801	80,530	
Chibuluma mines	Chibuluma	Copper	tons	7,548	6,887	5,247	5,699	9,718	12,636
		Cobalt	tons	88	0	–	–	–	
Bwana Mkubwa	Bwana Mkubwa	Copper	tons	7,499	29,471	41,605	49,081	50,647	25,069
NFC Africa	Chambishi	Copper	tons	0	6,300	19,432	19,789	22,603	24,185
Luanshya Copper Mines	Chambishi	Copper	tons	–	–	–	17,632	22,793	20,832
		Cobalt	tons	–	–	–	3,652	3,212	2,672
Kansanshi	Kansanshi	Copper	tons	–	–	–	79,626	127,316	165,994
Total		**Copper**	**tons**	**335,023**	**372,212**	**392,520**	**468,150**	**515,619**	**565,550**
		Cobalt	**tons**	**3,913**	**3,202**	**2,338**	**5,448**	**4,649**	**4,460**

(Source: Mines Development Department)

With the high prices of copper in recent years, copper production expected to reach 700,000 tons in 2008 has been planned to exceed 900,000 tons in 2009. However, since September 2008 a major

financial crisis has caused demand and prices to fall significantly and this is bound to have a negative impact on future production.

Currently, seven companies are producing cooper ore, copper concentrate, and/or cobalt in the Copper Belt. The Zambian government holds 20-30% shares in these mining companies through ZCCM Investment Holdings. The companies investing in major copper mines are shown in Table 2.7.2.

Table 2.7.2 Major Copper Mines in Zambia

Zambia Company	Mines	Controlling Company	Country
Mopani Copper Mines Plc (MCM)	Nkana and Mufulira Mines	Glencore (Swiss 73.1%) / First Quantum (FQM 16.9%) / ZCCM (GRZ 10%)	Switzerland / Canada-Australia / Zambia
Konkola Copper Mines Plc (KCM)	Konkola, Konkola Deep and North, Nchanga	Vedanta(51%) / Zambia Copper Investment (28.4%) / ZCCM (20.6%)	UK / Luxemburg /Zambia
Bwana Mkubwa Mining Ltd (BMML)	Bwana Mkubbwa / Lonshi	FQM (100%)	Canada-Australia
Chibuluma Mines Ltd.	Chibuluma South and West	Metorex / ZCCM	South Africa / Zambia
Non Ferrous Metals Africa Mining plc (NFC).	Chambishi	NFC(85%) / ZCCM (15%)	China / Zambia
J and W	Luanshya, Baluba	J and W (85%) / ZCCM (15%)	Switzerland / Zambia
Kansanshi Mine	Kansanshi	FQM (80%) / ZCCM (20%)	Canada-Australia / Zambia
Lumwana Mine	Lumwana	Equinox (100%)	Australia

(Source: MMMD)

From 1999 to 2005, the Zambian mining sector received more than 1.4 billion dollars in foreign investments. This money was used to develop copper mines, build smelters and cobalt processing plants, and develop a new mine (by FQM Co.) at Kansanshi. In addition, the Indian company Vedanta attracted world attention when it announced the Konkola Deep Mining Project (investment of US$ 674 million, extraction of 7.5 million tons of 3.8% grade copper ore per year by 2009).

2.8 Reserves of Mineral Resources

Zambia's position in the international markets is as a resource and production country. According to Mineral Commodity Summaries 2008, there are 490 million tons of known copper reserves in the world, of which 19 million tons are in Zambia. That places Zambia as Number 10 in copper reserves in the world, with a 4% share. In addition, there are 7 million tons of known cobalt reserves in the world, of which 270,000 tons are in Zambia. This makes Zambia the world's 4th largest source of cobalt reserves, also with a 4% share (Fig. 2.8.1).

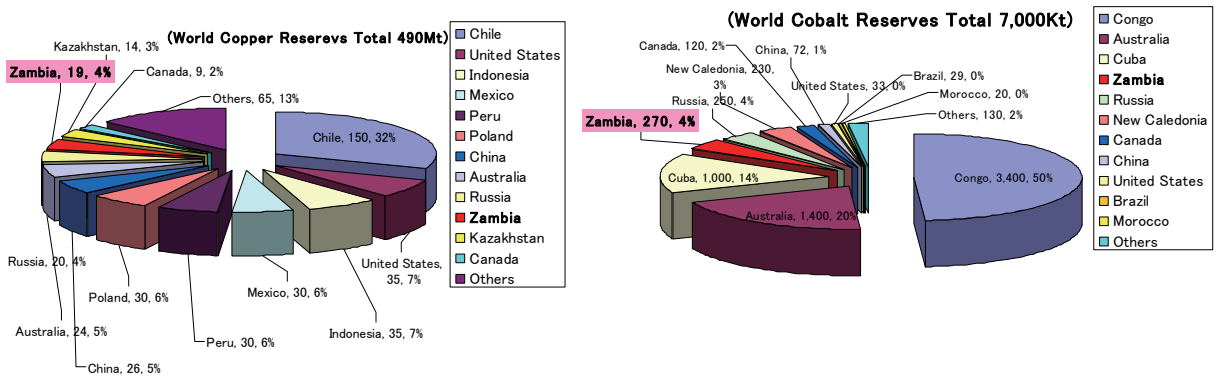

Fig. 2.8.1 Copper and Cobalt Reserves by Country

Because reserves of operating mines in Zambia are not reported to the GSD, it is not possible to get an accurate understanding of reserves at individual mines. The data on reserves and resources and grades listed below were taken from individual interviews conducted by the Study Team or acquired from Internet web sites.

Table 2.8.1 Resources and Reserves of Major Copper Mines in Zambia

Company	Mine		Resources					Reserves				
			Ore Mt	Cu Mt	Cu %	Co Kt	Co %	Ore Mt	Cu Mt	Cu %	Co Kt	Co %
Konkola Copper Mines	Nchanga	OP	160	2.4	1.5	na	na	na	na	na	na	na
		UG	60	1.2	2.0	na	na	na	na	na	na	na
	Konkola		240	9.1	3.8	na	na	na	na	na	na	na
	Total		460	12.7	2.8	na	na	na	na	na	na	na
Mopani Copper Mines	Nkana		252	5.8	2.3	217.0	0.1	55	1.1	2.04	63	0.11
	Mufulira		64	1.5	2.3	88.0	0.1	9	0.4	4.00	25	0.28
	Total		316	7.3	2.3	305.0	0.1	64	1.5	2.29	88	0.14
Chibuluma mines	Chibuluma		na	na	na	na	na	8	0.3	4.3	2.3	0.03
Bwana Mkubwa	Bwana Mkubwa		na	na	na	na	na	na	na	na	na	na
NFC Africa	Chambishi		127	2.8	2.2	-	-	102	2.2	2.21	-	-
Luanshya Copper Mines	Chambishi		na	na	na	na	na	na	na	na	na	na
Kansanshi	Kansanshi		433	5.0	1.16	na	na	na	na	na	na	na
Total			1,336	27.8	2.1	305	0.1	174	4	2.3	90	0.13

OP: open pit, UG: underground, na: not available, -: zero

Table 2.8.2 Reserves and Resources of Major Development Projects

Project	Reserves												
	Ore Mt	Cu Mt	Cu %	Co Kt	Co %	U_3O_8 Kt	U_3O_8 %	Ni Kt	Ni %	Pd t	Pd g/t	Pt t	Pt g/t
Lumuwana	321.0	2.3	0.7	48.0	0.0	4.1	0.1	-	-	-	-	-	-
Munali	6.7	0.01	0.17	4.4	0.07	-	-	82.4	1.23	3.6	0.53	1.5	0.23
Project	Resources												
	Ore Mt	Cu Mt	Cu %	Co Kt	Co %	U_3O_8 Kt	U_3O_8 %	Ni Kt	Ni %	Pd t	Pd g/t	Pt t	Pt g/t
Lumuwana	417.0	2.5	0.6	-	-	0.02	0.1	-	-	-	-	-	-
Munali	10.3	0.02	0.2	7.2	0.07	-	-	123.6	1.2	6.2	0.6	3.1	0.3

Table 2.8.3 Resources of Major Exploration Projects

Project	Resources						
	Ore Mt	Cu Mt	Cu %	U_3O_8 Kt	U_3O_8 %	Au t	Au g/t
Mukushi	18.5	0.2	0.8	-	-	-	-
Cheowa	6.5	0.1	1.1	-	-	2.0	0.3
Churundu	14.0	-	-	4.3	0.0	-	-
Luiri Hill	5.0	-	-	-	-	15.0	3.0

Table 2.8.4 Resources of Other Major Minerals

Project	Resources							
	Ore Mt	Zn Kt	Zn %	Pb Kt	Pb %	Fe %	CaF_2 %	P_2O_5 %
Kabwe	4.5	108.0	2.4	54.0	1.2	-	-	-
Bob, Mumbwa	0.3	32.0	11.6			-	-	-
Mpongo	0.2	10.0	6.4	1.5	1.0	-	-	-
Nyimba	2.1	82.0	3.9			-	-	-
Total	7.0	232.0	3.3	55.5	1.2			
Iron ore	940	-	-	-	-	30 - 68	-	-
Fluorite	6.1	-	-	-	-	-	84	-
Phosphate	470	-	-	-	-	-	-	2.5 - 4.6

(after GSD Memoir No.6)

2.9 Current State of Exploration and Development

2.9.1 Approval of Licenses

With the privatization of the mining sector, numerous licenses for prospecting and mining have been applied for and granted, and mining activities are proceeding. Table 2.9.1 provides a quantitative confirmation of the vitalization of the Zambian mining industry. Since 2004, at least 20 large-scale mining licenses have been issued every year.

As reported in Section 2.10, the Cadastral Unit of MDD has completed both the “hard” and “soft” aspects of the Concession Management System as part of World Bank/SEED and EU/MSDP projects, the system for issuing licenses has been improved, and the process has been made more transparent. A trial run of the new system has been conducted for 10 months, from 1 July 2007 to 1 May 2008, during which time the issuance of concessions has been suspended. Practice called for 600 overlapping concessions to be straightened out during the trial run.

Table 2.9.1 Number of Licenses Issued

	2000	2001	2002	2003	2004	2005	2006	2007	2008*	Cumulative Total
PLLS	15	22	9	13	20	39	38	66	7	229
LML	3	6	1	1	2	0	13	2	1	29
PP	7	16	24	49	48	44	31	61	9	289
SSML	12	27	29	44	47	18	48	95	10	330
GL	68	74	83	64	57	20	10	10	1	387
AMR	63	104	95	116	117	96	91	57	4	743

(As of 27 Oct., 2008; Source: Cadastral Unit)

PLLS:	Large-scale Prospecting License	SSML:	Small-scale Mining License
LML:	Large-scale Mining License	GL:	Gemstone License
PP:	Small-scale Prospecting Permit	AMR:	Artisanal Mining Right

2.9.2 Exploration and Development Projects

With the recently rising prices of metals and crude oil, investment in exploration has increased for metal resources, such as copper, gold, nickel and uranium, as well as diamonds. Although production

and exploration activities have been concentrated in the Copperbelt and North Western provinces, as much as 70% of Zambian territory is covered by various prospecting licenses. Mineral development and exploration projects in Zambia are outlined in Table 2.9.2 and shown in detail in Appendix II-5, and main projects are described below:

Table 2.9.2 Overview of Exploration and Development Projects

	Company	Commodity	Project name	Location	Stage
1	Equinox Minerals (Australia-Canada)	Copper Uranium	Lumwana	65km west of Solwezi	Mine construction Feasibility Study
2	Albidon (Australia)	Nickel	Munali	60km south of Lusaka	Start of production
3	AIM Resources (Australia) /BHP Billiton (Australia-UK)	Copper, gold	Mumbwa	West Central of Zambia	Exploration
4	CGA Mining (Australia) /African Eagle (UK)	Copper	Mkushi	265km northeast of Lusaka	Exploration
5	ICS Copper Systems (Canada)	Copper	Mokambo	15km from Mufulira, Copperbelt	Advanced exploration
6	African Eagle Resources (UK) /Phelps Dodge Mining (Zambia)	Copper	Ndola	Surround the Buwana Mkubwa mine	Exploration
7	African Eagle Resources (UK) /Copperbelt Minerals	Copper	Mikambo	90km northeast of Ndola	Exploration
8	African Eagle Resources (UK)	Copper, gold	Sasare Eagle eye	450km east of Lusaka	Exploration
9	African Eagle Resources (UK)	Copper, gold	Lunga	320km northwest of Lusaka	Exploration
10	Zambezi Resources (Australia) / Glencore Inernational (Swizterland)	Copper, gold	Cheowa	120km southeast of Lusaka	Pre-feasibility
11	Zambezi Resources (Australia)	Copper, gold	Chongwe	100km east of Lusaka	Exploration
12	Caledonia Mining (Canada)	Cobalt, copper	Nama	Northwest of Konkola Copper mine	Advanced exploration
13	Caledonia Mining (Canada)	Copper, cobalt, gold	Kadola	West of Kapiri Mposhi	Exploration
14	TEAL Exploration & Mining (Canada)	Copper	Konkola North	Copperbelt	FS
15	Luiri Gold (Canada)	Gold	Luiri Hill	120km west of Lusaka	Exploration
16	Zambezi Resources (Australia)	Gold	Chakwenga	200km east of Lusaka	Exploration
17	Denison Mines (Canada)	Uranium	Mutanga	200 km south of Lusaka	Exploration
18	African Energy Resources (Australia) /Albidon (Australia)	Uranium	Njame North, Chirundu	85km south of Lusaka	Pre-feasibility
19	African Energy Resources (Australia) /Albidon (Australia)	Uranium	Kariba Valley	80km south of Lusaka	Exploration
20	Lithic Metal & Energy (Australia) /Zambezi Resources (Australia)	Uranium	Oryx	80km southeast of Lusaka	Exploration
21	Lithic Metal & Energy (Australia) /Zambezi Resources (Australia)	Uranium	Mpande	60km southeast of Lusaka	Exploration
22	Lithic Metal & Energy (Australia)	Nickel	Mitaba Hill	100km southeast of Lusaka	Exploration
23	Alberg Mining and Exploration (South Africa) /ZCCM-IH (20%)	Zinc, lead	Kabwe	Central of Zambia	Re-open
24	Allied Energy (USA)	Tin, tantalite	Starfield	Southern Zambia	Production
25	Motapa Diamond (subsidiary of BHP Billiton) /Caledonia Mining (Canada)	Diamond	Mulonga Plain	Western Zambia	Exploration
26	Spirit of the River (Canada)	Diamond		Western Zambia	Exploration

(1) Development Projects

1) Lumwana Copper Project

The Lumwana copper project is located in the North Western province of Zambia, 220km west-northwest of the Copperbelt city of Chingola, and 60km west-southwest of the provincial capital Solwezi. The project covers 1,355km^2 and includes two major deposits, Chimiwungo and Malundwe, the smaller and less-studied Lubwe deposit, and a number of other copper occurrences.

The deposits were discovered in the early 1960's. Equinox Minerals Ltd (Australia-Canada) has taken 100% ownership in the project, which is one of the world's largest undeveloped copper projects.

Malundwe and Chimiwungo, the main, large, low-grade copper deposits, are hosted within the eastern lobe of the Mwombezi Dome. The copper mineralization at Lumwana is hosted almost entirely within high-grade metamorphosed, intensively mylonitesed, recrystallised quartz-kyanite schists with disseminated sulfides dominated by chalcopyrite and bornite.

Measureed and Indicated Reserves total 321 million tons, averaging 0.73% Cu (2.3 million tons of contained copper) and 0.015% Co (48 thousand tons of contained cobalt). Additional inferred resources total 417 million tons, averaging 0.6% Cu (more than 2.5 million tons of contained copper).

Lumwana is estimated to contain Probable Reserves of 3.3 million tons at 0.123% U_3O_8 and Inferred Resources of 2.4 million tons at 0.078% U_3O_8, within discrete zones which could be mined separately from the copper ore.

Construction of the mine started in late 2006. Building it has cost about US$760 million. It had been scheduled for commissioning in mid-2008. However, it is now expected to be produced copper concentrate during December 2008 due to the project delay associated with a transformer fire in June 2008. Full production is anticipated to be reached in 2009.

Equinox will mine an average of 20 million tons per year to produce an average of 122,000t of copper per year over the 37-year mine life. Because of higher head grades during the first six years of operation, the mine will initially produce an average of 169,000 tons of copper per year. China's Chambishi copper smelter has agreed to process 230,000 tons of copper concentrate per year (55% of the planned output) from Lumwana under a new five-year deal. Concentrates will be smelted and refined into metal at smelters either in Zambia, South Africa and/or offshore. Negotinations are underway with a number of regional smelters, such as Palabora Mining Co. of South Africa, Ongopolo Miming of Namibia, and Mopani Mines of Zambia.

2) Munali Nickel Project

The Munali nickel project is located approximately 60km south of Lusaka. The Enterprise deposit was discovered in 1969 and the project is 100% owned by Albidon Ltd. A bankable feasibility study was completed in 2006, and initial site work commenced in September 2006. Underground development intersected the Enterprise Orebody in January 2008, and extraction of ore began the

same month. The first nickel concentrate was processed and delivered to the storage shade on 27 June 2008.

Probable Reserves at Enterprise have been calculated at 6.7 million tons, with 1.23% Ni, 0.17% Cu, 0.07% Co, 0.53g/t Pd, and 0.23g/t Pt. The Probable Reserves contain over 82,00t of Ni, 11,7000t of Cu, 4,400t of Co, 114,400 ounces of Pd, and 50,400 ounces of Pt. The project is designed to produce approximately 8,500 tons per annum of nickel in concentrate from a 9,000,000 tons per annum underground mining operation. The current reserves base for Enterprise is sufficient for a 10 year mine life.

In December 2006, Jinchuan Group, China's largest nickel refiner, agreed to invest US$100 million in the Munali Nickel project and has signed an off-take agreement for the nickel production. Saleable Ni-Cu-Co-PGE concentrate is currently being stockpiled ahead of collection for smelting by Jinchuan.

In addition to the resource drilling at Enterprise, a systematic approach to drilling at the Munali Intrusion has been adopted. This had success with the discovery of the Voyager prospect approximately 750m north of Enterprise. The geological setting of the mineralization intersecting along the southwestern side of the Munali Intrusion is consistent, with the same controls on nickel sulfides over the entire length of the intrusion (over 2,5km).

Current published Indicated and Inferred Resources of the deposits at a revised cutoff grade of 0.6% Ni are as follows:
Enterprise deposit: 9.1Mt @ 1.23% Ni, 0.2% Cu, 0.07% Co, 0.6g/t Pd, 0.3g/t Pt.
Voyager deposit: 1.2 Mt @ 0.9% Ni, 0.1% Cu, 0.05% Co, 0.7g/t Pd, 0.4g/t Pt.
Total Resources: 10.3Mt @ 1.2% Ni, 0.2% Cu, 0.07% Co, 0.6g/t Pd, 0.3g/t Pt.

(2) Exploration Projects

1) Mkushi Copper Project

The Mkushi copper project area is located 265km by road northeast of the capital Lusaka and 160km southeast of Ndola. The project area contains a chain of at least seven known copper deposits along the 15km long Mtuga shear zone. Discovered in 1922, the Mkushi copper deposits were firstly mined at Mtuga and Munshiwemba by underground workings, and then developed as an open pit operation in the 1960's.

A resource estimate dating from 1990 reported that a global resource of 30 million tons at 1.2%

copper could still exist on the property containing more than 350,000 tons of copper. African Eagle Resources (AFE; UK) acquired a Prospecting License at the project in 2002. AFE has completed more than 55 diamond and percussion drill holes for a drilling total approaching 10,000m. The Inferred Resource in February, 2008 was 10.7 million tons at a grade of 1.11% Cu. The definitive feasibility study is scheduled for completion in fourth quarter 2008.

In 2006, CGA Mining Limited (Australia) entered into an agreement with AFE for a joint venture in the Mkushi project. CGA has acquired a 51% interest in the project, with AFE retaining a 49% interest in the project.

2) Mumbwa Copper Gold Project

The Mumbwa copper-gold project is located in west central Zambia. The Mumbwa licence area covers approximately 1,325 km^2 with an exploration strategy that is modelled around an iron oxide copper-gold (IOCG) style deposit similar to Olympic Dam in South Australia.

AIM Resources (Australia) entered into a joint venture agreement with BHP Billiton (Australia-UK) in late 2004 enabling AIM to earn up to a 70% interest in the project over a 4-year period. AIM is on track in terms of its budgetary commitments and onsite activity to fulfil the joint venture obligations.

Billiton explored the Mumbwa license area during the mid to late 1990's. The Kitumba region contains a large low-grade copper or copper-gold bearing, breccia system. The mineralization at Mumbwa is associated with large–scale highly variable magmatic-hydrothermal iron oxide breccia complexes that display evidence of multiple brecciation.

Interpretation culminated in a total of 23 anomalies being identified by the Falcon survey of 8,725km, of which 11 priority drill targets were indentified for drilling. AIM has planned the next phase of drilling, which commenced in January 2008. It has completed 16 drill core holes totalling 8,000m.

3) Mutanga Uranium Project

The Mutanga Project is located in the south, approximately 200 km south of Lusaka. The Mutanga Project (formerly called the Kariba uranium project) consists of a single prospecting license covering 1,893 km^2. The project is 100% owned by Denison Mines Crop. (Canada). There are two main deposits, Mutanga and Dibwe, and a number of exploration areas. Both deposits are shallow and amenable to open pit mining and alkali leach processing for extraction. A scoping study by the previous owner, Omega Corp Limited, identified an historical mineral resource estimate of 13.7

million pounds U_3O_8.

The scoping study is currently being updated and a feasibility study is targeted for completion in 2009. An intensive 47,000 meters reverse and diamond drill exploration is underway in an attempt to more accurately define the controls of the mineralization at Mutanga and Dibwe, to update the classification of indicated resources, and to explore for both of the known mineralization proximal to the proposed open pits and along the strike. When full production is reached, Mutanga should produce an estimated 1.5 million pounds of uranium oxide per year.

2.10 International Assistance

To promote sustainable development, the EU provides international assistance for mining activities through its Mining Sector Diversification Programme (MDSP), which is designed to promote sustainable development of the non-traditional mining sectors (NTMS) for gemstones, industrial minerals (excluding copper and cobalt), construction materials, and so on. This assistance is being provided in the form of a 16.5 million euro loan. In addition to this loan, workshops are being held, technical assistance is being provided in the fields of geology, mining, and dressing, and technical guidance is being provided for company management and marketing, among other things.

In addition, the World Bank is seeking to expand the tourism and gemstone sectors with a 24 million dollar loan provided through the Support to Economic Expansion and Diversification (SEED) Project. Moreover, the Concession Management System has been upgraded in an effort to avoid redundant licensing of concessions by improving the investment climate, promoting economic development, and reducing the scale of mines. The Concession Management System project has been undertaken in conjunction with EU/MSDP to computerize MDD's concession management, digitize maps and diagrams, and improve and upgrade equipment. It has been completed in 2007. The 2007 budget for the gemstone sector was 1.8 million dollars, of which 400,000 dollars was used for concession management.

Other types of technical cooperation include the World Bank's Economic Recovery and Investment Project Technical Assistance (ERIPTA) program, which was assisting in the creation of 1:100,000 geological maps of western provinces and the NE part of the Northern provinces for GSD, and joint exploration for emeralds with the Czech Geological Survey in Copperbelt province. In addition, JICA is providing technical assistance for the present study (see Table 2.10.1).

Table 2.10.1 Recent Cases of International Assistance in the Zambian Mining Sector

Organization/country	Type	Target	Project
EU	Loan TA*	NTMS MMMD	● MSDP (2002/2008)
World Bank	TA	GSD	● Geological mapping (1996/2001)
	Loan	Gemstone	● SEED (2005/2009)
	Loan	Mining	● Copperbelt Environment Project
Czech Republic	TA	GSD	● Emerald prospecting (2001)
Japan	TA	GSD	● Geological mapping and mineral information services (2007-2009)

*TA: Technical Assistance

Chapter 3 Geoinformation

3.1 Current Status of Geoinformation

(1) Geological Maps

The GSD carried out geological surveys from the late 1950's to the 1970's with the support of the British Geological Survey (BGS), in the late 1990's with the support of the EU, and from 1996 to 2000 with World Bank support. There are 1:100,000 maps available for 58% of the country, but maps for the remaining 42% are in various stages of preparation. Due to the lack of funding and technical ability, it has been difficult to create geological maps for the remaining 42% of the country. The index map in Fig. 3.1.1 shows the current mapping status and indicates the target areas for this study in blue.

In 1974-1975, the GSD compiled and created four 1:1,000,000 geological maps (shown in red in Fig.3.1.1). They have not been revised in the 30+ years since. The first 1:2,000,000 scale geological and mineral resource map was published in 1973 and revised in 1994. In 2000, with World Bank support, 1:1,000,000 geological maps were converted to GIS format and published on CD-ROM.

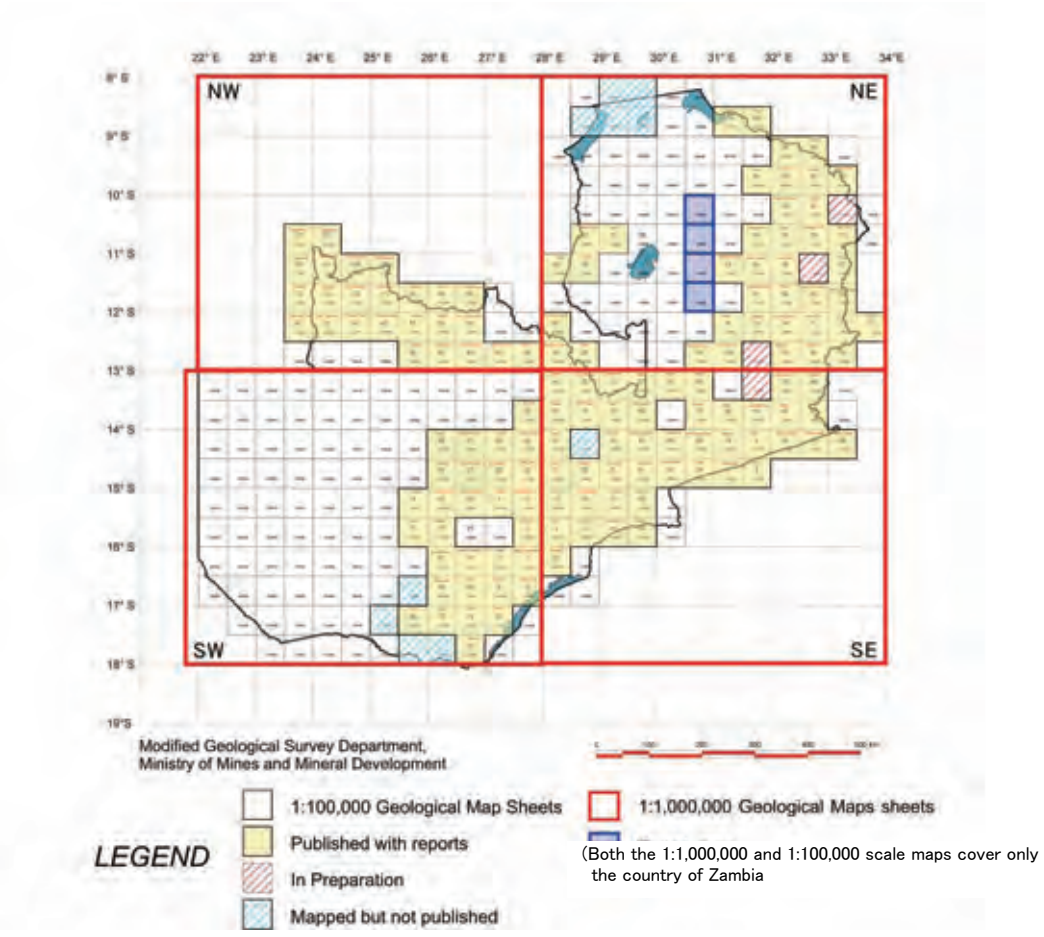

Fig. 3.1.1 Current Status of 1:100,000 Geological Mapping

GIS conversion of 1:100,000 scale geological maps began a few years ago, but with the staff lacking equipment and technical skills, only minimal details have been entered into the database. Specifically, only ore deposits, occurrences, locations, and ore deposit types have been entered. There is still no basic information on such attributes as geological stratigraphy, parent rock, structural minerals, deposit scale, and grade. Further, since corresponding explanations have not been entered, this information cannot be considered sufficient for investors to evaluate promising areas.

Status of geological maps is summarized as follows:

- 1:2,000,000 1 map (Geological and Mineral Occurrence Map)
- 1:1,000,000 4 maps
- 1:500,000 1 map (Metamorphic map of Zambia)
- 1:250,000 5 maps (Mwinilunga, Petauke, Ntambu, Chipata, Lusaka and Rufunsa areas)
- 1:100,000 113 maps

(2) Geochemical Prospecting Data

Most of the geochemical prospecting data were collected during 1:100,00 geological surveys until the 1970's, and the GSD has a total of about 30,000 data. These data are divided into 2 types: MapInfo format and OASIS montage.

1) Standard collected data

The data were obtained from about 27,000 samples which were collected from stream sediments during the 1:100,000 geological surveys. About 24,000 of these data were collected in the 1970's and 7 elements of each sample were analyzed by atomic absorpsion spectrometer at the GSD. The remaining 3,000 data were collected during the World Bank's ERIPTA project until 2000 and 40 elements were analyzed.

2) 3'grid data

3,000 strean sediments were collected in 3'×3' grids (approx. 5km^2) and 7 elements were analyzed by atomic absorption spectrometer.

These data are controlled by the OASIS montage and can be displayed by type of mineral commodity in an arbitrary region. The data are used as a layer of Mapinfo.

(3) Geophysical Data

There are several 1:50,000 aeromagnetic maps and one 1:2,000,000 Bouguer gravity anomaly map covering the whole territory of Zambia. Spatial interpolation is conducted for aeromagnetic data, after they are digitized and converted into 250m grids. Radioactive elements of U, Th and K are marked in 1:50,000 distribution maps.

(4) Reports and Books in Library

There are approximately 2,000 reports and books in the library of the GSD, but there are almost no books published after 1970. The document list is incomplete and kept on cards in alphabetical order. The reports are classified by country. In January 2006, registration of a book list was started using CDS/ISIS version 1.5, and 846 data had been input into the list as of 28 February, 2007.

However, books and reports are not searched well due to the incomplete book list. The staff of the GSD have little opportunity to obtain the latest geoinformation because the library does not subscribe to scientific and mining journals.

(5) Prospecting Reports of Private Companies

Mining and exploration companies submit to the GSD quarterly and annual reports in which prospecting results are reported by license. These reports are registered and kept in digitized format in a technical record unit. Geological reports accompanied with applications for exploration licenses are handled by the technical record unit. As a result of rising metal prices, prospecting projects have increased significantly, and submitted reports increased from 71 in 2004 to 110 in 2006, a rise of more than 50%.

The yearly number of digitizations is about 100; anything above that could not be handled adequately by the current number of personnel.

(6) Drilling Data

There is no drilling data in the GSD. Rather, these data are kept in the Chamber of Mines of Zambia (CMZ) which is an organization of private mining companies that is located in Kalulishi city in Copperbelt province. Previously, ZCCM had controlled all the cores of drill holes, but after ZCCM was dissolved, the CMZ has controlled all the cores. There are only a few dozen employees of CMZ, and columnar sections of drill holes are not digitized. In addition, it takes time to find appropriate cores for analysis.

3.2 Revision of Geological Maps

The revision of 1:1,000,000 geological maps has been discussed with senior staff of the GSD. The following is a list of some of the main revisions that have been made so far:

- Revision of the northeastern area of Zambia: - comparison with thirty 1:100,000 geological maps.
- Revision of the northwestern area of Zambia: - comparison with eleven 1:100,000 geological maps, and with the 1:250,000 geological map of the Mwinilunga area.

The 1:1,000,000 geological maps are composed of 35 geological units. During the revision of

geological maps, these geological units were used as a basis for making corrections. Formations and rocks depicted on 1:100,000 geological maps have been compared with stratigraphic and rock facies features depicted by the 35 geological units on the 1:1,000,000 geological maps. Geological maps used for the revision of the 1:1,000,000 geological maps are listed in Table 3.2.1, and shown in Fig. 3.2.1. Details of these geological maps are listed in Appendix III-1. Appendix III-2 represents a correlation of symbols between 1:1,000,000 geological maps and 1:100,000 geological maps.

Table 3.2.1 List of Geological Source Maps

Report No.	Quarter Degree Sheet	Map name	Published year
84	0932NW	Chozi	1995
84	0932NE	Nakonde	1995
86	0931SE	Makasa	1995
85	0932SW	Mututa Hills	1995
85	0932SE	Kalungu	1995
93	0933SW	Mafinga Hills	1994
92	1032NW	Mulilansolo Mission	1994
92	1032NE	Isoka	1994
95	1031SE	Ilondola Mission	1998
79	1032SW	Chinsali	1994
79	1032SE	Mutangoshi Hills	1994
113	1033SW, SE	Muyombe and Luwumbu river	unpublished
64	1131NE	Shiwa Ng'andu	1998
76	1132EW	Luswa River	1994
57	1133NW	Chama	1994
81	1131SE	Katibunga Mission	1994
82	1132SW	Mtofwe	1994
62	1132SE and 1133SW	Chikwa and Lake Beu	2000
78	1231NE	Nabwalya	1994
74	1232NW	Lumimba Mission	1994
71	1232NE	Lumezi River	1998
71	1233NW	Lundazi	1998
105	1231SW	Mupamadzi River	1997
91	1232SW	Mwanya	1997
50	1232SE and 1233SW	Lukusuzi	1998
35	1332NW	Machinje Hills	1992
49	1332NE	Chimwala	2000
13	1331SE	Lusandwa River	1964
42	1332SW	Mtetezi River	1992
41	1332SE	Chipata	1975
43	1224NW	West Lunga River	1994
44	1224NE	Kabompo Dome	1992
40	1225NW	Kabompo Gorge	1992
83	1225NE and 1125SE	MwombezhiDome and Jiwundu Swamp	1998
90	1225SE	Matebo	2000
90	1226SW	Luma River	2000
36	1226NW	Solwezi	1992
80	1226NE	St Francis Mission	1994
80	1226SE	St Francis Mission	1994
65	1227SW	Luswishi Dome	1994
66	1227SE	Chingola	1994
1:250,000	SC-35-13	Mwinilunga	2000

The GSD published 1:100,000 geological maps of the northeastern area of the country with consultation from BGS in 1993-1995 with World Bank support, and in 1996-1998 (some parts up to

2000) with the support of the EU. The GSD published 1:100,000 geological of the northwestern area with BGS consultation in 1992-1994 and 1996-2000 with support from the EU, and in 1993-1995 with support from the World Bank.

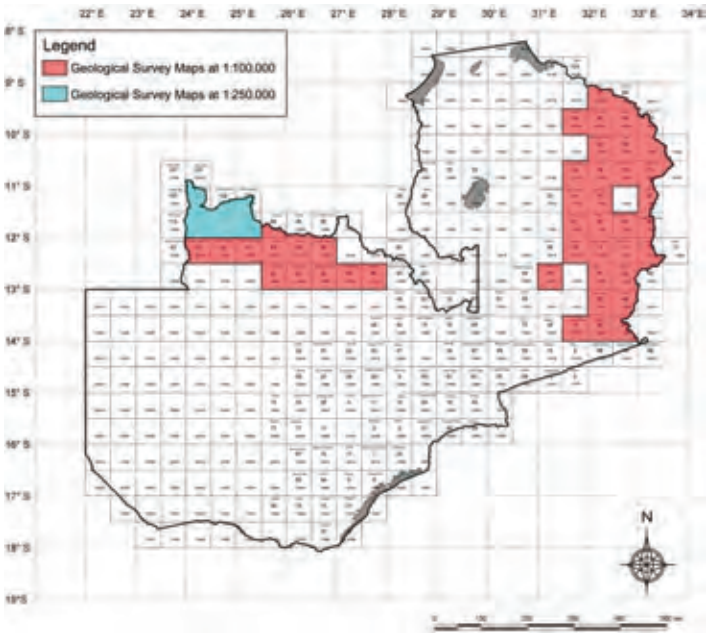

Fig. 3.2.1 Geological Source Maps

The main modifications to the existing 1:1,000,000 geological maps that were made during the revision work in this study are as follows:

- Quartzite-pelite sequences of the Muva Supergroup shown in geological unit 16 in the northeastern area were incorporated into Upper Shale of the Muva Supergroup shown in geological unit 20.
- Meta-quartzites shown as geological unit 8 and Lower Quartzite of the Muva Supergroup shown as 17 in the northeastern area were incorporated into Upper Quartzite of the Muva Supergroup shown as geological unit 19.
- A part of Lower Quartzite of the Muva Supergroup shown in 17 in the northeastern area was incorporated into Upper Shale of the Muva Supergroup appearing in geological unit 20.
- Boundaries between granites (geological unit 5) and the Mulungwizi Gneiss group (geological unit 12) occurring in the eastern district of Kalungu in the northeastern area have been clarified.
- Undifferentiated Mine Series of the Katanga Supergroup shown in geological unit 21 in the northwestern area has been incorporated into the Mwashia Group of the Katanga Supergroup shown in geological unit 24.

Chapter 4 GIS Database

4.1 Current Situation and Evaluation of the GIS Database

In 2000, the Geological Survey Department (GSD) created a Mineral Resource Database (Microsoft Access) with assistance from the British Geological Survey (BGS). There is also a GIS database which is using a part of the Mineral Resource Database. We investigated their current accessibility and management, and examined methods for their integrated utilization. GSD and the Mines Development Department (MDD) each have a GIS database, so we compared the data, software and systems of the respective databases to determine their compatibility.

4.1.1 Database in GSD

1) Mineral Resource Database

The Mineral Resource Database was made using Access2000. Recode items of the database are shown in Appendix IV-1 and the relationship between the tables in the database is shown in Appendix IV-2.

Regarding the status of records, a total of 3,035 occurrence records are registered, but about 30% of them are still not usable for lack of coordinate and occurrence information.

Table 4.1.1 Record of GIS Database in GSD

Total records	No. of missing coordinates	No. of missing occurrence names	Usable records
3,035	590	191	2,254

When data is updated or added, a data table for GIS is exported according to the following sequence using the graphical user interface of Access2000.

(1) Click the “Make GIS table” button
    Create a temporary table in the database
(2) Click the “Export to GIS” button
    Export an intermediate file, in dBaseIV format, for GIS from the temporary table
(3) Settled Path: G:¥Data¥Min_Occ¥Min_Locs.dbf
(4) Items: Name, AltName, Class, CommList, Status, GSnumber, LatDec, LongDec

All GIS software shares a common data format for exported files. Currently, the number of exported records is 2,706, but there are 452 duplicates of location, so the total is larger than the actual number of usable records.

The only time the database can be used by outsiders is when private companies come to GSD to obtain mineral occurrence information, but only the applicable information is displayed.

2) GIS Database of Mineral Resources

The GIS database has a hierarchical data structure in MapInfo (Ver.5). Thematic layers are shown in Table 4.1.2. A Mineral Occurrences layer was created using the intermediate file, in dBaseIV format.

Table 4.1.2 Thematic Layers in GIS Database of Mineral Resources

Themantic Subject	Layer name	Type
Boundary	Border	Polygon
	Provinces	Polygon
	Districts	Polygon
	Constituency	Polygon
Populated area	Principal City	Point
	Poly	Polygon
	Town	Point
	villege	Point
Infrastracture	Airport	Point
	Landmark	Point
	Hydro powerstation	Point
	Power line	Line
	Railway	Line
	Roads_majore	Line
	Roads_minore	Line
Drainage	Lake	Polygon
	M_rivers	Line
	Revers	Line
Geology 1/1million	Geol_1M	Polygon
	Faults_1M	Line
	Dykes_1M	Line
	Kimberlite_1M	Point
Geology(Copper belt)1/1million	Cpr_belt	Polygon
	Cpr_fault	Line
Mineral Occurrence	min_locs	Point
	Hydro_Au	Polygon
	Alluv_Au	Polygon

As with the above database, the only time th mineral resources database can be used by outsiders is when private companies come to GSD to obtain mineral occurrence information, but only the applicable information is displayed.

4.1.2 Database in MDD

A mining concession database is being created in MDD. The database has a hierarchical data structure in ArcView (Ver.3.2). Large-scale and small-scale concession areas are registered.

Attributes include the following basic information on licenses:

Holder, Location, Pll_No, Type, No., Year_Grant, Status, Grant_Date, Ex_Date, Comment.

The present method of utilization is inputting applied concession information and checking for redundant information about existing concession areas.

4.2 Revisions of Database and GIS

We checked existing geological information and related GIS data, and organized information to be integrated into the GIS database. We plan to support the acquisition of basic knowledge and integrated operation of a database and a GIS rather than handle data from a variety of sources using a variety of techniques.

It is important to make good use of the current system and we give top priority to maintaining mineral occurrence information. A total of 3,035 occurrence records are registered, but about 30% of these records are still not usable for lack of coordinate and occurrence information. Therefore, our first task is to acquire and maintain these data. For GIS, we think that the counterparts could create and import digital data, so it is better to master database searches and display techniques.

1) Working procedure

Each program will be carried out in stages according to the benchmark setting for two years. An overview of the content and scope of the work is shown in Fig. 4.2.1

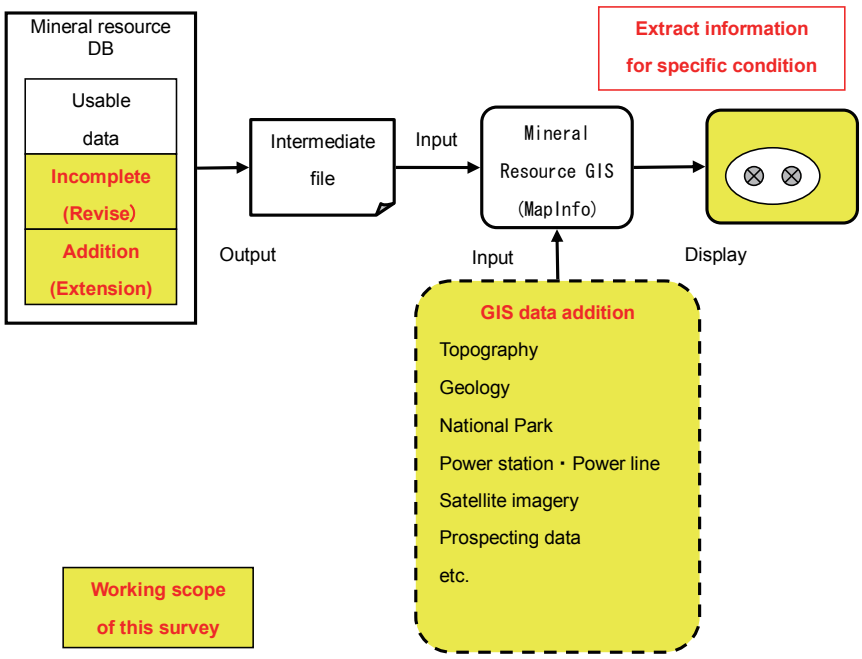

Fig. 4.2.1 Overview of the Content and Scope of the Work

2) Mineral Resource Database (Access)

a) Acquisition of Missing Data

In order to use the mineral occurrences data in the mineral resource GIS, data must be acquired on

locations for which no coordinate records currently exist. For 191 of the records with no occurrence name, it is necessary to verify the information.

b) Addition of new data after YR 2000

The items shown in Appendix IV-1 that are to be input to the database will be extracted from various reports and added.

c) Initial work

Work has started on finding coordinate records for missing location data. To know the characteristics of the location information in the records, it has been reclassified into the following three categories:

- Category 1: The sheet number is known: 420
- Category 2: There is no sheet number, but the Province or District name is known: 95
- Category 3: No information at all is available: 75

A sheet number is a grid number of a 1/250,000 scale topographic map which is expressed by meshes of 1 by 1 degree (lat. X long.).

Geographical coordinates are being determined according to the description of "Locality" in the database. The number of mineral occurrences in each sheet and sorted sheet number by descending number of occurrences are shown in Table 4.2.1. In order to undertake the work efficiently and encourage the counterpart's participation, the work has been carried out from category 1 to 3.

In this case, sheets which contain the two richest occurrences have been selected, 1528 and 1527. Actual work was done using one 1/250,000 sheet divided into sixteen 1/50,000 topographic maps (Fig. 4.2.2).

Table 4.2.1 Number of Mineral Occurrences in Each Sheet and Sorted Sheet Number, in Descending Order

No.	Sheet Num	Mineral occurrences	Sum of occurrences	Performance
1	1528	65	65	15.5%
2	1527	53	118	28.1%
3	1328	23	141	33.6%
4	1325	22	163	38.8%
5	1529	20	183	43.6%
6	1627	18	201	47.9%
7	1330	16	217	51.7%
8	1228	15	232	55.2%
9	1232	15	247	58.8%
10	1526	15	262	62.4%
11	1128	14	276	65.7%
12	1324	14	290	69.0%
13	1331	14	304	72.4%
14	1628	12	316	75.2%
15	1726	11	327	77.9%
16	1429	10	337	80.2%
17	1326	9	346	82.4%
18	1029	8	354	84.3%
19	1329	7	361	86.0%
20	1332	7	368	87.6%
21	1626	7	375	89.3%
22	1727	6	381	90.7%
23	1227	5	386	91.9%
24	1327	5	391	93.1%
25	1233	4	395	94.0%
26	1224	3	398	94.8%
27	1231	3	401	95.5%
28	1530	3	404	96.2%
29	1132	2	406	96.7%
30	1226	2	408	97.1%
31	1230	2	410	97.6%
32	1725	2	412	98.1%
33	1028	1	413	98.3%
34	1033	1	414	98.6%
35	1124	1	415	98.8%
36	1125	1	416	99.0%
37	1127	1	417	99.3%
38	1129	1	418	99.5%
39	1131	1	419	99.8%
40	1225	1	420	100.0%

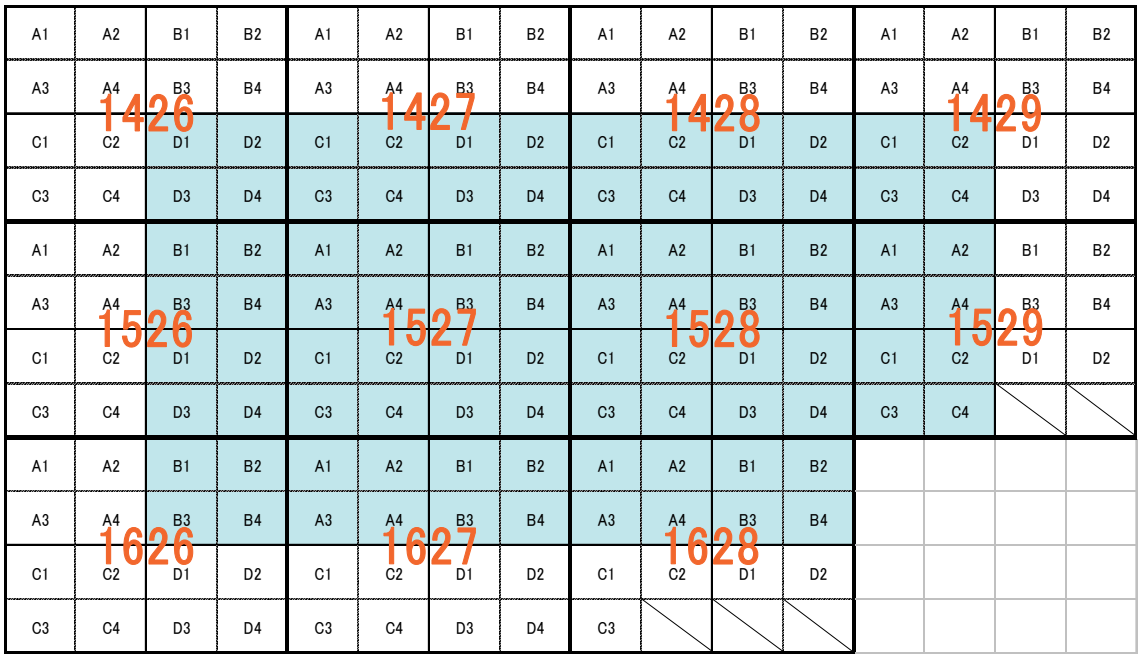

Fig. 4..2..2 1/250,000 Sheets Divided into 1/50,000 Topographic Maps

d) Switch of the work plan

While we have been carrying out the initial work, we have recognized problems of consistency with recorded information. For instance, there are differences between the descriptions of location of mineral occurrences (locality, distance and direction from a place etc) and sheet number that express the coordinates. It was difficult to determine which information should be given priority. We started the initial work with the assumption that the contents in the mineral resource database are correct. However we have determined that it is necessary to reconsider the way this work is undertaken.

For a government agency, it is not desirable to offer inaccurate information for new future investment. Therefore, the GSD staff should work to guarantee the quality of and maintain the existing data, rather than trying to focus on understanding the database system or inputting new data. It is counterproductive to display inaccurate information on GIS.

Therefore, we decided to review not only occurrence names and coordinates but also all data in the mineral resource database to check consistency and identify problems.

(1) Review of records

We have reviewed the number of recorded information.

- Registered occurrence records : 3,034

  Records with coordinates : 2,444 ; Records with no coordinates : 590

Records of occurrence with no commodity : 177

Table 4.2.2 Review of records

		with coordinates (2,444)		No coordinates (590)	
commodity		Yes	No	Yes	No
occurrence name	Yes	2,227	26	587	4
	No	44	147	—	—

- Registered commodity records : 3,740

(2) Review of reference sources

It is necessary to have a clear, identifiable source to verify the reliability of the information. For that reason, we have checked reference information for registered records. Only 1/10 of the records had an identifiable source and almost all of them (about 340) are limited to initial registrations. It is difficult to identify all of reference sources in short period, so the investigation will require a concerted effort for several years.

There are 320 records for development, but 97% of them are limited to referenced mineral occurrence sites.

Registered occurrence records with reference source : 322 out of 3,034 records
Registered commodity records with reference source : 687 out of 3,740 records

(3) Confirmation of contents

According to the review and confirmation of contents, the following items have been recommended for discussion. A partial list of items is shown in Appendix IV-3.

- Duplicate registrations for Occurrence name and coordinates

Same coordinates and same or similar “Occurrence name” : 195 sets (412 records)

Table4.2.3 Duplicates for coordinates

	Same commodity (174)	Diff. commodity (21)
Case 1 (same occ. name)	127 set (40/127)	17 set (4/17)
Case 2	39 set	4 set
Case 3	8 set	—

Case 1 : Latitude/Longitude same, UTM same

Case 2 : Latitude/Longitude same, UTM different

Case 3 : Latitude/Longitude different, UTM same

In Case 1, there are 40 completely identical occurrence name registration sets within the same commodity, and 4 registration sets among different commodities.

- Duplicate registrations for Occurrence Locality

Occurrence name is different but the description of "Locality" is the same : 64 sets

- Need reexamination (from "Comments")

Based on the information in the "Comments" column, the following six categories have been created to determine the reliability of contents.

There is a total of 635 records including 78 records with no coordinates and 191 records with no occurrence name.

i. No detailed information : 49 records
(No coordinates : 32; no occurrence name : 0)

ii. Descriptions are almost the same : 82 records
(No coordinates : 36; no occurrence name : 0)

iii. Coordinates are discerned from topographic maps : 180 records
(No coordinates : 0; no occurrence name : 16)

iv. No economic interest : 28 records
(No coordinates : 8; no occurrence name : 0)

v. Same Comments but no Locality : 260 records
(No coordinates : 0; no occurrence name : 172)

vi. Comments left blank and no information : 36 records
(No coordinates : 2; no occurrence name : 3)

- Wrong sheet number

The number of a sheet that denotes a grid on a 1/250,000 scale topographic map, is wrong: 8 cases

- Discrepancies in coordinate values　Latitude/Longitude – UTM (WGS84)

In wild area of Zambia, there are few domiciles and no place names, so coordinate information is extremely important. We have confirmed that are there no discrepancies between Latitude/Longitude and UTM using coordinate transformation calculations.

Table 4.2.4 shows the number of registrations for which there were especially large discrepancies (d), for each UTM zone. In one of these cases, there was not even one match between Latitude/Longitude and UTM coordinate values. Accordingly, these coordinate values could have been obtained separately or were incorrectly entered. It appears that no investigation has been conducted so far, so a recheck is necessary.

Table 4.2.4　Cases of large discrepancies between Latitude/Longitude and UTM coordinate values

UTM zone	150m≦ d ＜500m	500m≦ d	No Occ. name
Zone34　(　11 record)	1	—	—
Zone35　(1717 record)	419	46	6
Zone36　(716 record)	20	6	185
Total　(2444 record)	440	52	191

- Field investigation survey

It is necessary to conduct an investigative survey for the following 770 records that are missing accurate location information:

Occurrence with no coordinates : 590 records

Occurrence coordinates are discerned from topographic maps : 180 records

Table4.2.5　Coordinates of mineral occurrence areas discerned from topographic maps

UTM zone	From map	150m≦ d
Zone34　(　11 record)	—	—
Zone35　(1717 record)	113	17
Zone36　(716 record)	67	2
Total　(2444 record)	180	19

- Ranking of data quality

This time, 1,923 of 3,034 occurrence records were selected for reevaluation. However, because the investigation was carried out only to check consistency with the data in the database, this does not guarantee the contents of the remaining 1,111 records.

The reliability and importance of the information according to geological re-estimation should be ranked after the data are checked by GSD staff.

(4) Management of contents

We recommend constructing a framework in GSD for mineral resource management with a full-time chief economic geologist and a database engineer, even though GSD is currently facing an understaffing situation. It will take much time and labor to finish all of the work mentioned above.

However since GSD is a geological contents provider, GSD staff will have to undertake the work on their own without outside help.

(5) Addition of new data

The most recent information is in the report "Memoir No.6 The Geology and Mineral Resources of Zambia 2000". To add new data to the mineral resource database, it will be necessary to extract information applicable to the registration items shown in Appendix IV-1 from the report.

As mentioned earlier, the reliability of contents is quite important. Therefore, data quality will have to be checked before they can be entered into the database.

3) Mineral Resource GIS

This system is currently used to display all mineral occurrences in an area specified by a user. An area can be a province, district, or user-specified polygon. It is recommended that users master the search query function so that they can easily find the information that they wish to obtain, for example, specific minerals in specific geological units, mineral occurrences existing around specific geological structures, and so on.

As a prerequisite to do this, basic data related to mines and mineral occurrences other than geological information must be collected.

a) Basic data collection

Work has started on collecting the following types of data for the GIS database.

- Topographic data: DEM of SRTM3 Version2 distributed by NASA.
- Mine data: From Mines Development Department (MDD), Shape format. The file format of mining concession data controlled by MDD is Shape, so that it will be possible to import the data to the GIS of GSD in the future.
- National Park/ Protective Zone data: From Zambia Wildlife Authority (ZAWA)
- Power Station/Power line data: From Zambia Electricity Supply Corporation (ZESCO)
- Magnetism data: In GSD
- Gravity data: In GSD

b) Extraction of specific information

Until recently, it had been hard to display specific mineral occurrences on GIS, because the mineral resource database didn't have a function that could export occurrence data in a suitable transfer format for GIS operation.

Therefore we have added another function to the database that enables mineral occurrence data to be exported in a suitable format to a selectable display for GIS.

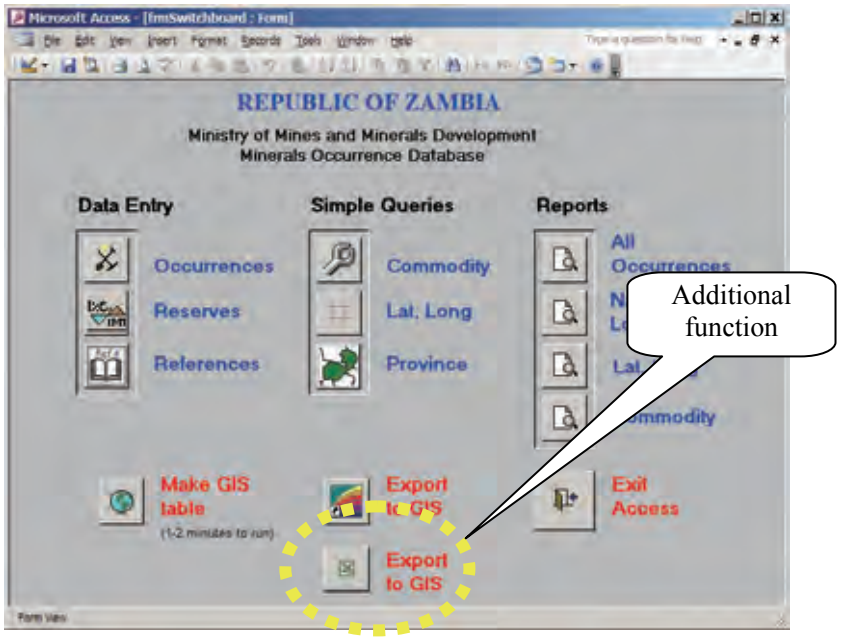

Fig. 4.2.3 GUI of the mineral resource database

In the existing data export method, output file format (dBase IV), folder saved and drive (G:) in PC are fixed and has little flexibility. For this reason, we have adopted an Excel file format and included a choice of destination folders for saving files to improve the usability.

A comparison of the exported records from the database of No.21 mineral occurrence was made between Table 4.2.6 (using only previously existing functions) and Table 4.2.7 (using added functions). Three commodities (Manganese, Copper, Zinc) are registered at this occurrence, although only two records were exported, as differences in commodity classes, not the commodity itself. Moreover, since the three commodities are expressed as a string in the database field (Comm_list), it is hard to display each on GIS. Therefore, the export function was modified to express each one individually with existing information. The yellow colored columns in Table 4.2.7 indicate the added items.

Table 4.2.6 Export results using only previously existing functions

Field Items	Exported Record 1	Exported Record 2	Exported Record 3
Number	21	21	
Name	LUAPULA AREA	LUAPULA AREA	
AltName	BUKANDA, CHIMPATIKA,	BUKANDA, CHIMPATIKA,	
Class	Ferrous metals	Base metals	
CommList	Manganese, Copper, Zinc	Manganese, Copper, Zinc	
Status			
GSnumber			
LatDec	-10.5	-10.5	
LongDec	29.08333333	29.08333333	
Lat	103000	103000	
Long	290500	290500	

Table 4.2.7 Export results using added functions

Field Items	Exported Record 1	Exported Record 2	Exported Record 3
Number	21	21	21
Name	LUAPULA AREA	LUAPULA AREA	LUAPULA AREA
Alternative_name	BUKANDA, CHIMPATIKA,	BUKANDA, CHIMPATIKA,	BUKANDA, CHIMPATIKA,
Full_Class	Ferrous metals	Base metals	Base metals
CommList	Manganese, Copper, Zinc	Manganese, Copper, Zinc	Manganese, Copper, Zinc
CCode	MN	CU	ZN
Commodity	Manganese	Copper	Zinc
Commodity_type	FE	BM	BM
Status			
GSnumber			
Importance	U	U	U
UTMZone	35	35	35
UTMEast	728018	728018	728018
UTMNorth	8838653	8838653	8838653
LatDec	-10.5	-10.5	-10.5
LongDec	29.08333333	29.08333333	29.08333333

Individual commodity could be displayed on GIS by importing these data as CAD format.

2,270 mineral occurrences exported from existing functions overlaid on 1/1,000,000 geological boundary maps are shown in Fig. 4.2.4 using TNTmips 2007:73 which was recently installed in the

PCs at GSD. The remaining 1,111 mineral occurrences are shown in Fig. 4.2.5.

Plot images of only Copper, Lead and Zinc occurrences from among the 1,111 mineral occurrences are shown in Fig. 4.2.6, Fig. 4.2.7 and Fig. 4.2.8, respectively.
A 1/1,000,000 geological map is shown in Fig. 4.2.9. As an example, an image displaying a specific geological unit (Undiff granite gneiss) and Copper occurrence is shown in Fig. 4.2.10.

Examples of operation windows of GIS software (TNTmips 2007:73) are shown in Fig.4.2.11.

b) Free GIS Software
The counterpart asked us to recommend free GIS software, so we compared several and recommended the following. They are also all open source software. This free software should be adequate unless users require the highly specialized functions included in commercial software.

These software programs need no initial and update costs, but there is no technical support available and users must take all responsibility for their utilization of the free software and results obtained there from.

Name	Developer
GRASS GIS 6.2.2	GRASS Development Team
Quantum GIS 0.8.1	QGIS Development Team
ILWIS 3.4	52° North

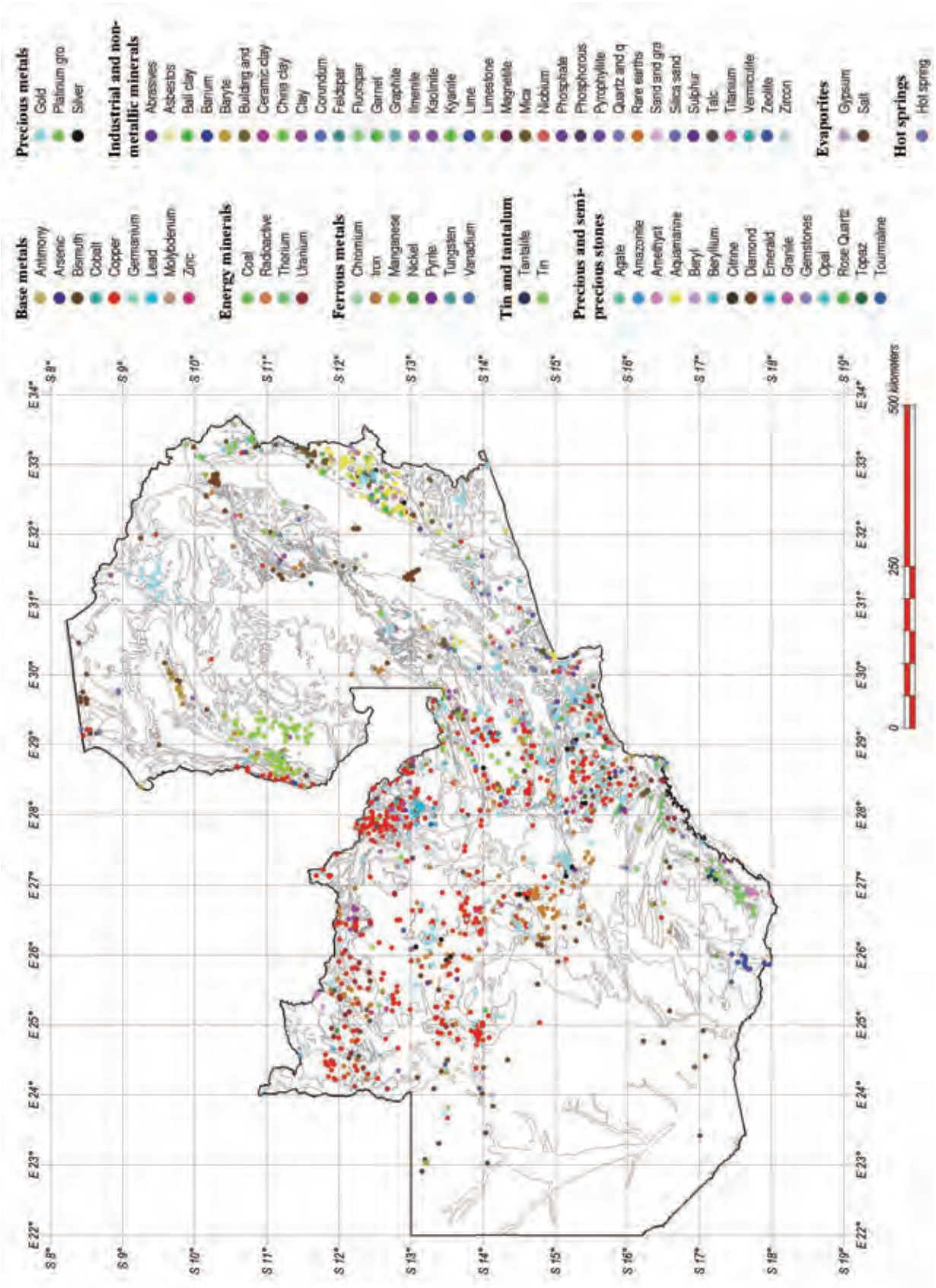

Fig.4.2.4 2,270 mineral occurrences exported from existing function
(on 1/1 million geological boundary map)

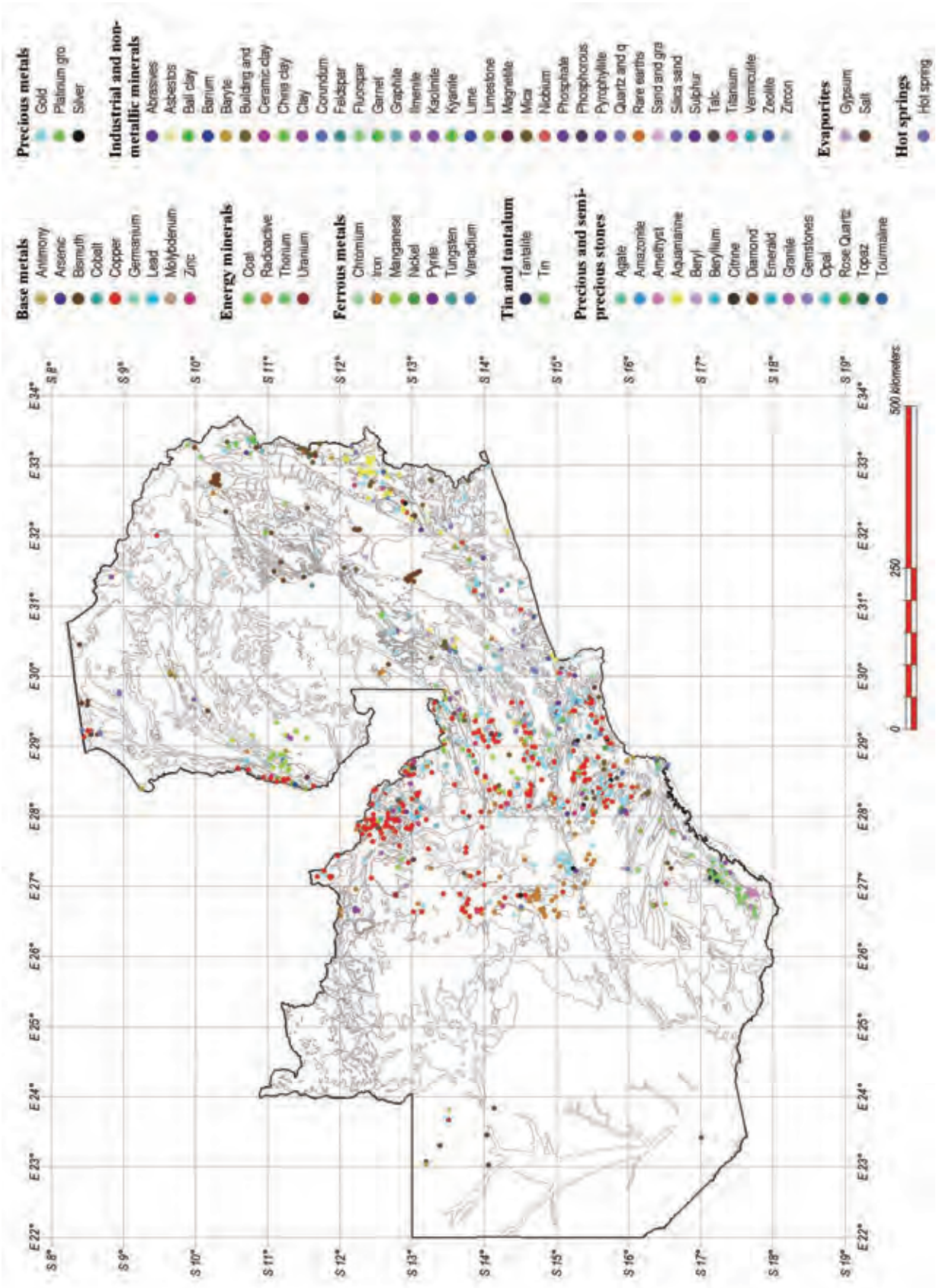

Fig.4.2.5 After investigation of data consistency, remained 1,111 mineral occurrences (on 1/1 million geological boundary map)

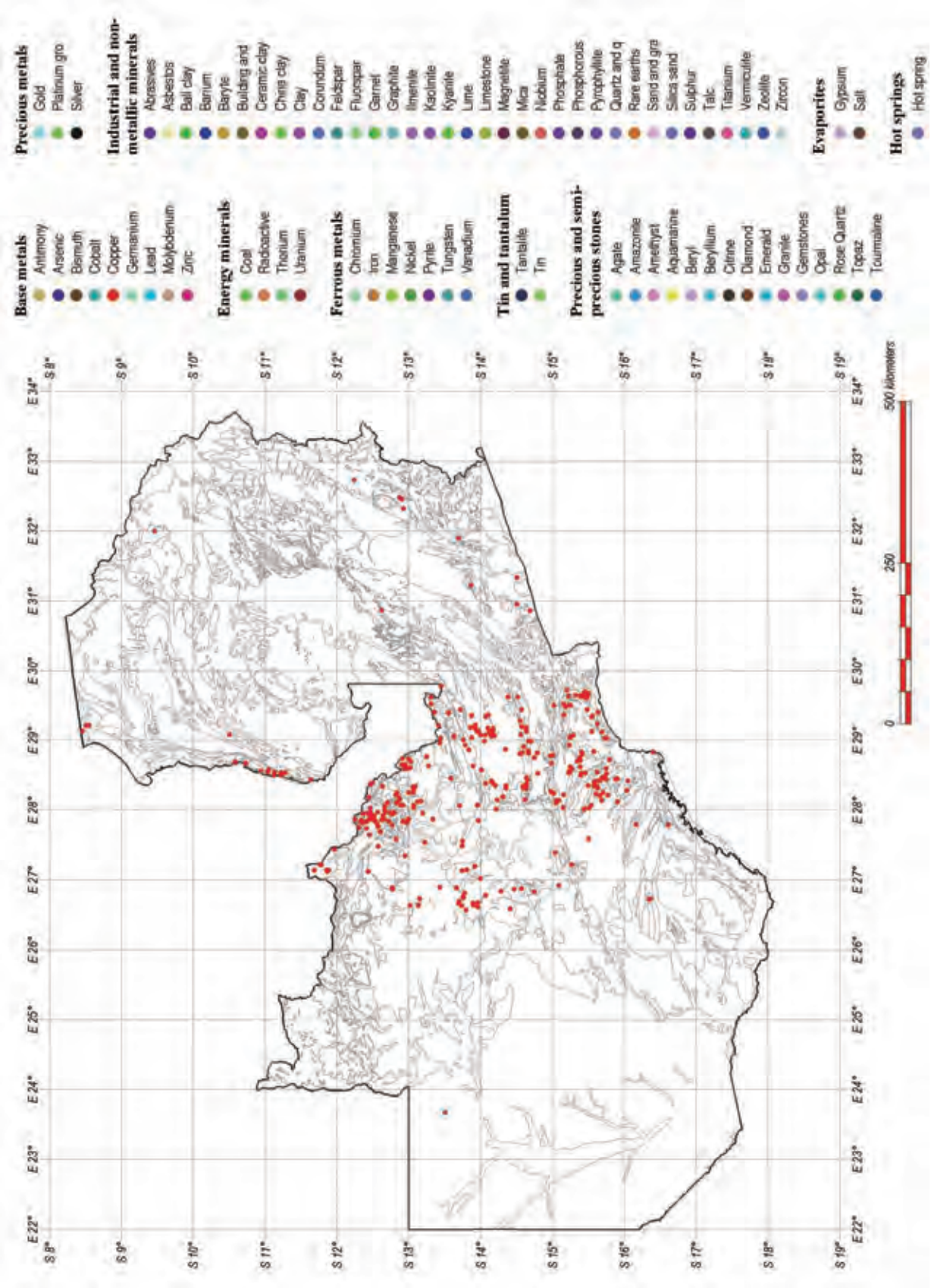

Fig.4.2.6 Copper occurrences (on 1/1 million geological boundary map)

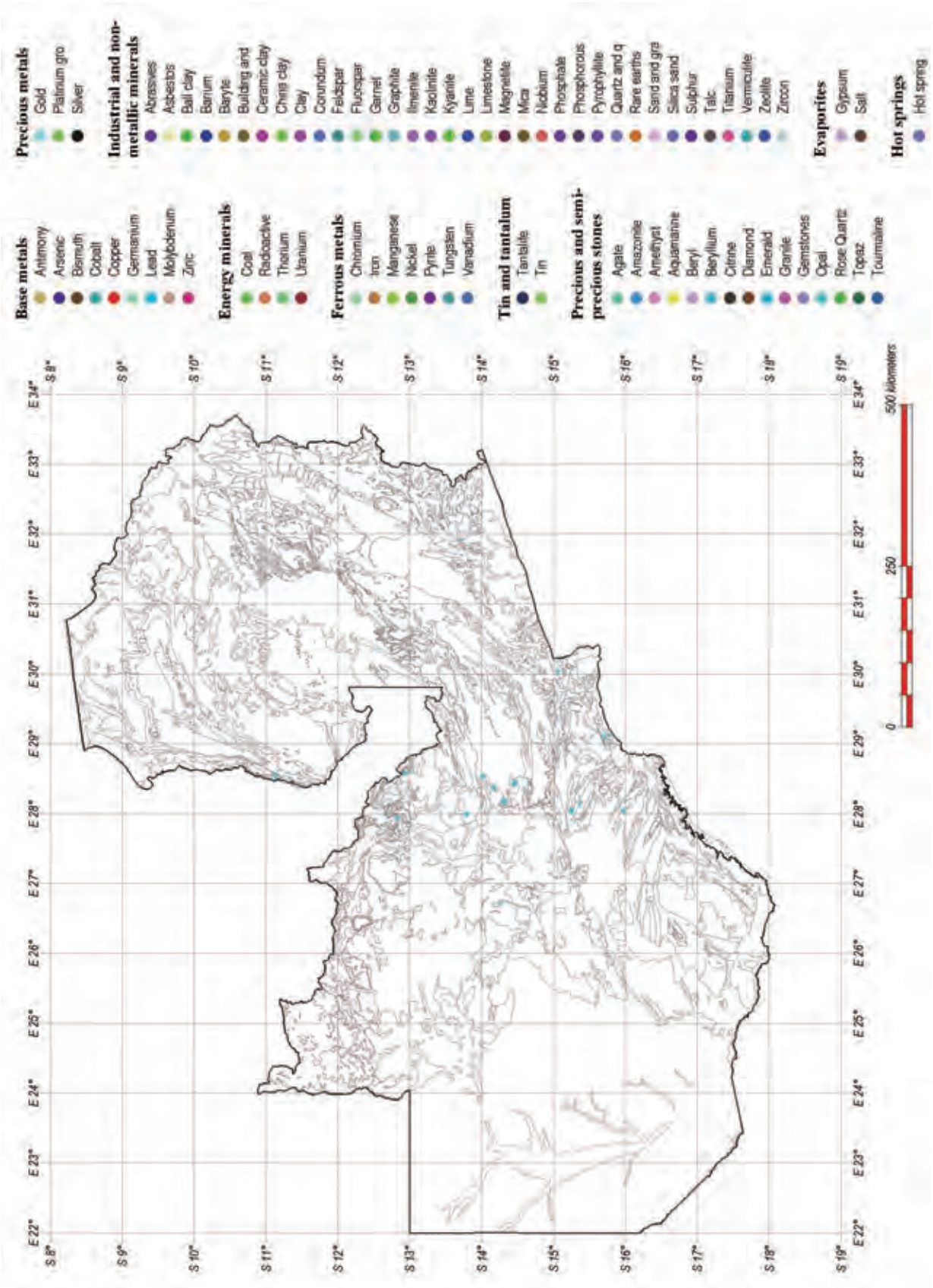

Fig.4.2.7 Lead occurrences (on 1/1 million geological boundary map)

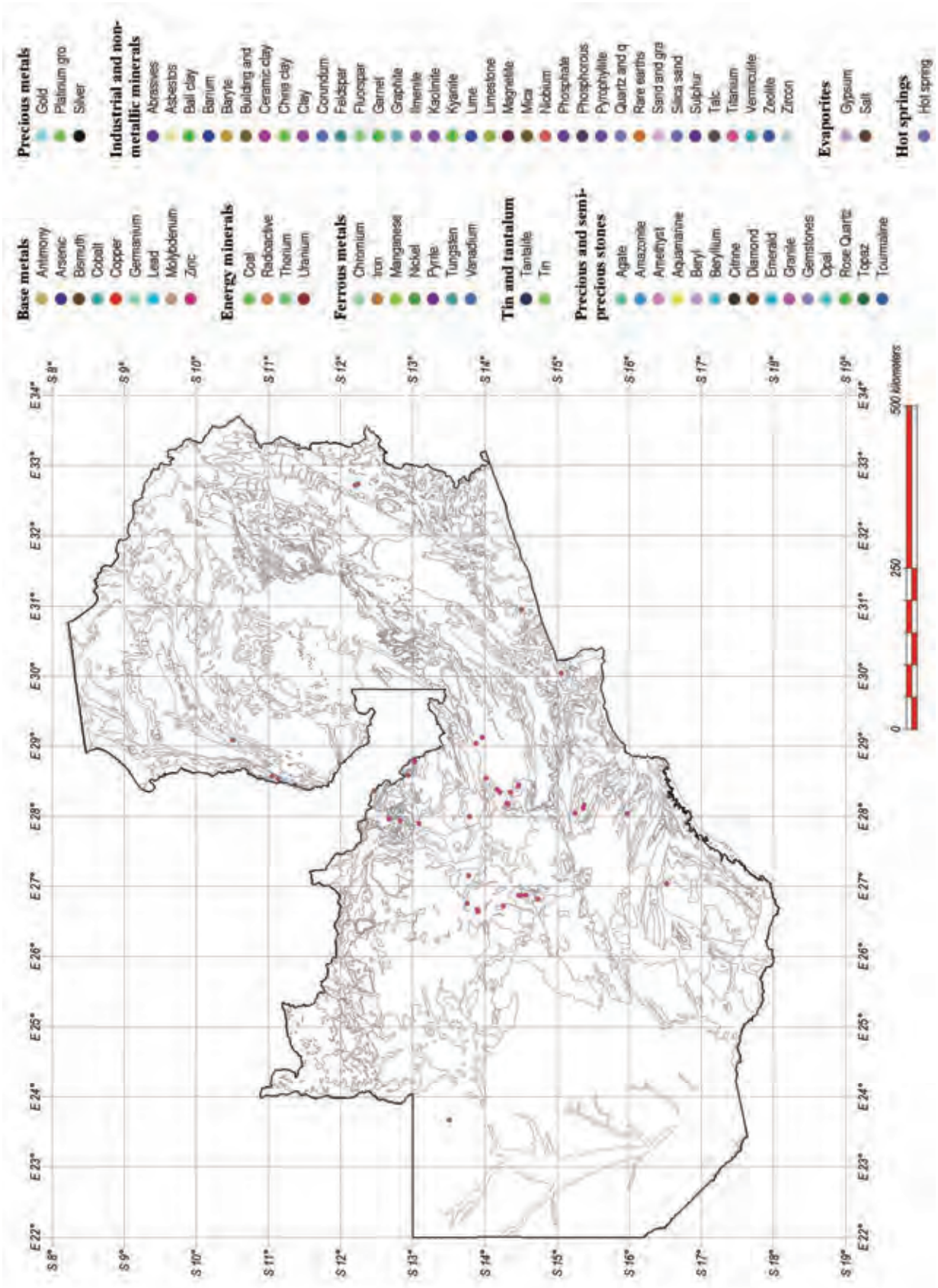

Fig.4.2.8 Zinc occurrences (on 1/1 million geological boundary map)

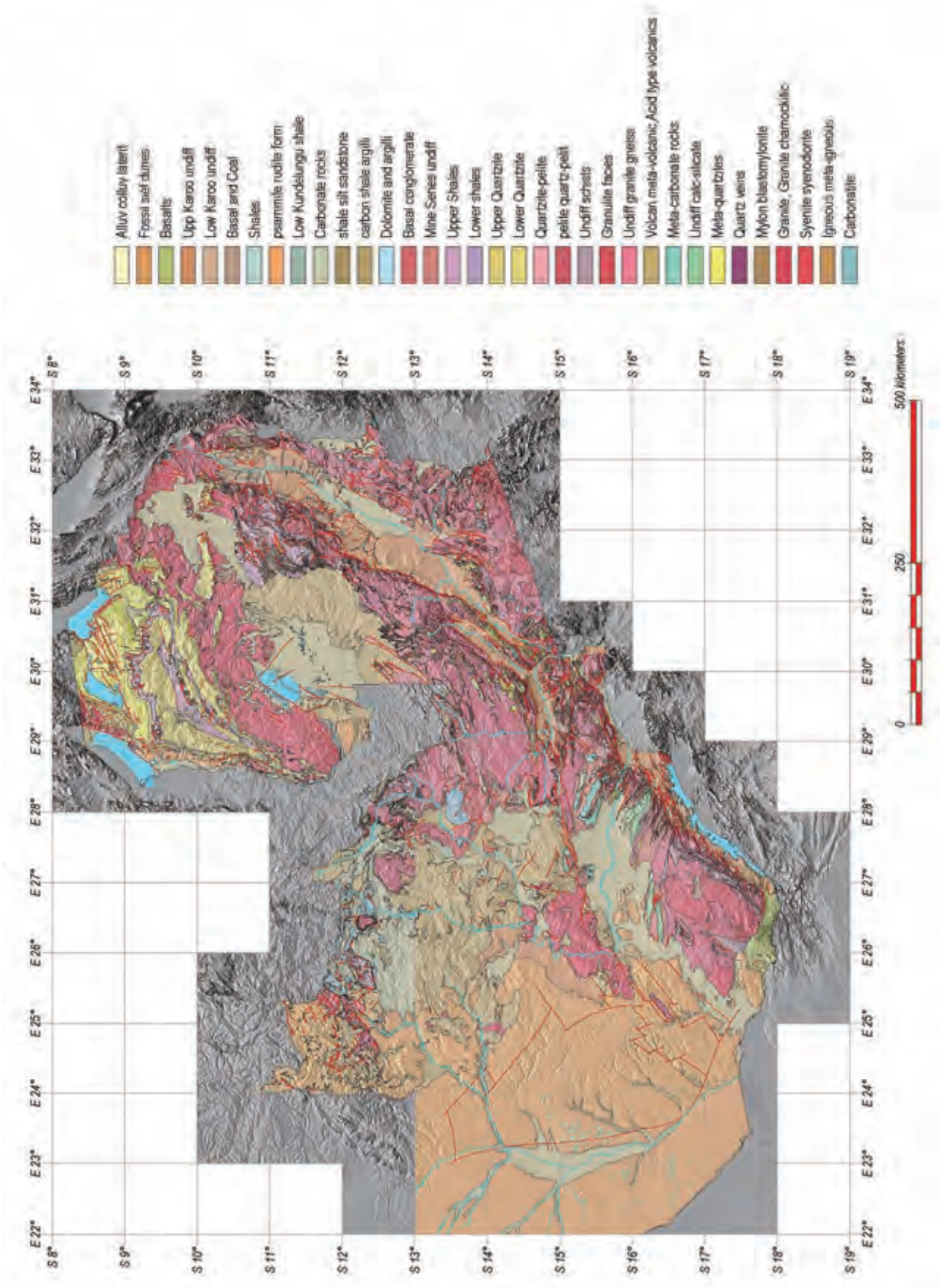

Fig. 4.2.9 1/1 million geological map

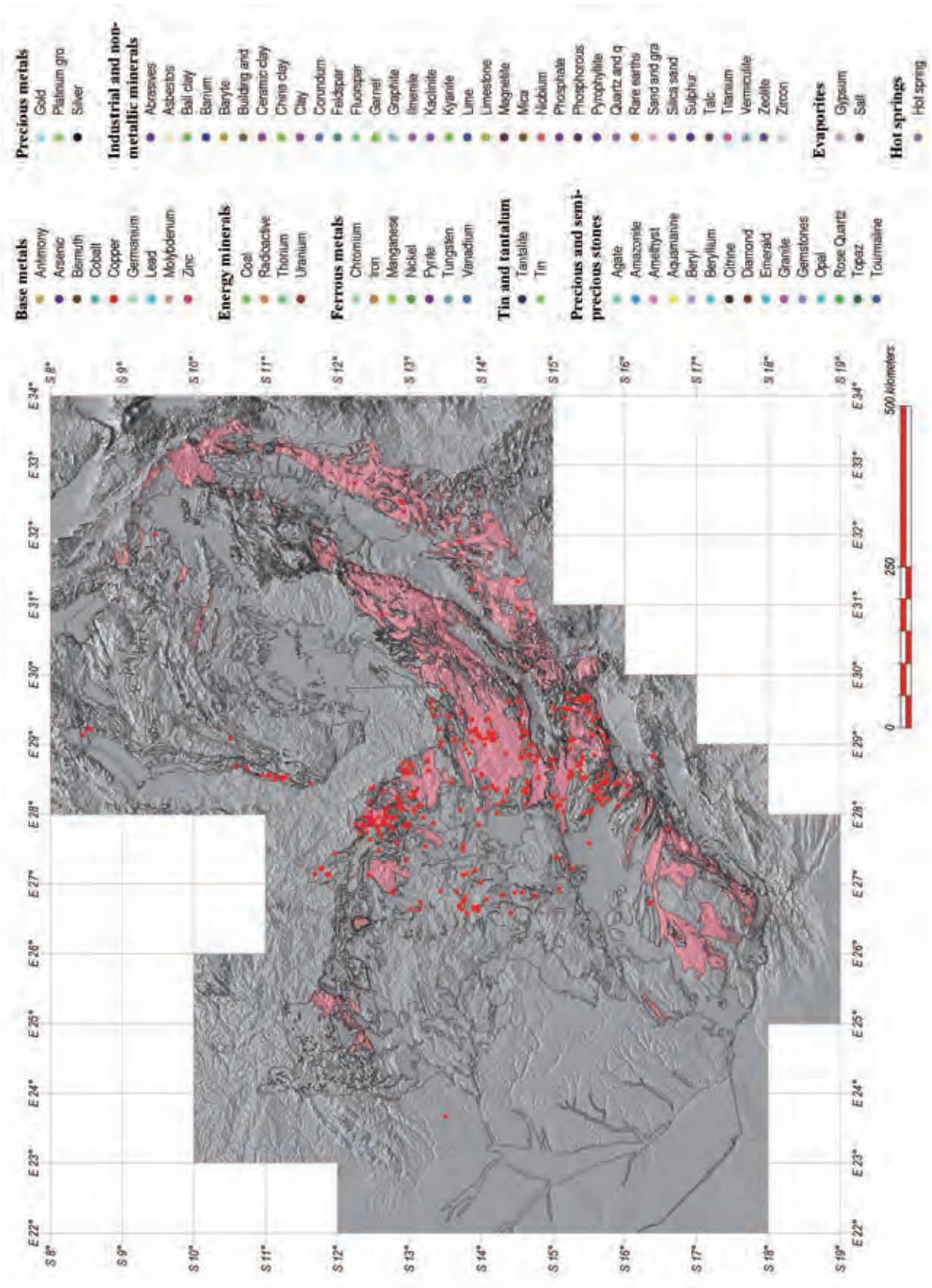

Fig. 4.2.10 Specific geological unit (Undiff granite gneiss) and Copper occurrence (on 1/1 million geological map)

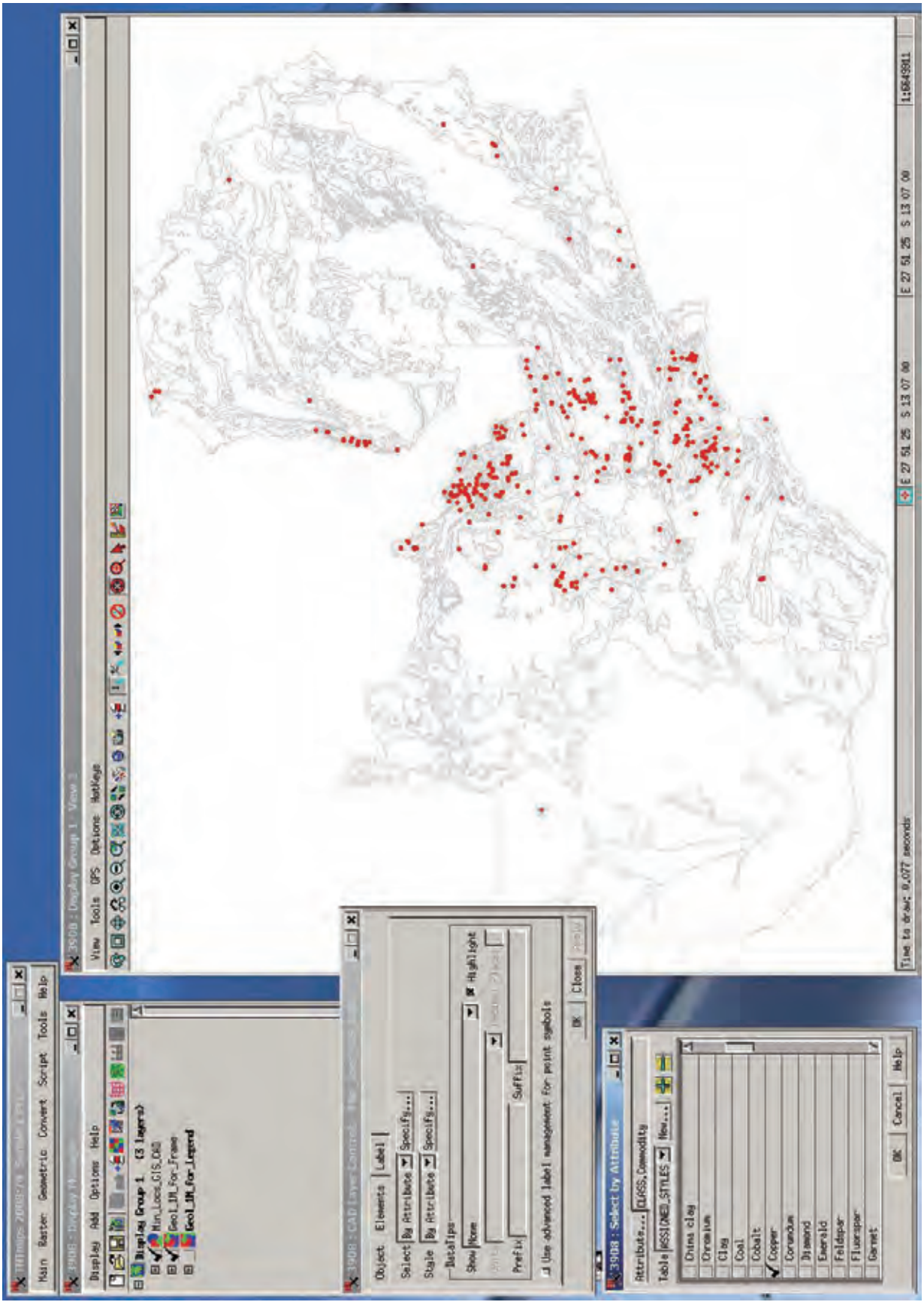

Fig.4.2.11 Example of operation windows of GIS software (TNTmips 2007:73)

4.3 Current Situation of and Issues with the Website

We checked the current situation of disclosure of geological information and response to requests from GSD. The address of the GSD web site is:

http://www.zambiageosurvey.gov.zm/

The top page of the GSD site is shown in Appendix IV-4. This site was opened last May, but it still does not provide enough information about GSD. A web site contractor developed the site, but the counterpart wants to train someone who can manage the web site at GSD instead of outsourcing, so that GSD can add and update information freely by themselves. Currently there is no one who has that skill at GSD, so some of the counterparts would like for JICA and other international organizations to provide support for human resource development in Lusaka.

4.4 Knowledge sharing and Management

Various types of data (reports, imagery, analyzed results, etc) are generally stored in each person's PC. For that reason, if a PC is in a room that is closed, no one can access its data. Therefore, we recommend the installation of a local area network (LAN) in GSD as intelligence infrastructure. Moreover, the public data server needs to be set to allow all GSD staff to be able to share various data. However it is necessary to employ or train a network administrator for stable operation of the system.

Currently, there are PCs that are infected with computer viruses. If the LAN is operated under this type of situation, there is a risk that the whole system might crash. Therefore, antivirus software must first be installed in all PCs, including the public data server, and be kept up to date for the stable maintenance and operation of the network system.