No.

MINISTRY OF ENERGY AND MINES
THE LAO PEOPLE'S DEMOCRATIC REPUBLIC

THE GEOLOGICAL MAPPING AND MINERAL INFORMATION SERVICE PROJECT FOR PROMOTION OF MINING INDUSTRY IN THE LAO PEOPLE'S DEMOCRATIC REPUBLIC

FINAL REPORT

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JAPAN INTERNATIONAL COOPERATION AGENCY

MITSUBISHI MATERIALS TECHNO CORPORATION
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PREFACE

In response to a request from the Lao Peoples Democratic Republic, the Government of Japan decided to conduct a study on "The Geological Mapping and Mineral Information Service Project for Promotion of Mining Industry in the Lao Peoples Democratic Republic" and entrusted to the study to the Japan International Cooperation Agency (JICA).

JICA selected and dispatched a study team headed by Mr. Yoshiaki Shibata of Mitsubishi Materials Techno Corporation and consists of experts from Mitsubishi Materials Techno Corporation and Kokusai Kogyo Co., Ltd. between March 2006 and October 2008.

The study team conducted field surveys in the study area and held discussions with the officials concerned of the Government of the Lao Peoples Democratic Republic. This final report was completed in October 2008.

I hope that this report will contribute to the promotion of mining development in the Lao Peoples Democratic Republic 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 the Lao Peoples Democratic Republic for their close cooperation extended to the study.

Mr. Seiich Nagatsuka
Vice President
Japan International Cooperation Agency

October 2008

October 2008

Mr. Seiich Nagatsuka
Vice President
Japan International Cooperation Agency
Tokyo, Japan

Letter of Transmittal

Dear Sir,

We are pleased to submit herewith a final report of "The Geological Mapping and Mineral Information Service Project for Promotion of Mining Industry in the Lao Peoples Democratic Republic".

In Lao PDR, potentials of mineral resources such as gold, silver, copper, lead and zinc are expected to be very high. Mining development of these mineral resources can earn foreign currency income in future. However, mining investment has not been active for mineral potentials because information of domestic mineral resources and investment climate are not prepared well enough.

In order to accelerate investment in mining of Lao PDR, the study team and Laotian counterparts prepared information of geology and mineral resource of LAO PDR and disseminated the prepared information domestically and internationally during the project term from March 2006 to October 2008. Capacity development of Department of Mines and Department of Geology of the Ministry of Energy and Mines was also implemented at the same time during the project period. The team hopes the information prepared by the Project will be utilized for mineral exploration and development in future and engineers trained by the project will contribute further to enhancement of institutional capacity.

We would like to express our heartfelt appreciation to the people of Lao PDR for their active participation in the study, especially the Ministry of Energy and Mines, the Department of Mines and the Department of Geology. We also deeply indebted to the officials of JICA, the Ministry of Economy, Trade and Industry, the Ministry of Foreign Affairs, the Embassy of Japan in Lao PDR, and the JICA office in Lao PDR for their continuous support throughout the Project.

Finally, we hope that our outputs will contribute to development of mining sector of Lao PDR and to fostering a long-lasting partnership and friendship between Japan and Lao PDR.

Yours faithfully,

Yoshiaki Shibata
Leader of the JICA Study Team

THE GEOLOGICAL MAPPING AND
MINERAL INFORMATION SERVICE PROJECT
FOR PROMOTION OF MINING INDUSTRY
IN THE LAO PEOPLE'S DEMOCRATIC REPUBLIC

FINAL REPORT

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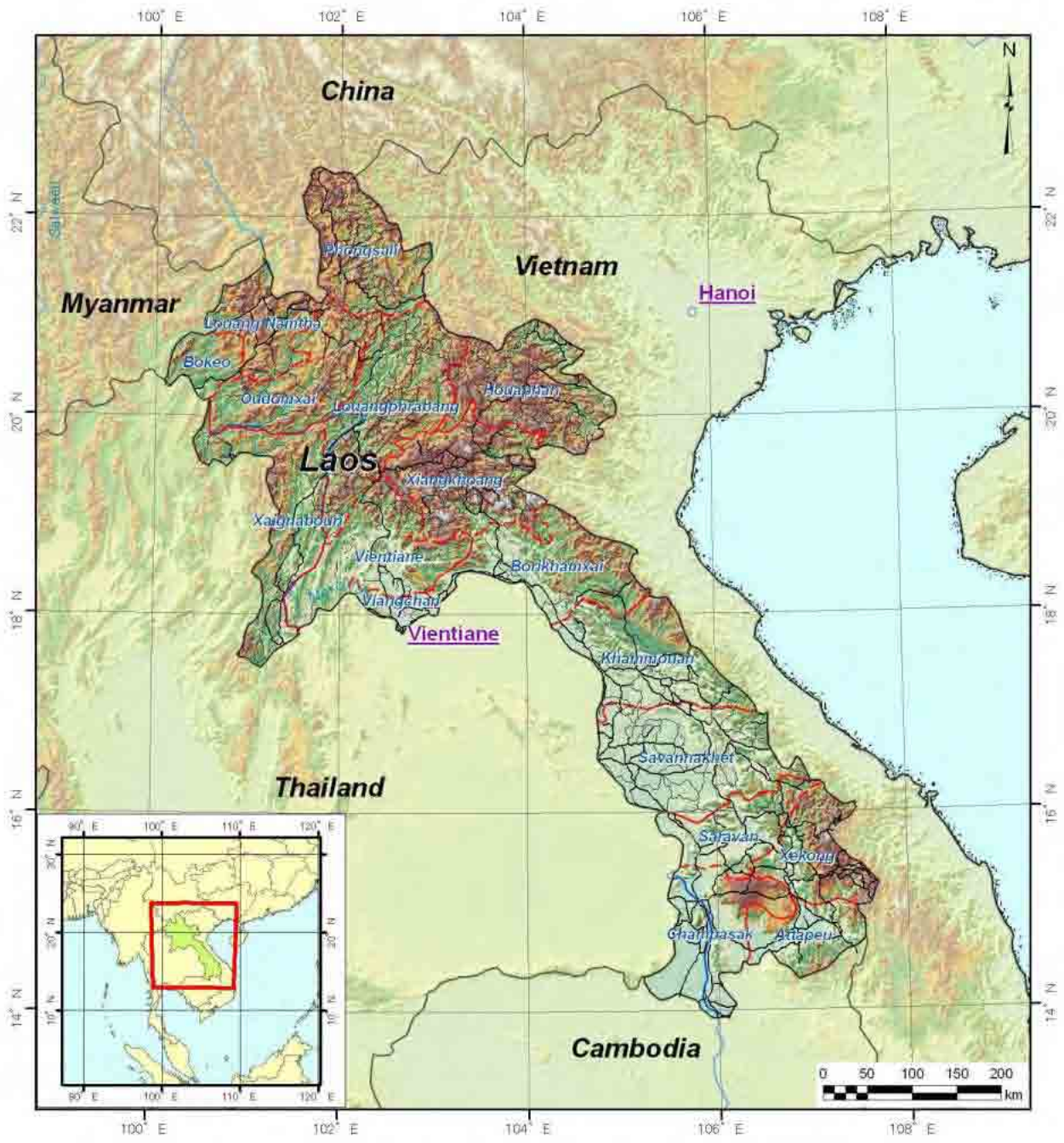


Location map of the Lao People's Democratic Republic

CHAPTER 1 INTRODUCTION

1.1 Preface

This Report shows the result of the project of "The Geological Mapping and Mineral Information Service Project for Promotion of Mining Industry in the Lao People's Democratic Republic" conducted from 2006 to 2008.

The project is an international cooperation project implemented by Lao People's Democratic Republic (referred as Lao PDR) and Japan aiming at establishment of mineral information service in order to promote investment to mining sector of Lao PDR.

1.2 Background of the Project

Abundant mineral resources are expected in the Lao PDR such as gold, silver, copper, lead, zinc and iron. Mineral resources development is an industry which can serve as one of the future precious source of foreign currency earnings.

Mineral resources development is under the management of Ministry of Energy and Mines (MEM), Department of Geology (DGEO) and Department of Mines (DOM). Detailed information of domestic mineral resources is not fully prepared and legal systems are also inadequate. The organization of DGEO and DOM is not fully established for the mining development by private sector investment.

In order to promote investment by private capitals to the mining field in the Lao PDR, the DGEO and DOM are requested to play substantial role in establishing scheme for smooth acceptance of investment and in providing necessary information of related mineral resources. Moreover, management of mining development plan paying attention to environment-concerned manner will be much more enhanced in the future. Consequently, the Lao PDR government has requested to implement investigation which will improve service of information on mineral resources, in order to promote investment to the mining industry from domestic sectors and foreign countries.

1.3 Objectives of the Project

The main objectives of the Project is to develop the capability of Department of Geology (DGEO)and Department of Mines (DOM), Ministry of Energy and Mines (MEM) (former Ministry of Industry and Handicraft: MIH) and which is responsible for mineral resources development as well as to organize information of geology and mineral resources in accessible form from outside in order to promote mining industry in the Lao PDR. The major objectives are as follows:

1) To revise the 1:1.000.000 geological and mineral resources maps
2) To conduct geological field survey and prepare 1:200,000 geological and mineral resource maps
3) To construct and publish GIS-based mining information.
4) To enhance human resources necessary to accomplish above objectives.

1.4 Study Area

The target study area covers whole territory of the LAO PDR. An "Important geological survey area for construction of mineral information system" is selected in Attapeu, Sekong and Champasak Provinces, southern Lao with an area of 180km in east-west by 80 km north-south.

1.5 Organization of Implementation

Members of the steering committee of the Project are as follows:

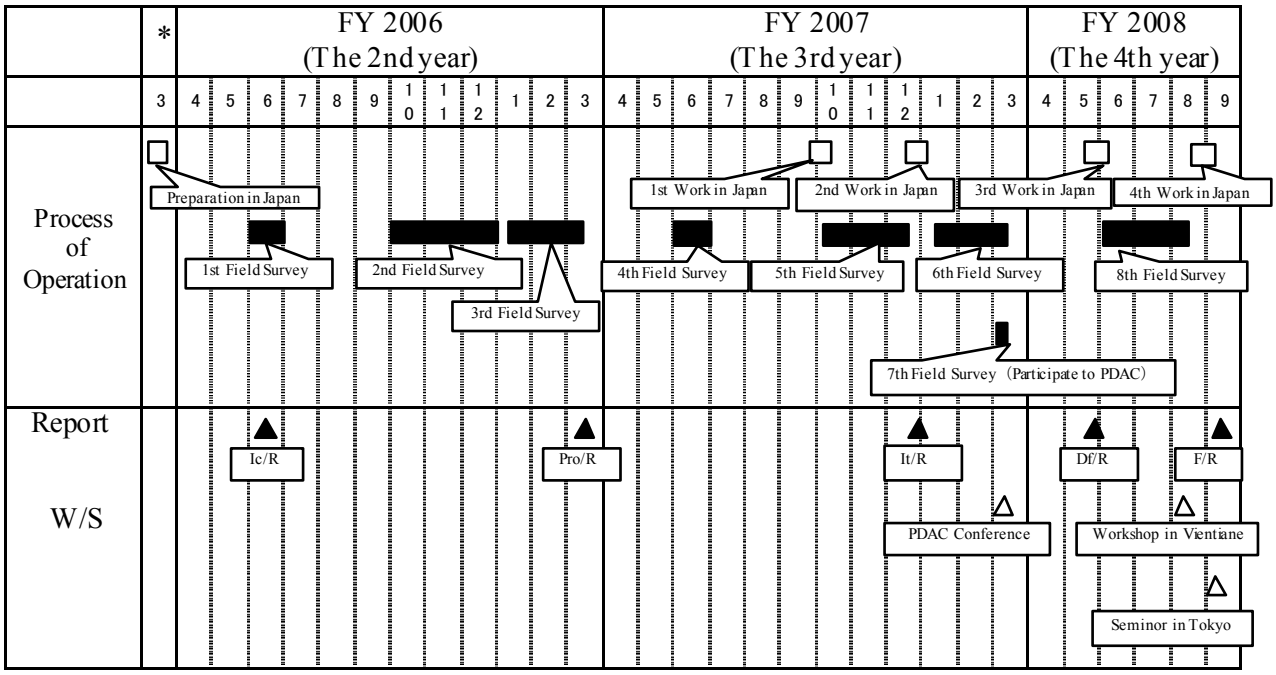
- Ministry of Energy and Mines: MEM
- Department of Geology: DGEO

- Department of Mines: DOM

1.6 Plan of the Project

General plan is shown in the Figure1.6.1. The survey consists of 4 years activities shown. Each activity is as follows:

- The first year : Preparation Work in Japan
- The second year : The 1st Field Survey in Lao PDR
  The 2nd Field Survey in Lao PDR
  The 3rd Field Survey in Lao PDR
- The third year : The 4th Field Survey in Lao PDR
  The 1st Study in Japan
  The 5th Field Survey in Lao PDR
  The 2nd Study in Japan
  The 6th Field Survey in Lao PDR
  The 7th Field Survey in Canada
- The fourth year : The 3rd Study in Japan
  The 8th Field Survey in Lao PDR
  The 4th Study in Japan



* : FY2005 (The 1st year)

Figure 1.6.1 The whole process of the Project

1.7 Outline of the Project

1.7.1 Preparation Work (March 2006)

In March 2006 Preparation Work was done in Japan for the 1st year of the Project.

Details of the works are as follows:

- Collection and compilation of information of geology, and preliminary analysis

- Discussion of basic policy of the Survey in general, solid contents and the way of implementation
- Preparation for the 1st Field Survey
- Discussion of the Inception Report

1.7.2 The 1st Field Survey (May ~ June 2006)

As the 1st Field Survey, first of all, the Inception Report prepared by the Japanese survey team was proposed to the MEM and the DGM (currently DGEO and DOM) and the contents of the Report were accepted.

The Japanese survey team held a workshop to introduce the Survey to the person concerned including the staffs of DGM (currently DGEO and DOM) on 6th June 2006. At the workshop, the details of activities of the Survey and related technology are introduced.

During their stay in Lao PDR, the Survey team studied various items such as; organisation structure, workforce and capacity of DGM (currently DGEO and DOM), facility and instrument for GIS and chemical analysis, materials providing geological information, and "Sector Plan for Sustainable Development of the Mining Sector in the Lao P.D.R." carried out by the World Bank.

Also the Survey team carried out geological reconnaissance and information gathering over the area of "Attapeu" as this area was selected as "Important geological survey area for construction of mineral information system" by the discussion between the DGM (currently DGEO and DOM) and MEM.

1.7.3 The 2nd Field Survey (September ~ December 2006)

In the 2nd Field Survey, various activities were conducted as follows:

- Geological field survey to draw out 1:200,000 geological map and mineral resources map of Attapeu area
- Gathering information and study of geology and mineral resources to revise 1:1,000,000 geological map and mineral resources map
- Construction of database system by GIS, input of existing information to the database, technical transfer to the Counterpart
- Preparation of materials and instrument of chemical analysis and technical transfer to the Counterpart

For the technical transfer to the Counterpart, a seminar focusing on technology relating geology was held on 4th and 5th October inviting geologists of the DGEO and DOM. Also workshop of ArcGIS software was held from 1st to 17th November for the technical staffs interesting in GIS.

1.7.4 The 3rd Field Survey (January ~ March 2007)

In the 3rd Field Survey, activities were conducted as follows:

- Geological field survey to draw out 1:200,000 geological map and mineral resources map of Attapeu area
- Gathering information and analysis of geology and mineral resources to revise 1:1,000,000 geological map and mineral resources map
- Chemical analysis (Analysis of mineral ore)

1.7.5 The 4th Field Survey (June ~ July 2007)

In the 4th Field Survey, several activities without geological survey were carried out as follows:

- Revision of the Website contents and preparation of the format for new map products

- Preparation of 1:200,000 geological map and mineral resources map of Attapeu area
- Discussion on the extraction of high mineral potential zone
- Chemical analysis (Analysis of mineral ore)

1.7.6 The 1st Study in Japan (October 2007)

- Extraction of high mineral potential zones in Attapeu area

1.7.7 The 5th Field Survey (October~ December 2007)

In the 5th Field Survey, activities were conducted as follows:

- Preparation of 1:200,000 geological map and mineral resources map of Attapeu area
- Exchange the geological information collected in the field and discussion on the geological mapping with DGMV survey team
- Chemical analysis (Analysis of mineral ore)
- Detailed geological survey in the high mineral potential zones
- Preparation of 1:10,000 geological map and mineral resources map of detailed survey areas
- Collecting information and analysis of geology and mineral resources to revise 1:1,000,000 geological map and mineral resources map
- Assessing GIS database structure for new input data and new map products

1.7.8 The 2nd Study in Japan (December 2007)

- Preparation of the Interim Report

1.7.9 The 6th Field Survey (January ~ March 2008)

In the 6th Field Survey, activities were conducted as follows:

- Presentation and discussion of the Interim Report
- Detailed geological survey in the high mineral potential zones
- Preparation of 1:10,000 geological map and mineral resources map of detailed survey areas
- Chemical analysis (Analysis of mineral ore)
- Preparation of new input data and new map products
- Discussion of the contents uploaded on the Website
- Preparation for the presentation of the international seminar at the PDAC
- Assessing GIS database structure for new input data and new map products

1.7.10 The 7th Field Survey (March 2008)

Presentation at the PDAC international conference in Toronto was conducted by the survey team and Laotian C/P to promote mining investment from foreign companies.

1.7.11 The 3rd Study in Japan (May 2008)

Preparation of the Draft Final Report was carried out in the 3rd study in Japan.

1.7.12 The 8th Field Survey (June ~ August 2008)

In the 8th Field Survey, activities were conducted as follows:

- Completion of 1:1,000,000, 1:200,000, 1:10,000 geological and Mineral resources maps were completed
- Chemical analysis (Analysis of mineral ore)

- Preparation of new input data and new map products
- Reconstruction and update of the Website
- Preparation and discussion of the Draft Final Report
- Organizing Workshop in Vientiane

1.7.13 The 4th Study in Japan (September 2008)

Preparation of the Final Report and organizing seminar in Japan were carried out in this priod.

1.8 Major topics during the Project

Some issues relating to smooth implementation of the Project are as follows:

- 30 geologists are working for DGEO and DOM. However, the number of geologists with expertise of geology and professional experience of field survey is rather limited.
- In Attapeu area selected for geological mapping, lowlands are dominant and eastern part is blocked by mountains. By these topographic settings, road conditions are extremely bad due to the floods in rainy seasons resulting high water level. Field survey work is very hard in rainy season and also field access is actually limited even after the rainy seasons.
- Lack of work force at DGEO and DOM, data storage and information sharing of materials such as publications, maps, reports of geology and mineral resources are not necessarily well maintained. In such situation, information and material gathering are time-consuming work.
- Financial difficulty at DGEO resulted in a delay of renovation of chemical instrument, insufficiency of consumables and out-of-date behind present standard. Workable analyses are limited both in the items and elements. Also control of accuracy and volume of analysis are limited.
- Computers and peripheral equipment, software required for GIS data generation and operation are not enough capacity and not updated due to financial difficulty at DGEO similar to chemical analysis.

1.9 Member List of the Project

The member involved in the Project and the Steering Committee for the Project are listed in Table 1.9.1 and 1.9.2.

Table 1.9.1 Member list of the Project

Name	Assignment
<JICA>	
Mr. Satoshi Kobayashi	Staff / JICA Headquarter
Mr. Sota Sekine	Assistant Resident Representative
<GSJ, AIST>	
Dr. Yasushi Watanabe	Adviser to Study Team
<JICA Study Team>	
Mr. Yoshiaki Shibata	Team leader
Mr. Motomu Goto	Geological Mapping
Mr. Yoshimitsu Negishi	Evaluation of Mineral Resources
Ms. Yasuko Kamegai	Geochemical Analysis
Ms. Chiyo Kigasawa	GIS Database Preparation
Mr. Masayuki Shirai	Evaluation of Information for Mining Investment
Mr. Masami Sugita	Construction of GIS Database
Mr. Kazuyasu Tsuda	Coordinator
<C/P Staff>	
Mr. Khampha Phommakaysone	Team Leader
Mr. Sixomxeum Duangsurigna	Geological Mapping
Mr. Siphandone Vilayhack	Geological Mapping
Mr. Sisaad Phomkenthao	Geological Mapping
Mr. Amkha Voravong	Geological Mapping
Mr. Phonetalome Vilaysan	Geological Mapping
Mr. Thavone Khounchanthida	Geological Mapping
Mr. Boualay Saatsy	Geochemical Analysis
Ms. Phengsy Sirithongdy	Geochemical Analysis
Mr. Soubinh Siphandone	Geochemical Analysis
Mr. Phonephet Chounlamonty	Sample Preparation
Mr. Inpong Homsombath	GIS Database Preparation
Mr. Chantala Keohavong	GIS Database Preparation
Mr. Kuangnuvong Thepvongsa	GIS Database Preparation
Ms. Vannapha Phommachanh	GIS Database Preparation

Table 1.9.2 Member list of the Steering Committee

Name	Assignment
<Ministry of Energy and Mines>	
Dr. Bountheung Phengthavongsa	Deputy Director of the Cabinet of Ministry of E / M
<Department of Geology>	
Mr. Chansone Senebouttalath	Director General
Ms. Chansavath Boupha	Deputy Director General,
Mr. Oudom Phommachanh	Director of Geological Information Division,
<Department of Mines>	
Mr. Thongphath Inthavong	Director General
Dr. Simone Phichit	Deputy Director General

CHAPTER 2 PRESENT MINING ACTIVITIES IN LAO PDR

2.1 Introduction

Present situation of mining activities in Lao PDR is described in this chapter. Public income from mining sector is rapidly increasing in Lao PDR because of steep rise of metal prices in recent days and the interest in a mining sector is becoming increasingly. These data and information are largely cited from DGEO and DOM as well as the report of "Integrated Assessment of Mineral Resources in the Greater Mekong Subregion " prepared by United Nation in 1999, "Survey on Natural Resources Development Circumstance(in Japanese)" prepared by Japan Oil, Natural Gas and Mineral Resources Corporation in 2005 and "Sector Plan for Sustainable Development of the Mining Sector in the Lao PDR" prepared by World Bank in 2006.

2.2 Mining Policy

2.2.1 Principle of Mining Policy

In 1985, the Government introduced the "New Economic Mechanism (NEM)" which is aimed at changing the basis of the national economy from centralized planning to free-market principles and a new constitution was promulgated in 1991. The government's strategy for the mining sector based on the above policy is as follows;

(1) Promote the ecologically sustainable use of the country's mineral resources.

(2) Promote systematic exploration of the country by modern and integrated techniques.

(3) Promote the immediate development of small scale and artisanal mining ventures.

(4) Promote the medium-term development of large scale mining operations.

To implement this strategy, the Government has initiated a number of measures, which include the followings;

A) Establishment of appropriate national mining, environmental protection and investment laws so as to provide a well defined investment climate for both mineral exploration and subsequent development projects.
B) Encouraging the existing parallel market operators (usually small scale) to transfer to the formal market.
C) Providing administrative and support services to investors in mineral exploration and development. -
D) Undertaking geological survey programmes to help identify those areas with high prospectivity. Identified areas can be promoted as exploration targets to private sector companies.
E) Developing government organizations and services necessary to support the mining sector and efficiently manage new mining projects.

To achieve its goals, the Government plans to embark on a mineral resources investment promotion programme both within the region and internationally. The primary targets of the investment promotion programme will be foreign mining companies with an established reputation for environmental sensitivity and good environmental management. This programme will highlight the favourable investment climate (legal, financial, institutional) and the mineral prospectivity and development potential in the country. To support this programme, the Government will continue to expand geological information, laboratory and title management services within the DGM (currently DGEO and DOM). These services will provide investors with current information on which to base their exploration and investment decisions.

The Government decided to restructure the ministry in 2006 for the institutional strengthening, improvement of legal framework and sector management and development of human resources. The

mining sector is detached from the Ministry of Industry and Handicraft (MIH) and reorganized as the Ministry of Energy and Mines (MEM) by the consolidation. Furthermore, the Government also decided to divide the DGM into two departments, namely Department of Geology (DGEO) and Department of Mines (DOM) in 2007.

2.2.2 Legislation and Regulation in Mining

Foreign Investment Law, Mining Law, Environmental Protection Law, Tax Law and decree are applied to the mining activities in Lao PDR. Mining Law was promulgated in 31 May 1997.

1) Outline of New Foreign Investment Law for the Mining Sector

The new foreign Investment Law namely "Law on the Promotion of Foreign Investment" was adopted by the National Assembly on the 22 October 2004. Under the new investment law, three forms of business are open to potential investors from overseas who seek involvement in Laotian commercial ventures. These are:

(1) Business cooperation by contract

(2) Joint venture between foreign and domestic investors

(3) 100% foreign owned enterprise

Foreign investors who invest in a joint venture must contribute a minimum of 30 % of the total equity investment in that venture.

2) Mining Law

The purpose of the Mining Law is to provide a system of management for the conservation, exploration, mining and processing of minerals, for both local consumption and export, and for the use of mineral resources in industry and its processes and also to improve the quality of life for the people of the country.

Investment in mining activities (Article 21) shall take place under one of the following forms:

- Sole investment by the State
- Joint investment between the State and domestic and/or foreign parties
- Collective or private investment from domestic parties

Mining operations shall refer to all stages including prospecting, exploration, extraction, processing and trading of minerals. Prospecting, exploration and extraction shall be authorized only in areas where no mining activities for the same minerals are being conducted.

Persons or entities who seek to undertake mining activities shall apply for a prospecting license. When sufficient information has been gathered to justify further exploration, the person or entity shall apply for an exploration license.

After exploration, if a person or entity seeks to obtain a mining license, the following must be submitted to the Government: a study of the economic feasibility of the mine, an environmental assessment concerning the impacts of the mine on the environment, the ecology and society.

When a mining license is granted, the Government shall jointly invest in the mining operation. A person or entity who has been granted a mining license shall establish and register their enterprise in compliance with the laws of the Lao PDR.

Mineral prospecting refers to the procedure by which an evaluation of the geologic setting and the quality and distribution of mineral occurrences is determined by field observation. Mineral prospecting shall require the approval of the Government. The period of mineral prospecting shall not exceed 2 years but may be extended, with approval of Government, 2 times with each time for no more than 1 year.

Mineral exploration refers to geological and geophysical studies within a determined area for the acquisition of further detailed data on the geology and geological structures through testing, trenching, exploration drilling, analysis of the physical and chemical features of minerals in order to assess economic potential. Mineral exploration shall require the approval of the Government. The period of mineral exploration shall not exceed 3 years but may be extended, with the approval of Government, 2 times with each time for no more than 2 years.

After prospecting and exploration, licensees shall relinquish the undesired portion of the prospecting or exploration concession, in part or in full, and provide to the Government all data acquired from such prospecting and exploration. If it is discovered that a mineral occurrence extends beyond the licensed area, the licenses are entitled to apply for the addition of such area based on the acquired data.

An evaluation of the proposed mining project shall include an evaluation of the economics of the proposed mine and the foreseeable negative impacts of the proposed mine on the environment and the surrounding communities.

Mining, as referred to in this Law, refers to stripping, extraction, removal, processing, grinding, grading and storage of minerals. The period of the mining license shall not exceed 30 years from the date the concession is granted, but it may be extended twice, each time for no more than 10 years as approved by the Government who will consider the request for an extension upon a case by case basis and upon consideration of the scale of the mining operation.

Exploration and mining agreements (MEPA: Mineral Exploration and Production Agreement) which have been signed to date often contain basic provisions reiterating the ownership of mineral resources by the country and the development of these resources through agreements between the State, represented by the DIP (Department of Investment Promotion, Ministry of Planning and Investment) and relevant ministerial departments, and the investor.

With the Mining Act and implementing Decree enacted, there is a necessity for a capacity building programme in the fields of environmental impact assessment, social impact assessment, and public consultation within DOM. Expertise in these areas will be required to meet the needs of major new mining project(s) which are likely to reach the development stage over the next two or three years. Early training in proven environmental/social methodologies will enable Government to insure that the impacts of new projects are minimized.

3) Fiscal Regulation for the Mining Sector

In 1989, the taxation regime in Lao PDR was revised. Fiscal reforms included the introduction of new taxes, an extension of the tax withholding system, and the strengthening of the customs administration. In the past, the taxation on mining activity has generally been subject to the provisions of the general tax and investment law. Mining levies and charges are usually stipulated in governmental decrees.

The new Customs Law was promulgated in 1994. This Customs Law replaces the Decree No. 471CCM, dated 26/6/89, of the Council of Ministers on the state tax regime alone (Article 106).

For the fiscal obligations, under the Mining Law (Art. 42), the licensee shall have the obligation to properly and timely perform custom, tax and other fiscal obligations.

- Land rent is an annual payment to the government in kip or such other currency mutually agreed upon by the government and the mining company, to be measured by the number of hectares included in the contract area or mining area, respectively. Land rent for different types of mining activity, which are already in force, are enumerated under Article 16 of Decree No. 47 of 1989.
- Royalties, like land rents, are governed by Decree No. 47 of the State Tax System of 1989. Royalties for mineral production are computed and levied on the basis of the gross sales

value of the mineral in question, taking into account the purity of the mineral - and with the unit value determined in accordance with international norms and standards. For foreign companies doing mining business in Lao PDR under a contract of work/agreement, the rate of royalty is from 2.5-5 per cent for precious metals.

2.3 Investment Climate and Present Situation

Lao PDR is a land-locked country and a social infrastructure has been less prepared, which are negative factors for development. However, remarkable improvement of infrastructures of transportation, communication and electricity are expected recent years.

As Lao PDR is surrounded by Thailand, Vietnam, Cambodia, Myanmar and China and a economic size is relatively small, those neighbouring countries sometimes are economic threat to Lao PDR. On the other hand, there is another aspect that economic strategies of neighbouring countries involving Lao PDR are contributing economic development of Lao PDR itself. A concept of Greater Mekong Economic Zone will add significant strategic meaning to Lao PDR in the discussion of selecting destinations of foreign capital investments.

2.3.1 Transportation

For transportation, Indochina East-West Corridor which connects Thailand and Vietnam via No.9 National Road of Lao PDR was constructed. In December 2006 an international bridge crossing Mekong River at Savannaket of Lao PDR and Mukdahan of Thailand was completed by a soft loan provided by Japan (Figure2.3.1). No.13 National Road is under renovation from South to North, crossing the East-West Corridor in Laos. Moreover, in northern Laos a main road is expected to connect Yunnan of China and Thailand through No.3 National Road of Lao PDR shortly (Figure2.3.2). No. 18 National Road connecting Attapeu and Vietnam was constructed as a new major route in southern Laos. Asian Highway Project is also progressing.

Figure 2.3.1 Road construction plan in central part

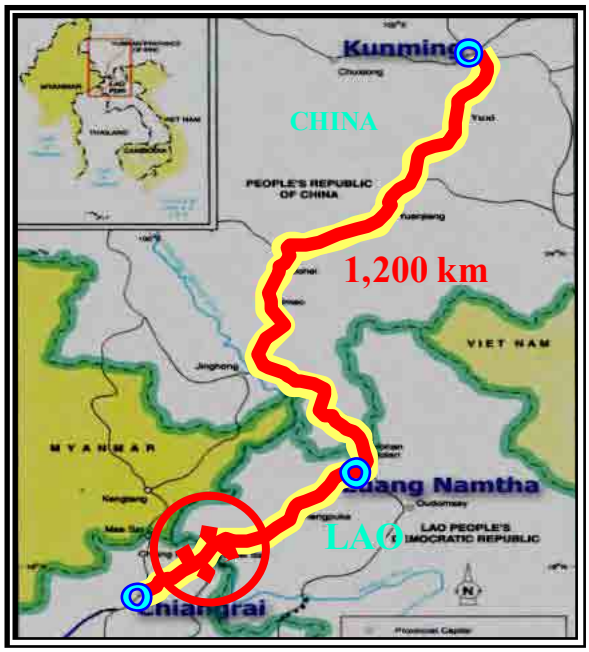


Figure 2.3.2 Road construction plan in northern part

2.3.2 Telecommunication

The penetration rate of telephone service has been dramatically increased in recent years. As of the year 2006, the number of subscribers of fixed line telephone service was reported as 91,235 (e.g. about 2% of coverage rate) and the number of mobile phone was 901,637 (e.g. about 16% of coverage

rate) by the Ministry of Public Works. As mobile phones are provided mainly by pre-paid system, actual penetration is thought to be far greater than that of announced number.

Optical fiber main network connecting major points of whole territory has been established and international connection with neighboring countries have also completed. However, constructions of branch lines and further lines up-to end-users are in primitive stage and eservice is limited to the urban areas like Vientiane and major cities. Comparing urban areas with rural districts, more than 60% of villages have been left out of telecommunication reach and there are no remarkable change of the gap existing between urban areas and rural villages.

2.3.3 Electric Power

The Lao PDR is highly endowed with water resources and hydropower generation is far exceeding the other power source. At the end of 2007, national total electric generation was 672.2 MW and 99.83 % are generated by 10 hydropower plants. In the midst of industrialization, present domestic demand for electric power is still modest comparing to the actual electric power production, surplus of electric power has been exported earning considerable amount of foreign income.

On the contrary, construction of domestic main power line networks is still lagging in behind. Especially a north-south major line which connects the north of power production to the south is not completed yet. Construction and improvement of major power line networks are on the way by the support of international aids and loans. (Figure 2.3.3)

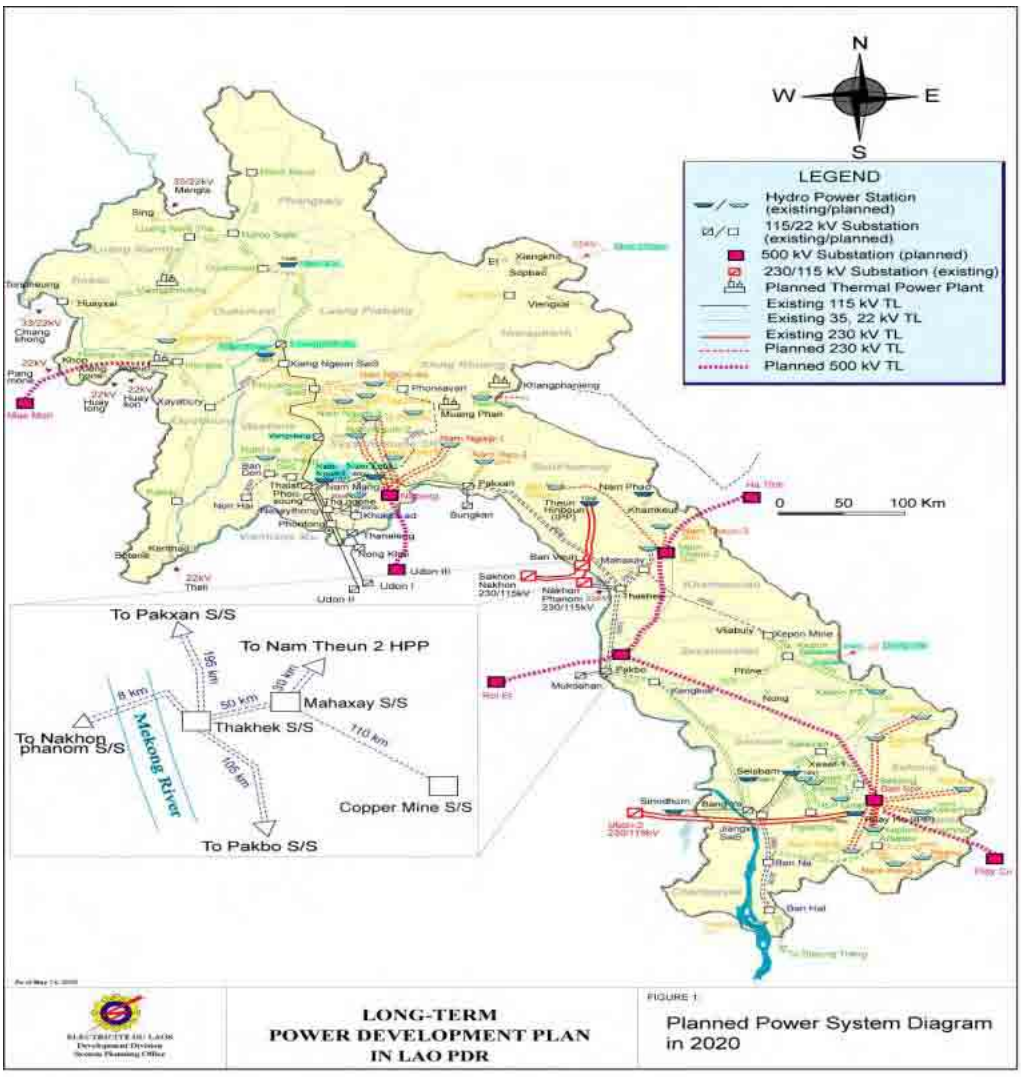


Figure 2.3.3 Planned power system diagram in 2020

2.3.4 Present Situation of Investment for Mining Sector

In the mining sector, Lao PDR became gold-copper producing country in 2003 when Sepon Mine started mining operation by Lane Xang Minerals Co., a local company of Australian Oxiana Limited. At present, besides Oxiana, Pan Australian Resources, an Australian company, started the operation of Phu Kham Copper-Gold Mine and more than 50 domestic and foreign companies are active in exploration for copper, zinc, iron and etc.

GDP growth of 2005 was 7.3% resulting great increase comparing with 6.4% of 2004. Mining development of copper, gold, gypsum, limestone and tin and rapid expansion of export of hydraulic generated electric energy are of great contributers. While 2.4% of GDP attributed to mining in 2004, contribution of more than 10% is estimated by mining sector in 2006. Corresponding to these developments, investment of foreign capital to the mining sector of Lao is also increasing (Table 2.3.1).

Table 2.3.1 Approved foreign investment in Lao PDR by sector 2000- September 2006

No	Sectors	Projects	Value of Investment (US$)
1	Electricity Generation	36	3,293,252,200
2	Agriculture	114	582,884,768
3	Mining	117	500,683,198
4	Industry & Handicraft	161	313,712,020
5	Trading	83	257,713,089
6	Construction	23	159,336,874
7	Services	131	127,251,907
8	Hotel & Restaurant	45	102,263,695
9	Telecom	3	39,940,000
10	Wood Industry	32	24,564,290
11	Others	52	34,569,032
	Grand Total	797	5,490,268,785

As of July 2008, there were 181 mining concessions (55 prospecting phase, 74 exploration phase, 3 F/S phase and 52 exploitation phase), held by 46 domestic companies and 72 foreign companies. Foreign concessions holders include 39 Chinese, 16 Vietnamese, 6 Thai, 4 Australian, 2 Korean, 2 Russian companies and 1 company each from North Korea, Poland and England (Fig.2.3.4).

Major mines and mineral occurrences in Lao PDR are shown in Fig. 2.3.5

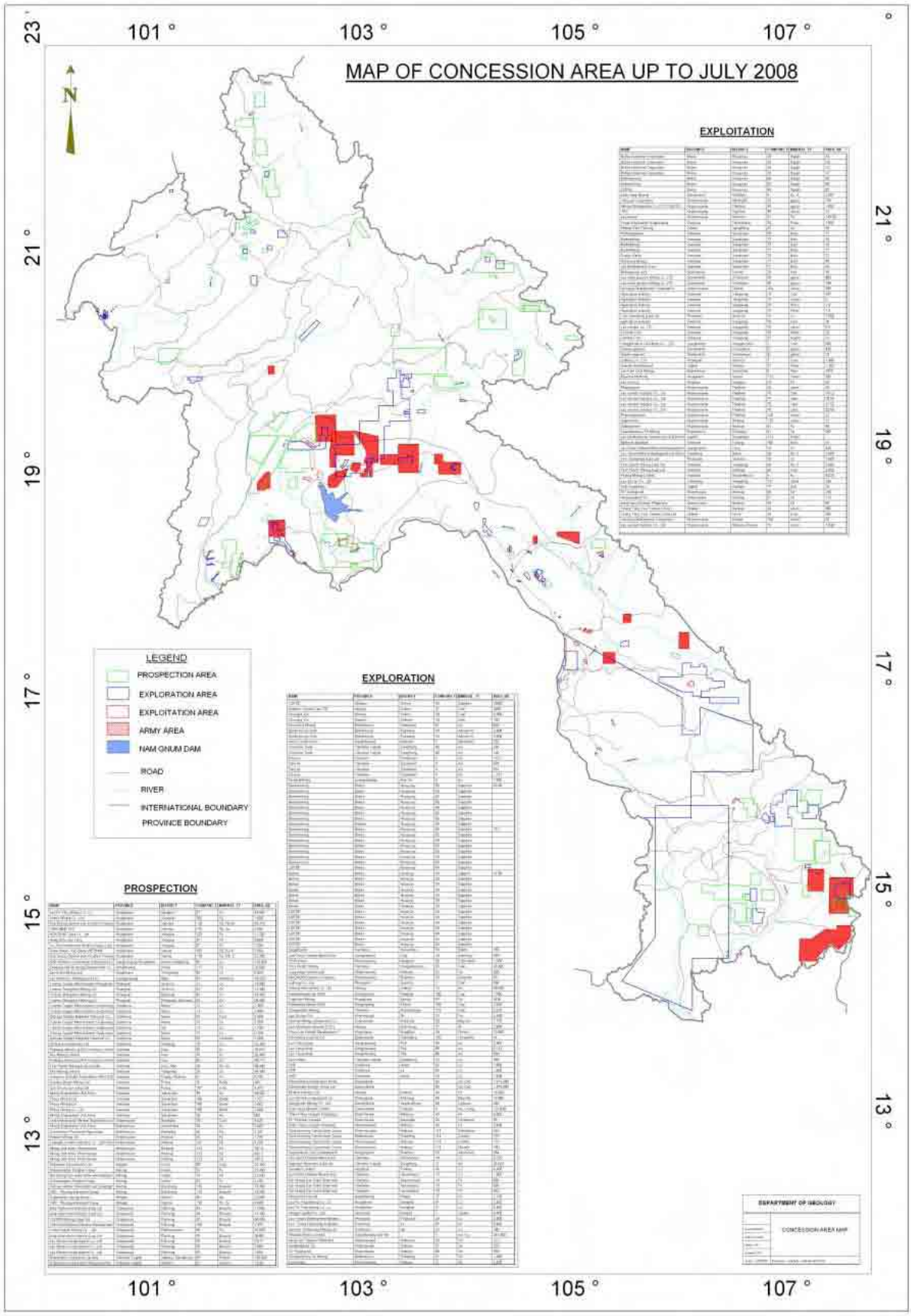


Figure 2.3.4 Map of concession areas up to July 2008

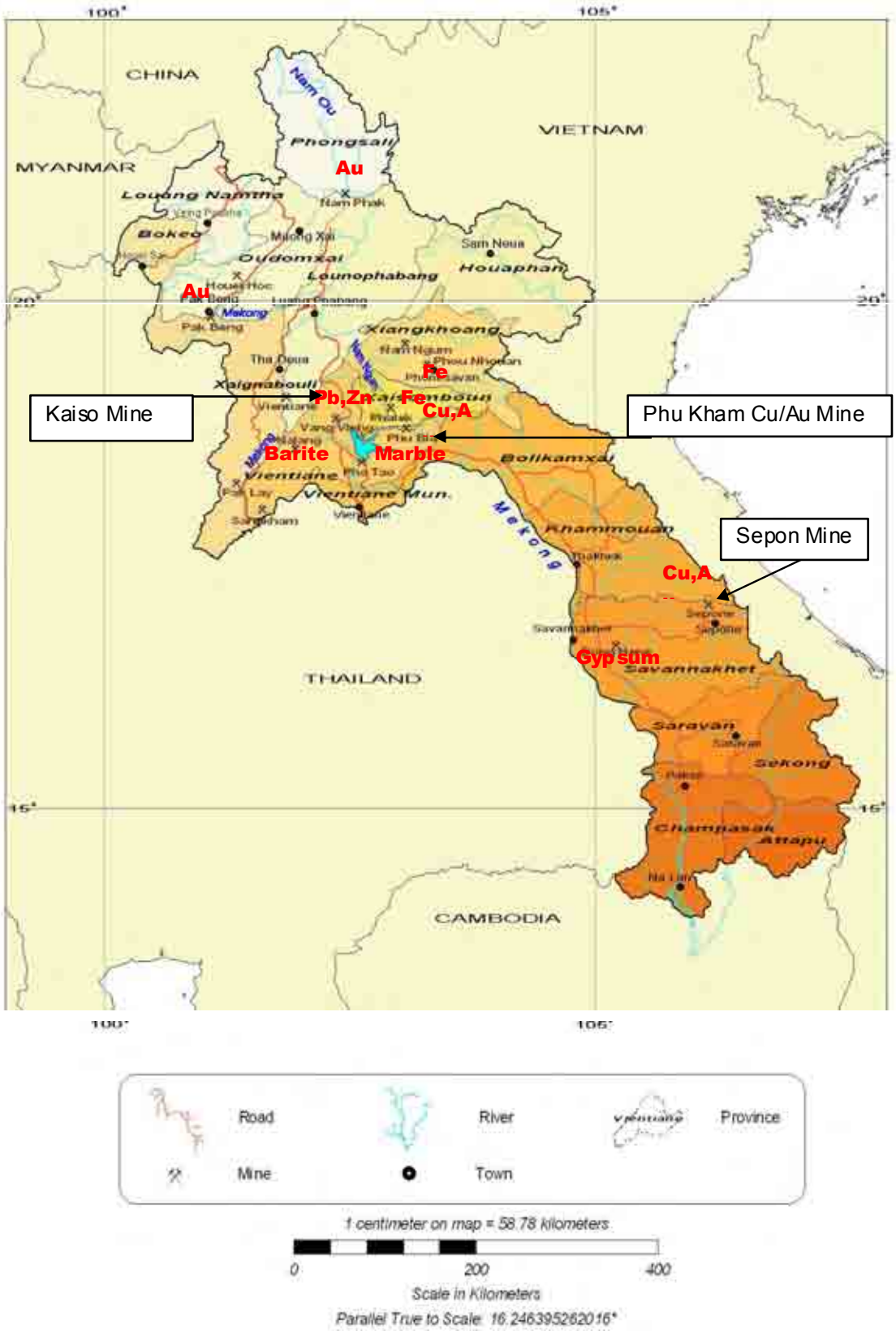


Figure 2.3.5 Location map of major mines and mineral occurrences in Lao PDR

2.4 Mineral Production

Ore deposits, such as tin, tungsten, rare metal, gold, iron ore, coal, gypsum, barite, limestone, potassium, and gem were confirmed by the investigations in the past. Mineral production value is increasing from 69,005,313 US$ in 2004 to 213,391,712 US$ in 2005.

Production of each major minerals was described below based on "Lao PDR Mineral Year Book 2006" prepared by DGEO and DOM.

2.4.1 Gold and Silver

The production of gold and silver began in 2003 with the start of the Gold / Copper Sepon project in Savannakhet province. The project is invested by Oxiana Ltd. The gold-bearing orebodies at Sepon contains 14 millions tons of ore with 1.5 millions oz of gold and 2.6 millions oz of silver.

An additional Phu Kham heap leach operation at Phu Kham Cpper-gold mine located in Saysomboun special zone is started to operation by Pan Australian Resource Limited in 2005. It has a reserve of 31.1 tons (1 million oz) of gold. Besides small scale mining of gold is currently undertaken by Lao-China Mining Industry in Khamkeut district, Bolikhamxay province and Phialat Gold Mining Company in Vientiane province. Gold prospecting and exploration were carried out by other 10 companies.

Gold and silver production in Sepon project is shown in the following table and figure.

Table 2.4.1 Production and sale of gold and silver in Sepon Project (2003～2006)

Year	Production(Tons)	Sales(Tons)
2003	8.879	8.879
2004	6.759	6.759
2005	10.109	10.109
2006	12.380	12.380

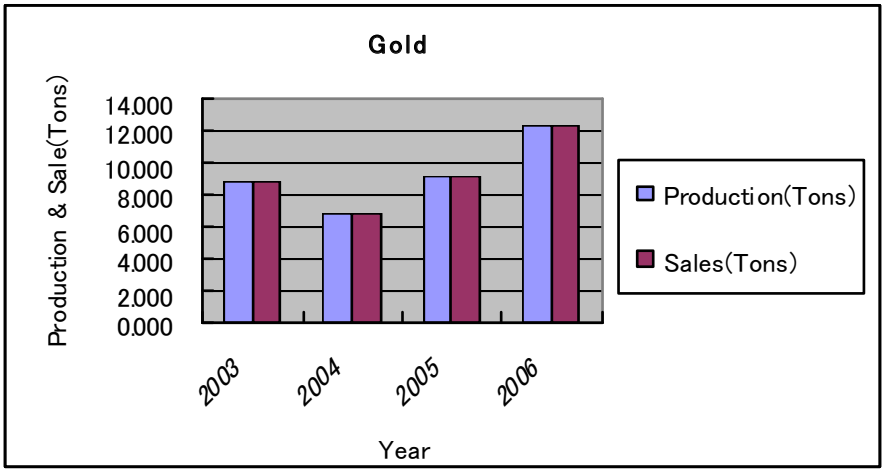


Figure 2.4.1 Production and sale of gold (2003～2006)

2.4.2 Copper

Copper was started to produce in 2005 at Sepon mine and the cathode is produced 30,514 tons in the first year. The production of 2006 reached 60,000 tons according to plan. Phu Kham copper/gold mine started copper operation by Pan Australian Resources Limited in May 2008 and initially produce over 200,000 dry metric tons of concentrate annually, containing on average 52,000 tons copper, 47,000 ounces gold and 400,000 ounces silver.

2.4.3 Zinc

The Kaiso zinc mine which is situated in Vangvieng district, Vientiane province, has been developed by Phadeang Industry Public (Lao) Company Limited since 2001. The ore deposit is a secondary type as well as Phadeang ore deposit in Thailand. The produced zinc ore is exported to Thailand.

First Pacific Mining Lao, Padaeng Industry companies are undertaking zinc prospecting and exploration in Vientiane province.

Zinc production until 2006 in Lao PDR is shown in the following table and figure.

Table 2.4.2 Production and sale of zinc (2001～2004)

Year	Zinc Production (Tons)	Zinc Sale (Tons)
2000	0	0
2001	18,000	18,000
2002	2,034	2,034
2003	2,035	2,035
2004	2,000	2,000
2005	NA	NA
2006	3,945	3,945

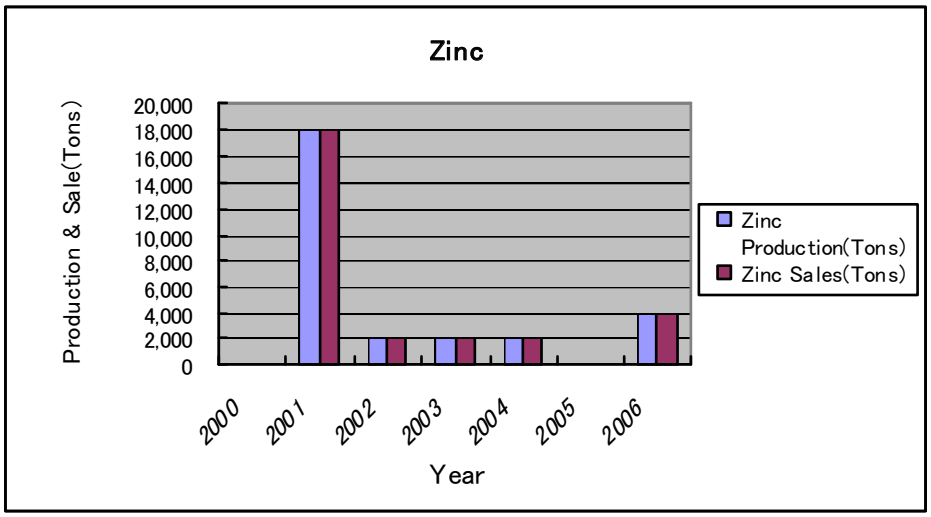


Figure 2.4.2 Production and sale of zinc (2001～2006)

2.4.4 Gypsum

There are four mining companies conducted gypsum exploration and exploitation in 2005. Three companies undertook exploration activities in Khammouan and Savannakhet Provinces. Gypsum Mining Co. Ltd. produced gypsum from the mine located in Champhone district, Savannakhet province.

The total production in 2006 was more than the previous year's production at 199,019 tons. The total product was exported to Vietnam.

It is reported that another mine located in Khammouan province will be operational by next year.

Gypsum production until 2006 in Lao PDR is shown in the following table and figure.

Table 2.4.3 Production and sale of gypsum (1997～2006)

Year	Production (Tons)	Sales (Tons)
1997	144,306	151,000
1998	130,764	130,764
1999	151,000	151,000
2000	147,720	142,197
2001	138,126	143,316
2002	83,146	78,402
2003	176,984	174,489
2004	244,145	201,094
2005	199,019	131,508
2006	206,104	206,104

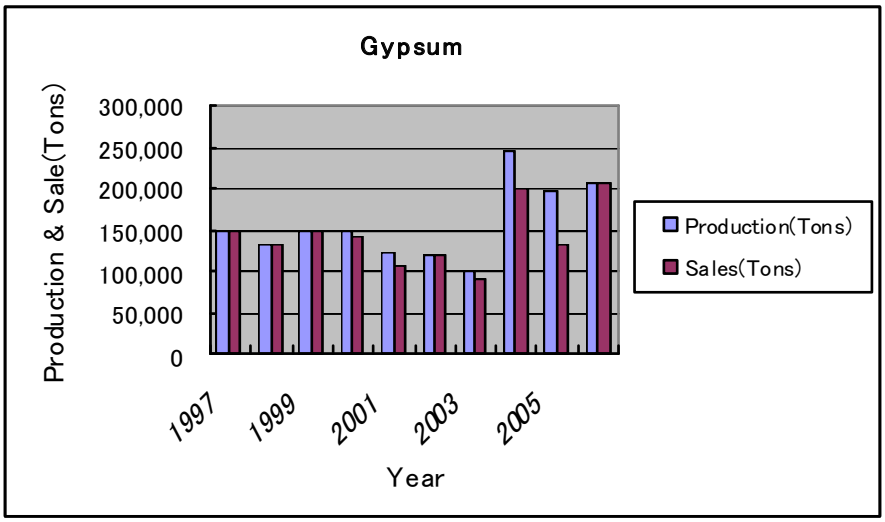


Figure 2.4.3 Production and sale of gypsum (1997～2006)

2.4.5 Coal

Coal is an important energy commodity for industrial development. Many coal deposits and prospects occur from north to south of Lao PDR. There are two types of coal: anthracite of Paleozoic to Mesozoic age and lignite of Tertiary age. There are 2 companies undertaking coal prospecting, 3 companies of coal exploration and 3 companies of coal mining.

Anthracite has been mined by a local company for local consumption, as a raw material for supplying to cement plant in Vangvieng, Vientiane province. In 2006, the production amounted to 63,500 tons.

Lignite has been mined by a Thai company in Louangnamtha province and exported to Thailand. The amount of lignite mined in 2006 was 432,421 tons.

One large lignite deposit with reserves of over 505 millions tons located in Sayabouly province is planned to be mined for supplying to a power plant.

Table 2.4.4 Production and sale of lignite (1997～2006)

Year	Production(Tons)	Sales(Tons)
1997	113,423	97,126
1998	106,632	103,730
1999	216,709	209,817
2000	214,086	197,304
2001	179,773	179,773
2002	233,923	209,973
2003	212,819	208,386
2004	332,907	332,907
2005	332,934	332,934
2006	432,421	432,421

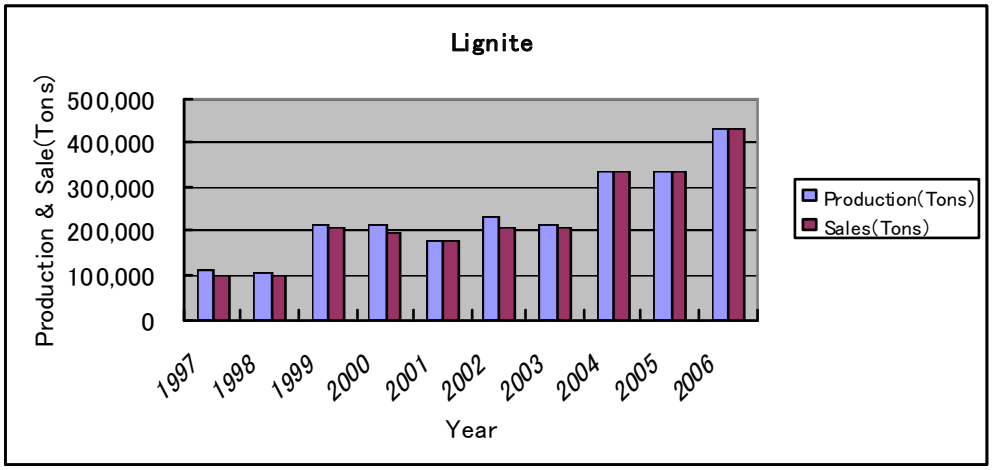


Figure 2.4.4 Production and sale of lignite (1997～2006)

2.5 Mineral Prospecting

Mineral prospecting has been carried out for many years under the cooperation of Vietnam government. At present there are other projects such as the Project by JICA and reconnaissance and detailed surveys by private companies over concession areas. A regional survey is also active as explained in the Chapter 3.

2.6 Mine Development and Mineral Exploration

2.6.1 Sepon Mine

Oxiana Limited owns the Sepon gold and copper operation. Sepon mine is an open pit mine producing gold and copper locating in the eastern part of Savannaket province in central Lao PDR.

Exploration by CRA/Rio Tinto between 1993 and 1999 resulted in the discovery of around 3 million oz of gold and an estimated 0.9 million tons of contained copper in six separated deposits. In 2000, Oxiana acquired the rights from Rio Tinto and started to the mine development.

Gold and copper deposits discovered in the Sepon district now contain an estimated 3.8 million oz of gold and 1.7 million tons of contained copper and the exploration by Oxiana Limited continues to increase these resources.

1) Development of Gold Deposit

Production started in December 2003. Annual capacity is 2,500,000 tons of ore and gold is recovered by Carbon-in-leach process. In 2006, 6,121kg of gold and 29,003kg of silver were produced and accumulated production figure is 19,413kg of gold and 54,751kg of silver. In 2006, 2,845,540t of ore with the grade of 2.15g/t and 10.19g/t were treated.

The currently defined gold deposits are Discovery, Discovery West-Colluvial, Nalou, Namkok West, Namkok East, Vangg Nang and Luang. Gold mineralization occurs as fine dissemination in highly altered calcareous sedimentary rocks with many affinities to the Carlin style gold deposits of Navada, USA.

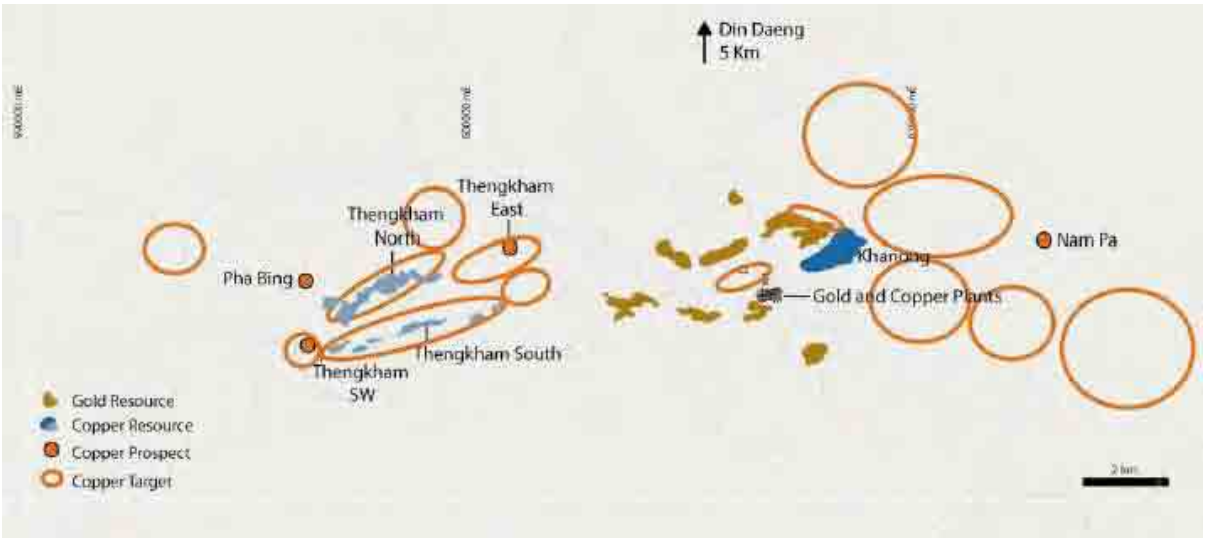
2) Development of Copper Deposit

The Khanong copper deposit was developed by open pit and copper is recovered at the 60,000t/year capacity SX-EW plant. The complex was completed February 2005 and the first produced copper cathode of Lao PDR exported to Thailand in March of the same year. In 2005, 455,000t of ore was treated and 30,514t of cathode was produced. In 2006, corresponding figures were1,216,000t and 60,758t.

The Khanong copper deposit is a near surface, high grade, supergene chalcocite and oxide copper body derived from the weathering of a replacement type massive sulphide deposit developed in shallow dipping, highly sheared carbonate rocks.

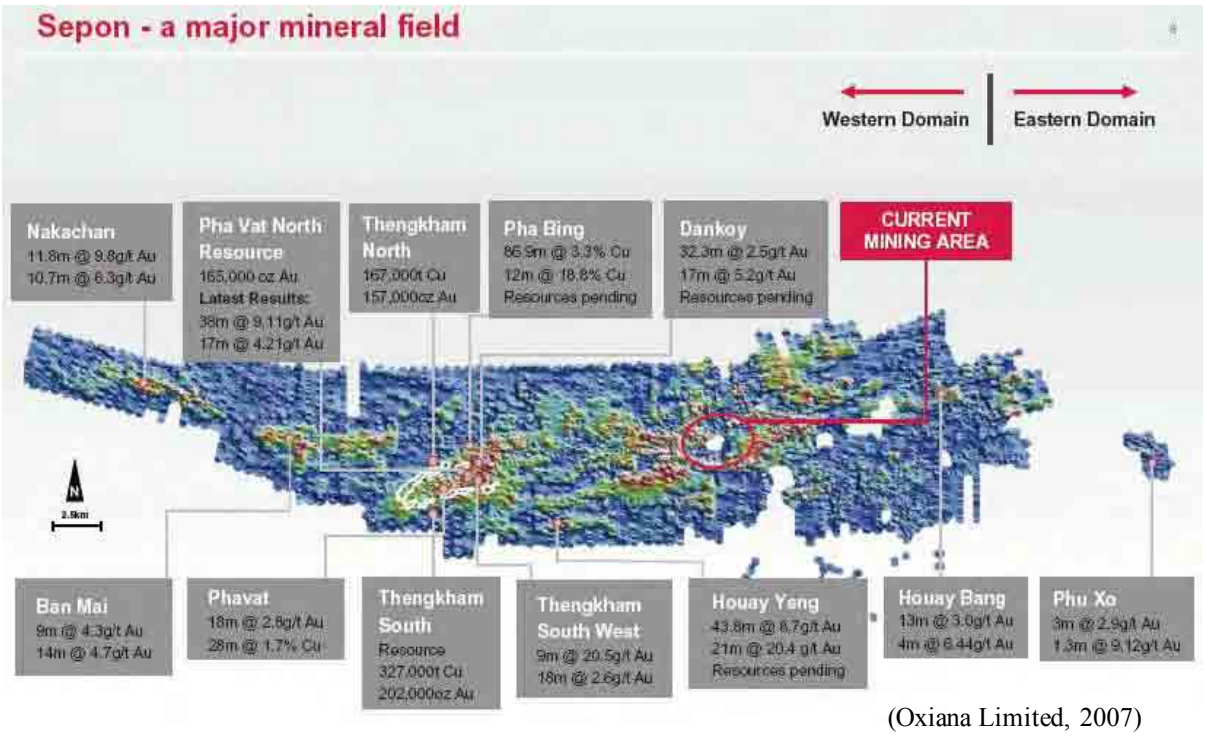
3) Exploration

Exploration has seen further copper resources discovered at the Thengkham North and Thengkham South deposits, approximately 7 km west of the plant (Fig. 2.6.1, 2.6.2). Many target areas remain to be tested and resent drilling results, including those from the newly discovered Pha Bing deposit, indicate the further high grade copper mineralization like that at Khanong and Thengkham is likely to be discovered elsewhere in the project area.



(Oxiana Limited, 2007)

Figure 2.6.1 Location map of copper deposits and target areas in Sepon



(Oxiana Limited, 2007)

Figure 2.6.2 Major mineral fields in Sepon

2.6.2 Phu Kham Copper-Gold Mine

Phu Kham copper-gold Mine is located approximately 120km north of Vientiane. Pan Australian Resources started exploration in this area in 2002 and entered gold production by heap leaching method in November 2005. The Phu Kham copper-gold deposit consists of an oxide gold cap and primary copper-gold zone shown in Fig. 2.6.3.

1) Development of Gold Deposit

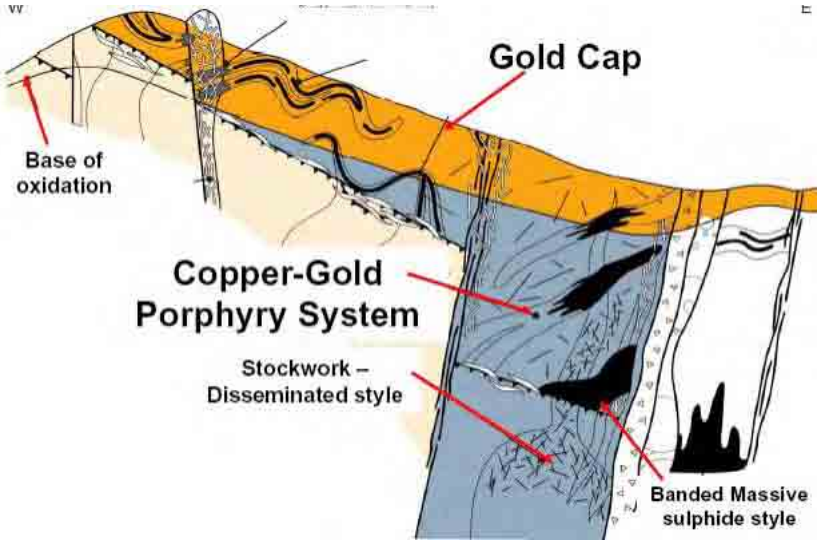
Production of gold was 481.3kg in 2005 and 1,391.5kg in 2006. The operation is currently conducting for Phu Kham Gold Cap which overlays the Phu Kham copper-gold deposit. Additional gold resources are found in the Ban Houayxai deposit. Total reserve is reported as 8,600,000t with the grade of gold 1.1g/t.

The mine is seasonal and produces gold during the dry months, from October to May. During the four-month wet season, the heap leach pads are protected from rainfall by a plastic cover.

2) Development of Copper-Gold Deposit

Pan Australian Resources started copper operation in May 2008. The mine initially produce over 200,000 dry metric tons of concentrate annually, containing on average 52,000 tons copper, 47,000 ounces gold and 400,000 ounces silver. Ore reserve is estimated as 192,000,000t with the grade of copper 0.62%/t and gold 0.24g/t allowing more than 12 years of mine life.

Primary copper-gold mineralization is associated with quartz-sulphide stockwork, disseminated sulphide and massive sulphide zones as shown in Fig. 2.6.3. The mineralization is hosted by a sequence of volcanic rocks (tuffs), limestone and carbonaceous siltstone. The deposit is interpreted to be related to a porphyry intrusion.



(Pan Australian Resources Limited,2007)

Figure 2.6.3 Simplified geology of the Phu Kham copper-gold deposit

3) Exploration

Pan Australian Resources has many prospective exploration targets within 2,637 km2 contract area (Fig. 2.6.4). In Ban Houayxai gold-silver deposit, located some 25km west of the Phu Kham deposit, drilling has identified oxide and primary mineralization from surface to a depth of over 300m.

(Pan Australian Resources Limited, 2007)

Figure 2.6.4 Location map of deposits and target areas in Phu Bia area

2.6.3 Other Exploration Projects

About 180 km north of Vientiane, Canadian junior Rox Resources Ltd. is in a joint venture with local partner First Pacific Mining Lao Co. Ltd. to explore the Pha Luang zinc-lead-silver deposits. Deeper drilling is underway in Pha luang and Nam Yen deposits.

Australian junior Argonaut Resources NL is exploring 50 km northwest of Vientiane in the Century area, and, in southeast Laos, in Sekong area. At Century, the Ang Noi area, where gold is hosted in mesothermal quarts veins, is the priority for future resource drilling.

In southern Lao PDR, Australian junior Ord River Resources Ltd. is a joint venture with China Nonferrous Metals International Mining to explore the Bolaven Plateau bauxite deposits.

CHAPTER 3 DATA REVIEW OF GEOLOGY AND MINERAL RESOURCES

3.1 Introduction

The revising of 1:1,000,000 geological and mineral resources map published in 1991 is carried out in this project. Many geological survey and mineral exploration were conducted since 1991 and abundant data were accumulated. Furthermore, the geological mapping projects of 1:200,000 in scale are in progress in many areas including this project. By 2008, approximately 65% of Lao PDR will be covered by 1:200,000 geological maps. The revising will be carried out based on the above geological information.

3.2 Existing 1: 1,000,000 Geological and Mineral Resources Map

The 1:1,000,000 geological and mineral resources map published in 1991 is prepared by British Geological Survey and British Mineral Consultants Ltd., commissioned by the Asian Development Bank. Although a simplification on geologic division has been made, all known mineral occurrences are added on the map. Main source of information for this map is as follows;

1) Geological map at 1:500,000 over whole Indochina prepared by Service Geologique de l'Indochine, based in Hanoi, Vietnam, in 1930.

2) Geological map of Xam Neua(northeast Lao PDR), Khang Khay(north of Xiengkhouang) and Vientiane area at 1:200,000 prepared by DGMV, in 1975 – 1990.

3) Geological map of whole Indochina at 1:1,000,000 prepared by DGMV, in 1988. Second edition was published in 1991.

4) Summary geological map of Lao PDR at 1:1,500,000 prepared by ESCAP, in 1990.

3.3 Mapping Program for 1:200,000 Geological and Mineral Resources Map

Geological maps at 1:200,000 produced by 2006 are 12 sheets in total covering central and northeastern parts of Lao PDR, which covered one-third of the whole country. As shown in Figure 3.3.1, however, mapping projects in northern and southern parts will be completed by 2008 and the coverage will reach approximately 65%.

3.3.1 Northern Part

4 sheets of geological map in north-eastern part and 1 sheet in Vientiane Province were already prepared by DGMV before 1988. The mapping project in northern area covering 12 sheets by DGMV was completed in 2007. However, the mapping in north-western area covering 5 sheets by DMR is suspended for a while.

3.3.2 Central Part

9 sheets of geological and mineral resources map in this part were already prepared by DGMV before 1999 and are available in digital form.

3.3.3 Southern Part

This part includes 2 sheets of map over Attapeu area in this project. DGMV is conducting geological mapping around Attapeu area and will complete it in 2008.

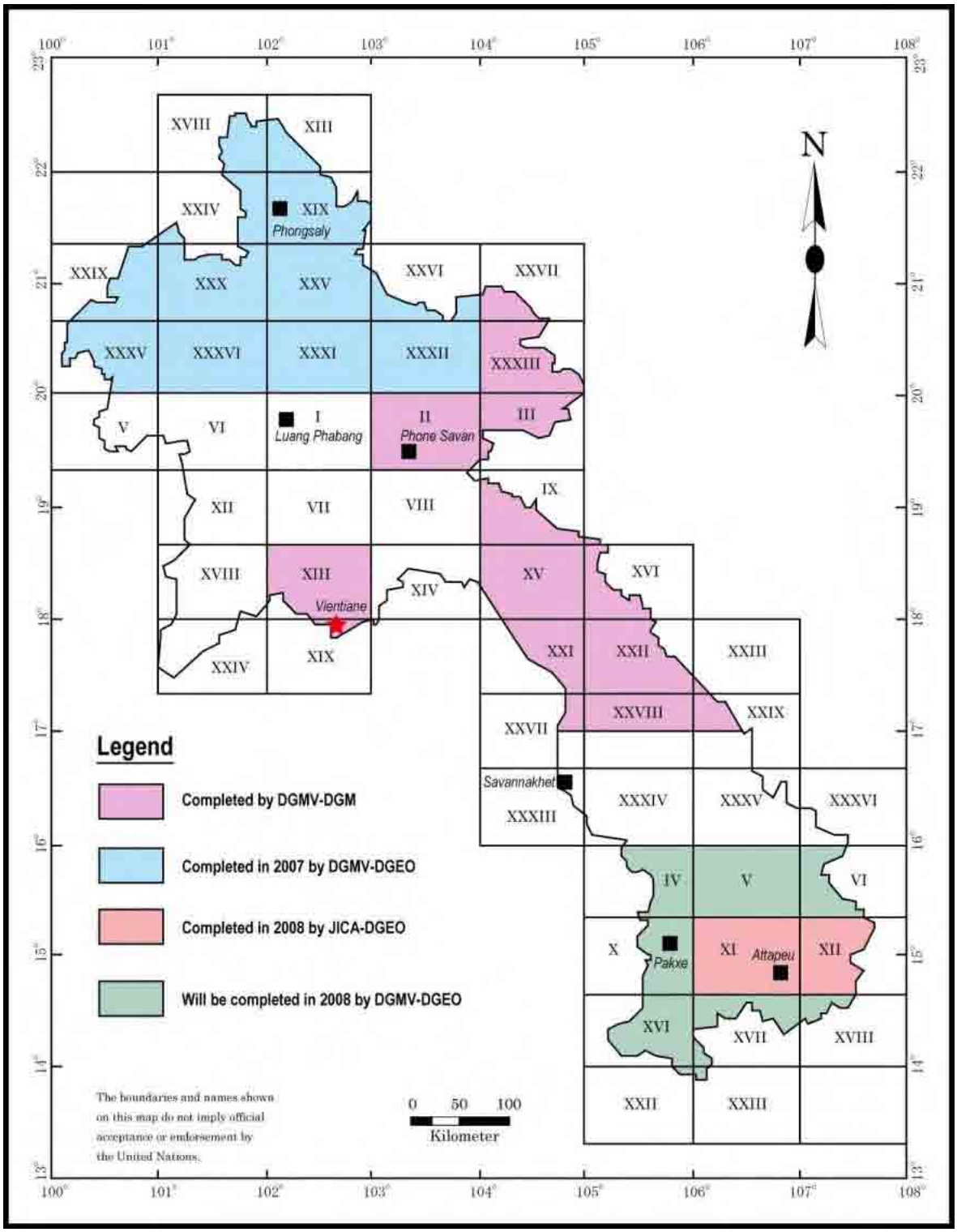


Figure 3.3.1 Index map of geological and mineral resources map at 1:200,000

3.4 Revising of 1:1,000,000 Geological and Mineral Resources Map

3.4.1 Revising of Geological Map

Revision work was applied to the 1:1,000,000 geological map sheet which was compiled by British Geological Survey (BGS) of 1991, referring to the 1:1,000,000 geological map of Indo-China Peninsular made by DGMV (Vietnam) in 1991, and also taking the result of 2 sheets of 1:200,000 regional geological map made by the Project as well as sheets over Lao PDR made by DGMV (Vietnam) after publication of the 1:1,000,000 geological map compiled by BGS. Details of 1:200,000 sheet used in the revision are shown below;

- Northern part: 12 sheets made by DGMV
  B.Muang-Ou-Tai(F-47-XVIII), B.Kaoho(F-48-XIII), B.Boun-Nua(F-47-XXIV), Phongsali(F-48-XIX), B.Meung(F-47-XXIX), Louangnamtha(F-47-XXX), Khoa(F-48-XXV), Xiangkhoun(F-48-XXXVI), Houayxai-B.Xiang Nou(F47-XXXV,E-47-V), M.Nale-B.Khon(F-47-XXXVI,E-47-VI), B.Nambak(F-48-XXXI), B.Houamuang(F-48-XXXII)
- Northeast and Central part: 13 sheets made by DGMV
  B.Xiangkho(F-48-XXVII), Xam-Nua(F-48-XXXIII), B.Xamtai(E-48-III), B.Phonsavan-Vientiane,(E-48-XIII,E-48-XIX), Ph.Ayen(E-48-XXIII), B.Donghen(E-48-XXVIII), M.Khamkeut(E-48-XV), B.Mahaxai(E-48-XXII), M.Mok(E-48-IX), B.Nape(E-48-XVI), Thakek(E-48-XXI), Xeno(E-48-XXIVII), M.Xepon-mai(E-48-XXIX)
- Southern part: 2 sheets made by the Project
  Attapeau(D-48-XI), B. Dakyoy(D-48-XII)

Revised 1:1,000,000 geological map is shown in Figure 3.4.1 (in reduced size).

3.4.2 Revising of Mineral Resources Map

In a sheet of 1:1,000,000 Mineral Resources Map of 1991 compiled by BGS showing 479 locations of mineral occurrence. After BGS's compilation DGMV surveyed over central area and 151 localities were described as "Record Book of Mineral Deposits and Ore Occurrences" In Attapeau district a new copper occurrence was discovered by the Project and in the northern part newly discovered mineral occurrences have been reported by DGMV survey team. Although these information was added on the list following a format arranged by BGS, there were uncertainty with information of locality of new discovery and separate files were generated depend on projects. A sample of deposit/mineral indication is shown in Table3.4.1

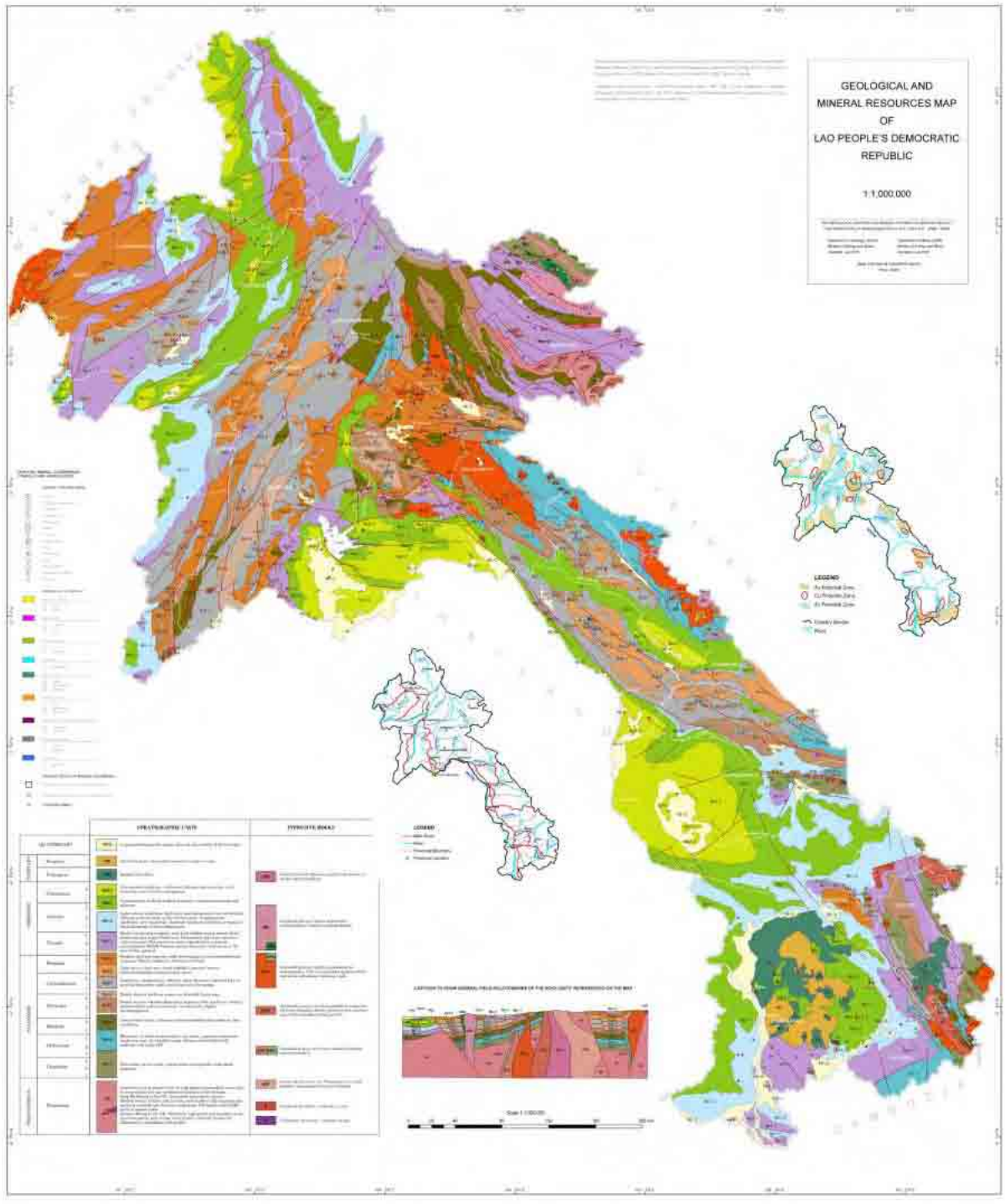


Figure 3.4.1 Revised 1:1,000,000 geological and mineral resources map

Table 3.4.1 List of deposits and mineral occurrences

ID_Code	Commodity	Map sheet no.	Province	Locality	Longitude	Latitude	Type		Notes	Reference	
2104	Au	F-47-118	Louangnamtha	Xiangkok	20.91	100.68	hydrothermal	Hyd	sulfide in fractured zone; Au 0.4-4.0g/t, Ag<10g/t	DGMV, 2007	57
2104	Au	F-47-98	Phongsali	Houaylot	21.20	102.62	hydrothermal	Hyd	sulfide in fractured zone; Au 0.2-0.4g/t, Ag<10g/t	DGMV, 2007	58
2104	Au	F-47-129	Bokeo	Ban Nam Pha	20.55	100.24	hydrothermal	Hyd	sulfide in fractured zone; Au 3.2g/t, Ag<10g/t	DGMV, 2007	59
2104	Au	F-47-129	Bokeo	Ban Nam Khali	20.64	100.44	hydrothermal	Hyd	sulfide in fractured zone; Au 0.4g/t, Ag<10g/t	DGMV, 2007	60
2104	Au	F-48-135	Houaphan	Nam Poung	20.15	103.27	hydrothermal	Hyd	sulfide in fractured zone; Au 0.3g/t, Ag<10g/t	DGMV, 2007	61
2104	Au	F-48-135	Houaphan	Phou Viang	20.06	103.40	hydrothermal	Hyd	sulfide in fractured zone	DGMV, 2007	62
2104	Au	F-48-136	Houaphan	Ban Vek	20.17	103.90	hydrothermal	Hyd	sulfide in fractured zone; Au 2.5g/t, Ag<10g/t	DGMV, 2007	63
2104	Au	F-47-144	Oudomxay	Kokhai	20.21	101.56	hydrothermal	Hyd	dissemination and veins; Au 0.2-1.0g/t, Ag 10-20g/t	DGMV, 2007	64
2104	Au	F-48-122	Louangphabang	Houaylek	20.53	102.67	hydrothermal	Hyd	sulfide in fractured zone; Au 0.5-2.5g/t, Ag 10-50g/t	DGMV, 2007	65
2104	Au	F-47-106	Louangnamtha	Phagnalouang	21.09	100.68	hydrothermal	Hyd	sulfide in fractured zone; Au 0.5g/t, Ag<10g/t	DGMV, 2007	67
2104	Au	F-47-129	Bokeo	Ban Phonxai	20.43	100.36	hydrothermal	Hyd	sulphide bearing veinlets; Au 0.5g/t, Ag<10g/t	DGMV, 2007	68
2104	Au	F-48-122	Louangphabang	Chongtai	22.41	102.81	hydrothermal	Hyd	quartz veins; Au 0.2-1.0g/t	DGMV, 2007	69
2104	Au	F-47-143	Oudomxay	Ban Kang	20.28	101.29	hydrothermal	Hyd	fractured zone and quartz veins; Au 0.4-0.5g/t	DGMV, 2007	70
2104	Au	F-48-135	Houaphan	Ban Sakok	20.19	103.20	hydrothermal	Hyd	fractured zone and quartz veins; Au 0.2-1.7g/t	DGMV, 2007	71
2104	Au	F-47-10	Bokeo	Hatsa - Ban Khe	19.93	100.64	hydrothermal	Hyd	fractured zone and quartz veins; Au 0.2-1.8g/t	DGMV, 2007	72
2104	Au	F-47-10	Oudomxay	Long Yong	19.84	100.97	hydrothermal	Hyd	fractured zone and quartz veins; Au 0.2-13.8g/t	DGMV, 2007	73
2104	Au	F-47-11	Oudomxay	Houay Xeng	19.93	101.02	hydrothermal	Hyd	fractured zone and quartz veins; Au 0.3-2.0g/t	DGMV, 2007	74
2106	Au	F-47-11	Oudomxay	Bon Kham	19.91	101.06	placer	Plc	highest grade of terrace deposit; 587mg/m3	DGMV, 2007	75
2106	Au	F-48-135	Louangphabang	Muangmouay	20.27	103.05	placer	Plc	terrace deposit; 32-53mg/m3	DGMV, 2007	76
1204	Cu	F-47-118	Louangnamtha	Houaymo	20.98	100.95	hydrothermal	Hyd	veins and stockwork; Cu 2.09-5.31%, Pb 0.68-1.08	DGMV, 2007	26
2204	Cu(-Fe)	F-48-109	Oudomxay	Tangngeuy	20.89	102.02	hydrothermal	Hyd	Cu 1.4%	DGMV, 2007	27
2204	Cu	F-47-72	Phongsali	Sinchai 1	22.22	101.88	hydrothermal	Hyd	dessemination; Cu 2.75%	DGMV, 2007	28
2204	Cu	F-47-72	Phongsali	Sinchai 2	22.23	101.93	hydrothermal	Hyd	dessemination; Cu 2.45%	DGMV, 2007	29
2204	Cu	F-47-72	Phongsali	Sinchai 3	22.24	101.89	hydrothermal	Hyd	dessemination; Cu 2.51%	DGMV, 2007	30
2204	Cu	F-47-72	Phongsali	Phou Hatsan	22.08	101.84	hydrothermal	Hyd	dessemination; Cu 2.68%	DGMV, 2007	31
2204	Cu	F-47-72	Phongsali	Tasan	22.17	101.84	hydrothermal	Hyd	fractured zone; Cu 11.41%	DGMV, 2007	32
2214	Cu	F-47-84	Phongsali	Ban Ngay Nua	21.85	101.89	?		malachite with azurite	DGMV, 2007	33
2204	Cu-(Ba)	F-47-85	Phongsali	Chaho	21.44	102.02	hydrothermal	Hyd	Cu 0.567%, BaO 32.29%	DGMV, 2007	34
2204	Cu-(Ba)	F-47-96	Phongsali	Makka Noy	21.55	101.99	hydrothermal	Hyd	fracture zone; Cu 0.35-3.8%, Barite reserves 62,220t	DGMV, 2007	35
2204	Cu	F-48-85	Phongsali	Tette	21.50	102.03	hydrothermal	Hyd	fracture zone; Cu 0.8-1.1%, Ag 29-46g/t	DGMV, 2007	36
2204	Cu	F-47-108	Oudomxay	Phou Thouloung	21.04	101.84	hydrothermal	Hyd	fracture zone; Cu 5.71-18.46%	DGMV, 2007	37
2204	Cu	F-47-108	Oudomxay	Houaylak	21.03	101.89	hydrothermal	Hyd	fracture zone; Cu 5.92%	DGMV, 2007	38
2204	Cu	F-47-132	Oudomxay	Nam Phao	20.51	101.81	hydrothermal	Hyd	Cu 1.031-3.984%	DGMV, 2007	39
2204	Cu	F-47-144	Oudomxay	Nam Hem	20.06	101.59	hydrothermal	Hyd	quartz veins; Cu 7.625-8.313%, Ag 47-51g/t	DGMV, 2007	40
2204	Cu	F-47-144	Oudomxay	Houay Thong	20.03	101.58	hydrothermal	Hyd	quartz veins; Cu 0.962-5.65%, Ag 20-120g/t	DGMV, 2007	41
2204	Cu	F-47-120	Oudomxay	Nathong	20.85	101.78	hydrothermal	Hyd	fracture zone; Cu 4.36-5.51%	DGMV, 2007	42
2204	Cu	F-47-120	Oudomxay	Kiouchep	20.83	101.79	hydrothermal	Hyd	fracture zone; Cu 2.82-4.38%	DGMV, 2007	43
2614	Fe	F-47-96	Phongsali	Houay Liak	21.61	101.93	?		hematite and limonite; T.Fe 52.33%	DGMV, 2007	20
2604	Fe	F-47-118	Louangnamtha	Houaymo	20.96	100.96	hydrothermal	Hyd	quartz veins; T.Fe 10.84-32.1%	DGMV, 2007	21
2604	Fe	F-47-118	Louangnamtha	Chasalicau	20.81	100.95	hydrothermal	Hyd	quartz veins; T.Fe 24.84%	DGMV, 2007	22
2604	Fe	F-48-135	Houaphan	Nam Khan	20.10	103.48	hydrothermal	Hyd	T.Fe 52.17-62.32%	DGMV, 2007	23
2903	Gp	F-47-72	Phongsali	Muang Ou Nua	22.31	101.81	evaporite	Evp	Mz2-2 (K2), CaSO4·2H2O 75.42%	DGMV, 2007	91
2903	Gp	F-47-72	Phongsali	Nam Tong	22.11	101.81	evaporite	Evp	Mz2-2 (K2), CaSO4·2H2O 75.62%	DGMV, 2007	92
2903	Gp	F-47-72	Phongsali	Nahok	22.31	101.88	evaporite	Evp	Mz2-2 (K2), CaSO4·2H2O 72.13%	DGMV, 2007	93
2903	Gp	F-47-72	Phongsali	Botay	22.25	101.83	evaporite	Evp	Mz2-2 (K2)	DGMV, 2007	94

3.5 Geology

3.5.1 Outline of the Geology of Lao PDR

Geological map of Lao PDR is shown in Figure 3.5.1, which is referred from the 1:1,000,000 geological map prepared by British Geological Survey (1991).

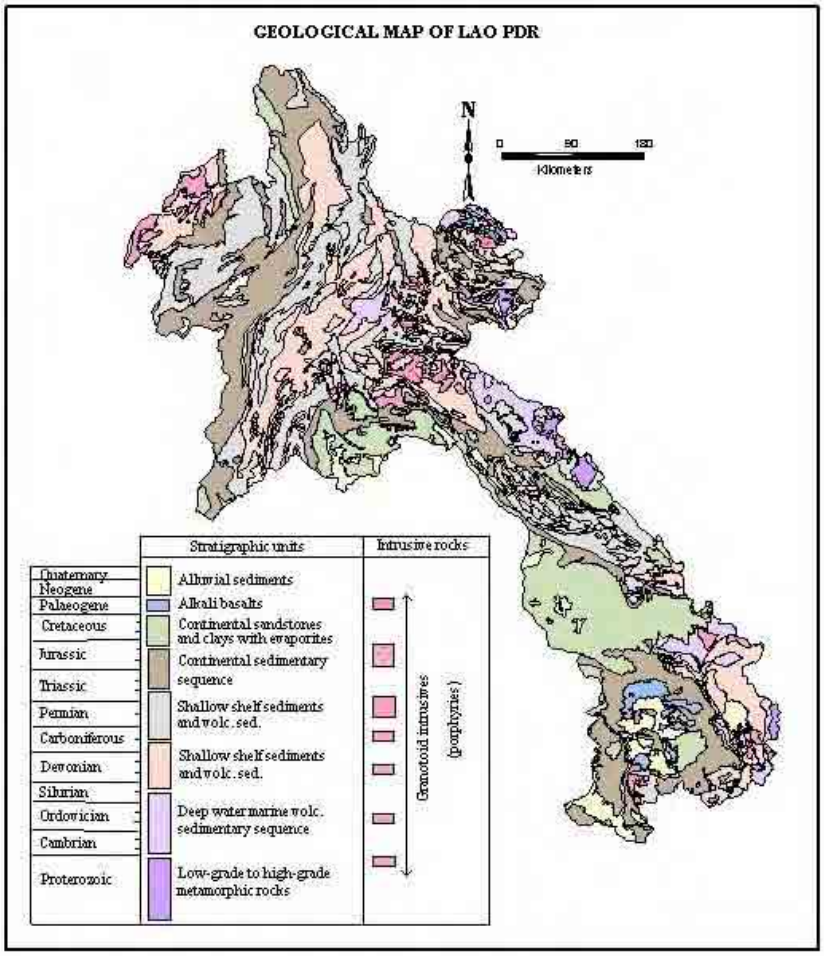


Figure 3.5.1 Geological map of Lao PDR

Outline of the geology of Lao PDR is described below after the "Atlas of Mineral Resources of the ESCAP region Vol.7: Lao People's Democratic Republic. United Nations Economic and social commission for Asia and the Pacific(1990)".

1) The Precambrian and Palaeozoic

The Precambrian is not known in the Lao People's Democratic Republic from direct stratigraphic or geochronological evidence but high-grade metamorphic rocks which are found in certain areas in the northwest, northeast and southeast are believed to be Proterozoic.

The Cambrian is known in the valley or the Nam Ma near the border within the northeast (where it extends into Vietnam to the northwest and southeast). The rocks comprise slightly metamorphosed limestone, shale (greenschists), sandstone (quartzite) and conglomerates. Similar rocks along the border in the southeast have been mapped as "Cambro-Ordovician". In the Middle Laos metamorphic rocks referred to Neoproterozoic – Lower Cambrian are limitedly exposed in the northern area, belonging to the Kham Keut district Bolikhamxay Province. They have been discriminated into the Sop Phan Formation of Neoproterozoic-Early Cambrian age.

There are a number of well-documented occurrences of fossilliferous marine Ordovician and Silurian (limestone, sandstone, shale etc.) in the north and east, notably in the mountains north of Phonsavan (Xieng Khouang) and along the border with to the east and southeast. The marine Devonian (similar facies) is also well known from many localities in the north and east. Rocks of Ordovician to Devonian age are also found in the area east of the Sekong River, in the southeast.

The Carboniferous and Permian were also times of predominantly marine deposition, mainly shale, sandstone and limestone. The latter forms and outstanding karst topography in parts of the north and east of the country. In a few areas, continental deposits of Carboniferous and Permian age have been found. These include coal near the Vientiane and Saravane (Carboniferous) and at Phongsaly in the far north (Permian).

2) Permo-Triassic Volcanicity

In the north of the country, and especially in the Pak Lay – Luang Phabang area and further northwest towards the Myanmar border, there are widespread occurrences of volcanic rocks which are believed to be mainly Permian and are thought to be the products of subduction – related volcanism. These are dominantly andesites and dacites, with some basalts.

The abundant rhyolitic and dacitic rocks of the Xam Nua area in the northeast are considered to be mainly Triassic. The rhyolites and tuffs which cover large areas in the Sekong valley and along the Cambodian border in the south (and form the Khone Falls on the Mekong) are also regarded as Triassic.

3) Marine Mesozoic

In general; there is evidence of widespread emergence by the late Permian. The marine Triassic is restricted to certain areas where sedimentary basins persisted into or developed in the Triassic. The best known of these is in the Xam Nua area where the marine Middle – Late Triassic (limestones, sandstones, siltstones etc.) is widely distributed, associated with the volcanic rocks referred to in the previous section. There are also occurrences of the marine Triassic in the northwest.

Occurrences of marine Liassic in the Sekong valley near the border with Cambodia Constitute the youngest marine beds known in the Lao People's Democratic Republic.

4) Non-Marine Mesozoic

Late Triassic loading and uplift created a mountainous terrain which was subjected to intensive erosion. Much of the territory was covered with the products of this erosion, in the form of continental and paralic sandstones and conglomerates ranging in age from Late Triassic to Cretaceous. The Middle Cretaceous had reduced much of the land to a very subdued relief and there was widespread sedimentation in the form of muds, silts and fine sands, often red, interspersed with periods of deposition of evaporates.

5) Cenozoic

In the Lao People's Democratic Republic, the Paleocene is unknown. Freshwater deposits in numerous small –intermontane valleys in the north represent the Neogene. The deposits are mostly shale and sandstone, with some marls and, in places, lignite.

The late Cainozoic uplift was followed by rapid erosion of the highlands, entrenchment of the Mekong and other major rivers, and deposition of fluvial sands and gravels in the plains. There are fairly extensive flood plain deposits in parts of the lowland area through which the Mekong flows, but they are for the most part thin and intermittent.

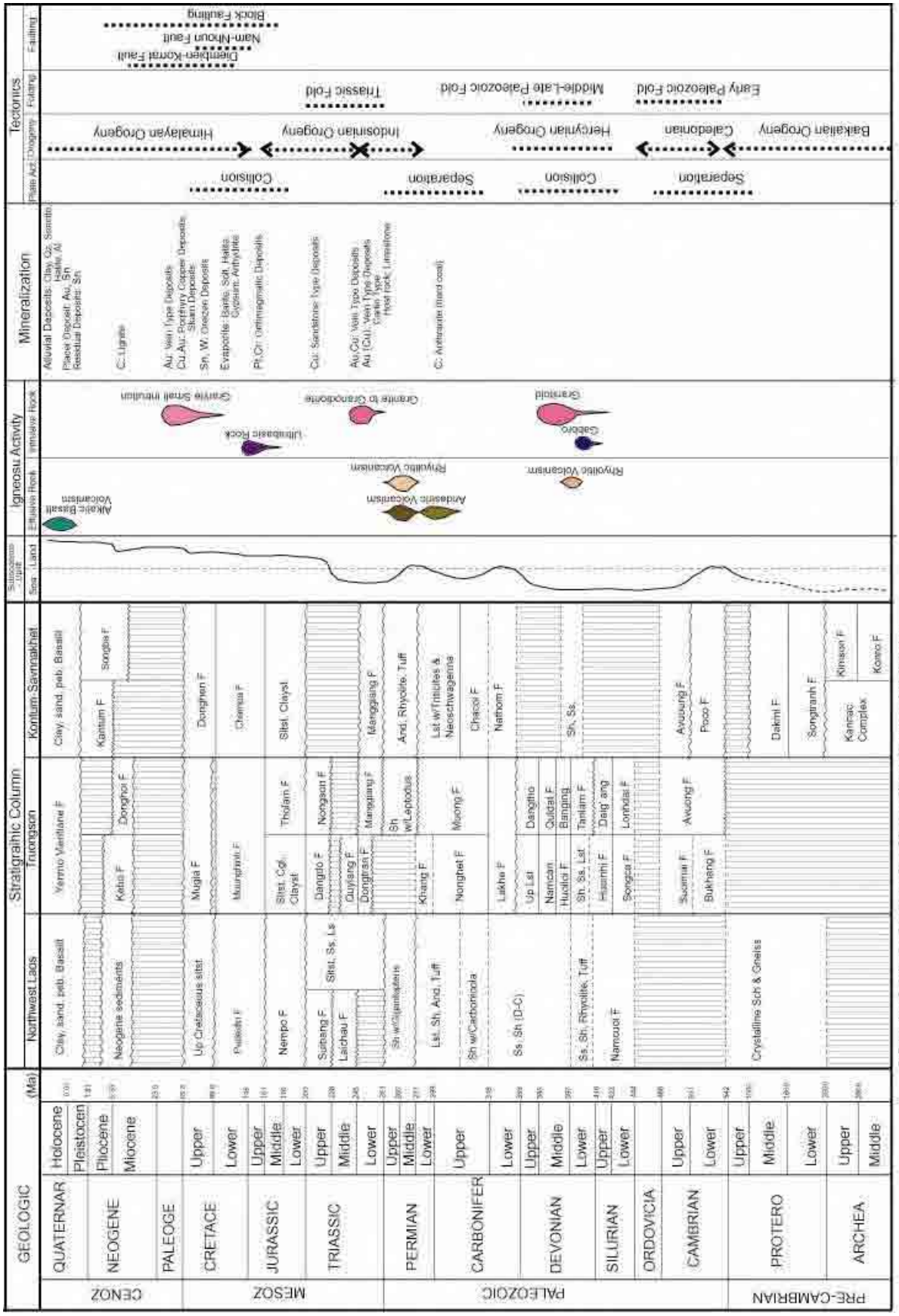


Figure 3.5.2 Outline of stratigraphy, igneous activity, mineralization in Lao PDR

The Quaternary is well developed in many separate localities in valleys in the mountainous area of the north, as well as on the Plain of Jars. It consists of fluvial terraces of gravels, sands and silts as well as loess and ash deposits. Erosion surfaces within and on top of the succession are commonly lateritised.

6) Quaternary Volcanism

The Bolaven plateau east of Pakse and some other smaller upland areas in the east and southeast are made up of basaltic lavas resting upon Mesozoic sandstones. These lavas, like similar occurrences nearby in , Cambodia and Thailand, are Pleistocene, and perhaps partly Neogene, in age. Similar basalts are found in the extreme northwest near Ban Houei Sai, but these cover only a small area.

3.6 Mineral Deposits and Showings

On the map prepared by the British Geological Survey (BGS) it is noted that "A total at 479 mineral occurrences is documented in a computer-based archive set up by BGS consultants". Those locations are shown in Figure 3.6.1. and major minerals are described below.

Lao People's Democratic Republic has a high potential for metallic and bulk minerals but this potential has not yet been realized in development of a economically viable mining industry.

3.6.1 Metallic Minerals

1) Gold

Alluvial gold is panned from streams over much of Lao PDR. In many areas, especially along the Mekong River in the northern half of the country where gold is being released from intruded sediments, it is panned year after year by the villagers.

After 1975, and particularly during the 1980s, major studies were carried out by the Vietnamese, aid missions from the former Soviet Union, and to a lesser extent by Czechoslovakian and Bulgarian programmes on geology of gold deposits as well as other minerals.

The major part of the Vietnamese work was carried out during geological mapping and mineral exploration of three 1:200,000 scale map sheet areas: Xam Nua, Khang Khay and Vientiane, although a small gold prospecting programme was earlier done on the Houei Xeng in the Pak Beng area. Work carried out by the former Soviet aid mission was directed at assessing the gold potential of four areas in Lao PDR. The major results were presented in 1985 with a subsequent subsidiary report. Most of the areas were mapped geologically at 1:250,000 scale and most of the known gold-bearing streams were sampled, initially on a reconnaissance scale.

The potential of alluvial gold deposits along the Mekong river was investigated during the period from 1984 to 1988 by a Lao-Czechoslovakian mission. The area explored was from Pak Beng to slightly downstream of Muong Tha Deua (Xayabouli).

Stream sediment sampling of the Bulgarian mission confirmed the occurrence of alluvial gold in the middle of the eastern part of the country.

The sources of primary gold mineralization are still relatively unexplored, but several extensive areas show good potential for bedrock deposits associated with intermediate to acidic volcanic rocks of Permian to Triassic age. The brief review of the areas with the highest potential for primary gold deposits is given below.

(i) Sanakham-Pak Lay volcanic belt

There have been several recent exploration ventures in this belt, which is the continuation of the Loei gold belt in Thailand. The Triassic andesitic volcanic rocks are probably the primary gold source but the metal has been redistributed into quartz veins and alteration zones adjacent to contemporaneous granodiorite and porphyry intrusions. Similar volcanic rocks are found in the Nam

Seng-Nam Lik belt and there is a group of base metals, cinnabar and gold anomalies in heavy mineral concentrates from this drainage area. The presence of cinnabar may point to an epithermal origin.

(ii) Xiengkhouang volcanic zone

The Phu Bia mining district is located in this volcanic zone. This highly prospective zone comprises Permian rhyolite, intruded by contemporaneous granodiorite which has caused the development of metasomatic pyritic alteration zones in the adjacent country rock. Copper-rich bodies are known in these alteration zones and the Nam Ngum River which drains the area is highly anomalous in gold. There is an abandoned alluvial deposit in this river and there is every indication that a primary gold source exists in the rhyolite or the alteration zones.

The Xiengkhouang zone terminates to the east against the north-south fold belt of the Luang Phabang region. In surrounding gold areas, there are a number of lead-zinc occurrences and the major skarn iron deposit at Phalek may well be related to the same metallogenic event that produced the gold.

(iii) Epithermal gold in Triassic rhyolites, Champasak

A large area of rhyolite is exposed adjacent to the Cambodian border, and this has indications of epithermal alteration to kaolin and pagodite (kaolin + pyrophyllite). Minor base metal anomalies are recorded and the area is prospective for epithermal gold. Twenty one new occurrences of gold (in alluvium) have been found during a regional geochemical reconnaissance survey conducted by the DGM under a UNDP project in 1992 and geological mapping and mineral resource assessment of three selected areas in Sekong, Attapeu and Champasak Provinces.

(iv) Luang Phabang - Nam Ou gold zone

This zone is mainly present in alluvial deposits with minor indications mostly of copper and zinc mineralization in quartz veins. Regional swarms of quartz veins in low-grade metamorphic rocks offer attractive targets for large scale mining, and small workings on single vein structures could also be economic in this relatively accessible area. The Luang Phabang - Nam Ou belt extends northwards along the Nam Ou river valley and may continue into Phongsaly province at Nam Hou and Nam Phak.

A possible zone of base metal sulphide mineralization without gold may be present to the north, as evidenced by the localities along the Mekong river west of Luang Phabang. This base metal zone extends to the south towards Xayabouli and Muong Tha Deua.

(v) Prospective gold zones in the Annamite Mountains

Prospective areas of Permo-Triassic volcanic rocks in the Annamite mountain range to the south-east of Xiengkhouang contain a few gold occurrences and these are regarded as prospective for epithermal and vein type gold deposits.

Similar areas are found to the north-east of Thakhek and in the Nam Kok area of Savannakhet. Another area of gold mineralization, developed over granodiorite near the south-eastern corner of Lao PDR, is indicated by a number of heavy mineral gold anomalies found by recent Russian surveys. This area may be the source for the extensive alluvial deposits in the plain near Attapeu.

2) Copper

Several types of copper mineralization have been reported in Lao PDR. Judging from the successful development of the Sepon copper deposit, the Phu Kham copper deposit, and features of copper mineralization in many localities, copper potential in Lao PDR could possibly range 8 to 10 million tons of copper metal.

The brief review of the areas with the highest potential for copper deposits is given below.

(i) Copper porphyry type mineralization in Xiengkhouang

This type of mineralization has been mentioned previously with respect to gold but some of the occurrences may have more potential for copper deposits. Copper skarns are also very favorable exploration targets and although most of the metasomatic rocks are iron-rich, there is potential for more sulphide and copper-rich orebodies. The Phu Kham copper deposit shows a typical mineralization of this type.

(ii) Champasak copper occurrences

A thin horizon of red-bed copper mineralization was described from the Champasak region by Baniczky (1980). This occurs in shales and sandstone just above the base of the Upper Triassic succession and is discontinuously developed at one stratigraphic horizon, which may extend for considerable distances. There are also references to silver and gold grades on the Russian map of Attapeu and Champasak (Bakoulin and others, 1986). The copper occurrences in Attapeu, Sekong and Champasak province (Burton, 1994 La0/93/005-Mission Report) are generally small in size and widely dispersed, although interesting grades, with precious metals, may be attained locally. It is thought that these are exhalatives, formed by emanations of volcanic or igneous origin far from their source, whilst deposits of larger size may exist nearer to the origin of the emanations.

(iii) Nam Phak copper deposits, Oudomxai Province

This group of old workings is described as veins and breccia fillings of covellite, chalcocite, chalcopyrite, and copper secondary minerals cutting red sandstone and conglomerate (Veux, 1959a; Baniczky, 1980). Whilst the veins are clearly later than the continental red-bed sediments, it is considered that they are closely related to the formation brines within the sedimentary basin.

Similar cross-cutting veins in the Permian limestone nearby at Ban Na Teuy carry zinc and lead sulphides and a similar basin dewatering models is proposed for their region. The economic significance of this mineralization is probably small except as an indication that further exploration should be carried out in this remote province.

(iv) Copper mineralization in Luang Phabang belt

Geochemical surveys by Czech and British teams have revealed copper anomalies in sediments from streams draining into the Mekong river and whilst the source of these may only be minor dissemination of chalcopyrite in the andesites, there is some potential for deposits associated with small intrusive bodies.

Regional geochemical surveys have revealed copper anomalies in stream sediments from tributaries of the Mekong river in the Luang Phabang Belt and many small occurrences of lead have been recorded in veins cutting carbonate rocks of Devonian to Permian age, most of which were probably worked for their silver content.

3) Lead and Zinc

The lead and zinc occurrence in the Phou San-Pa Hia region in Xiengkhouang Province is one of the occurrences of interest to geologists in the past. Galena and sphalerite, with associated silver, are found in sulphide-rich formation at the Pa Hia, Phou San region.

The lead-zinc occurrences at Pha Luang, Vang Vieng, Vientiane province, are some of the more important ones with galena and sphalerite spread over relatively wide areas. The minerals occurring with galena are anglesite, and minor pyrrhotite. According to the reconnaissance survey report of Pha Luang region by geologists (1988-1989), the mineralization is composed of 50-60% galena and 17-22% anglesite. Lead is seen with barite and fluorite in the north-western part of Pha Luang.

Lead and zinc occurrences are also reported in the Sepone region, Savannakhet Province, of central Lao PDR. In the Mouang Phine region, at Nam Meng, galena occurs with sphalerite and pyrite.

Lead and zinc occurrences are also observed at Ban Na Lan, and Na Kham in Champasak Province, but no detailed exploration for development purposes has been undertaken to date.

4) Tin and Tungsten

(i) Nam Pathene tin deposit, Khammouam Province

Tin has been worked at Nam Pathene in central Lao PDR more than 30 years from alluvial and residual material. Improvement in the processing technology could greatly increase the yield of tin. Most of the mining to date has been carried out in the superficial deposits, but there is a potential for larger scale operations.

(ii) Other potential tin granites

Granites in the Annamite mountains (along the border with) shed cassiterite into the drainage system and part of a metallogenic province, but no indication of economic mineralization is known to date.

(iii) Luang Namtha tin-tungsten-antimony belt

A belt with potential for tin-tungsten-antimony deposits is located in the north-west of Lao People's Democratic Republic near Luang Namtha on the south-eastern margin of the Shan-Thai continental massif. This belt is the northern continuation of the Chiang Mai-Chiang Rai tin-tungsten belt of Thailand and extends northwards into China where it is known as the Sanjiang fold belt.

Outside the Luang Namtha scheelite occurrence, associated with stratabound cassiterite, other potential areas exist in Houaphan and Xiengkhouang Provinces, where scheelite values have been found in heavy metal concentrates.

5) Platinum group metals and chromite

Ultramafic rocks crop out along the northward extension of the Nan-Uttradit suture line from Thai to Lao PDR and this area could be prospective for platinum group metals. Detrital chromite, presumably derived from these ultramafic rocks, is found in Oudomxai Province, and such an area could be the focus of exploration for platinum, chromite and gold.

The possibility of placer platinum should not be overlooked, since a deposit of this type was discovered in the north-eastern Thailand not far from the Laotian border. The metal has also been reported in occurrences along the Mekong river in Champasak Province which may have some potential for platinum group metals.

6) Iron ore

Lao PDR has significant iron ore deposits to the north-west of Vientiane. The iron ore in the Phou Nhouan and Pha Lek regions have been known for a long time.

The Phou Nhouan iron ore deposits are composed of magnetite-hematite overlain at the surface by limonite. The magnetite-hematite iron ore has a grade of up to 64 per cent iron.

Iron ore at Pha Lek has also been known for a long time. An aeromagnetic survey was conducted in 1960 by an American company (Aero Services of Philadelphia), and preliminary surface reconnaissance has been undertaken by Vietnamese geologists in 1986. However, the reserves and geological conditions of the magnetite-hematite deposit of Pha Lek have not yet been evaluated in detail.

7) Alumina

The Bolovens basaltic plateau of the southern Lao PDR has been estimated to contain a potential bauxite reserve of 2,000 million tons, although little geological evidence has been advanced to support this figure. Given the abundant potential sources of hydroelectric power in Lao PDR, there might be opportunities for an aluminium smelting operation if a market could be identified.

3.6.2 Non-metallic Minerals

1) Phosphate

Phosphate has been reported in Khammouane Province. A phosphorite occurrence was first uncovered, located 6 kms west-southwest of Ban Tha Pa Chon, Khammouane Province (Tran Van Ban, 1997).

There is considerable potential for phosphate deposits in the karstified massive limestone of mid-Carboniferous age in the mountain ranges bordering the north and east edges of the Savannakhet basin. The Palaeozoic limestone in Houaphan also has potential. These limestons lie north-west along the strike from phosphorite occurrences reported in (Premoli, 1988).

3.6.3 Evaporites

1) Salt (halite) and potash

Rock salt is mined on a small scale in the Vientiane and Savannakhet sedimentary basin and a large potash resource is located in the Vientiane basin and could form the basis of a future fertilizer industry when combined with the availability of cheap hydroelectric power.

In 1974, the Done Tiou potash exploration borehole of the Vientiane basin was reported. In the years 1983-1987, Laotian and Vietnamese geologists have prospected the potash deposit in the Vientiane plain. In addition to geological mapping, more than 30 boreholes were drilled and studied. Drill data indicated that the potassium-magnesium salts have a thickness varying from 10 up to 150 metres. The most abundant mineral is carnalite ($KCl.MgCl2.6H2O$) and sylvite (KCl) as well as halite-rich layers.

Potash deposit in the Vientiane plain is considered to be the largest known potash deposit both in Lao People's Democratic Republic and in the region.

2) Gypsum

Existing resources of gypsum in the evaporite basin of Savannakhet appear to be adequate for the present level of demand but additional reserves could probably be found if required for a larger industrial use such as plaster board.

Recently, a new deposit has been discovered at Ban Bung Houa Na, Khammouane Province and is now being earmarked for exploitation.

3.6.4 Industrial Minerals

1) Barite

Barite deposits at Nalang area (Vientiane province) have been exploited, and the remaining reserves are estimated at over 240,000 tons (United Nations Project, 1990). The Muong Xai and Luang Phabang belts are also considered prospective for barite.

2) Limestone

Local sources of limestone are found in many provinces and can be used for cement manufacture, construction aggregate or roadstone. Dolomite is also available in Khammouane province in the central part of the country and probably elsewhere were karstified limestons are found.

Dark gray-black and brown-black brecciated and white-veined marbles are known from the Mesozoic succession at Pha Tao, 20 kilometres ESE of the Nam Ngum Dam (Vientiane) and many other such occurrences may exist close to access routes.

3) Clays, sands and gravel

Clays, sands and gravels are abundant in Quaternary superficial deposits and local sources can be found adjacent to most centres of demand. Quartz sand for optical and foundry use are probably also available.

Mica and feldspar occurs in pegmatite in Houaphan Province and may be worth exploiting for export through .

The rhyolite in Champasak Province are altered to pyrophyllite, kaolin and, probably, alunite. In the area of Ban Na Huong (Lak Xao area, Bolikhamxai Province), the prospecting shows an existence of two discontinueous clay bodies distributed along the valley from Ban Na Sa Lom to Ban Na Huong (Tran van Bah, 1997).

3.6.5 Gemstones

Gemstones have an attractive potential as high unit value commodities which can be easily transported and can be extracted with relatively simple equipment.

1) Sapphires

Gem and industrial quality sapphires are currently produced by a group of individuals and one private company at Ban Houei Sai in north-western part of the country. A Lao-Czech exploration team recently outlined further potential in the same area. The Bolaven plateau is also regarded as having a speculative potential for sapphires.

2) Amethyst

Amethyst has been extracted from vugs and fissures in Triassic rhyolites in Champasak province.

3.6.6 Fossil Fuels: Coal, Oil and Natural Gas

1) Coal

There are several reports available from the DGEO on coal exploration in Lao PDR and French geologists have written reports on the coal at Saravane, Vientiane, Xiengkhouang, (Mouang Phane and Khang Phanieng) and the coals of the northern Lao PDR (Hong Sa). There are still many important coal occurrences, which have not yet been surveyed in detail.

Anthracite has been mined by a local company for local consumption, as a raw material for supplying to cement plant in Vangvieng, Vientiane province.

Lignite exploration and exploitation is currently underway in Hong Sa and in Vieng Phoukha (Luang Namtha Province) by two private Thai companies. One large lignite deposit with reserves of over 500 millions tons located in Xayabouli province is under investigation for supplying to a power plant.

2) Oil and Natural Gas

Previously, numerous research studies have been undertaken for oil and gas in the country. A report on the preliminary evaluation of data assessing the potential of oil and natural gas was written by Laotian and Soviet geologists (1987-1989) and summarizes all relevant data. The oil companies (Enterprise, Hunt and Monument) have together a total concession area for oil exploration of 85,650 square kilometres in central and southern Lao People's Democratic Republic (parts of Sayaboury, Vientiane, Bolikhamsay, Khammouane, Savannakhet, Saravane, Sekong, Attapeu and Champasak provinces).

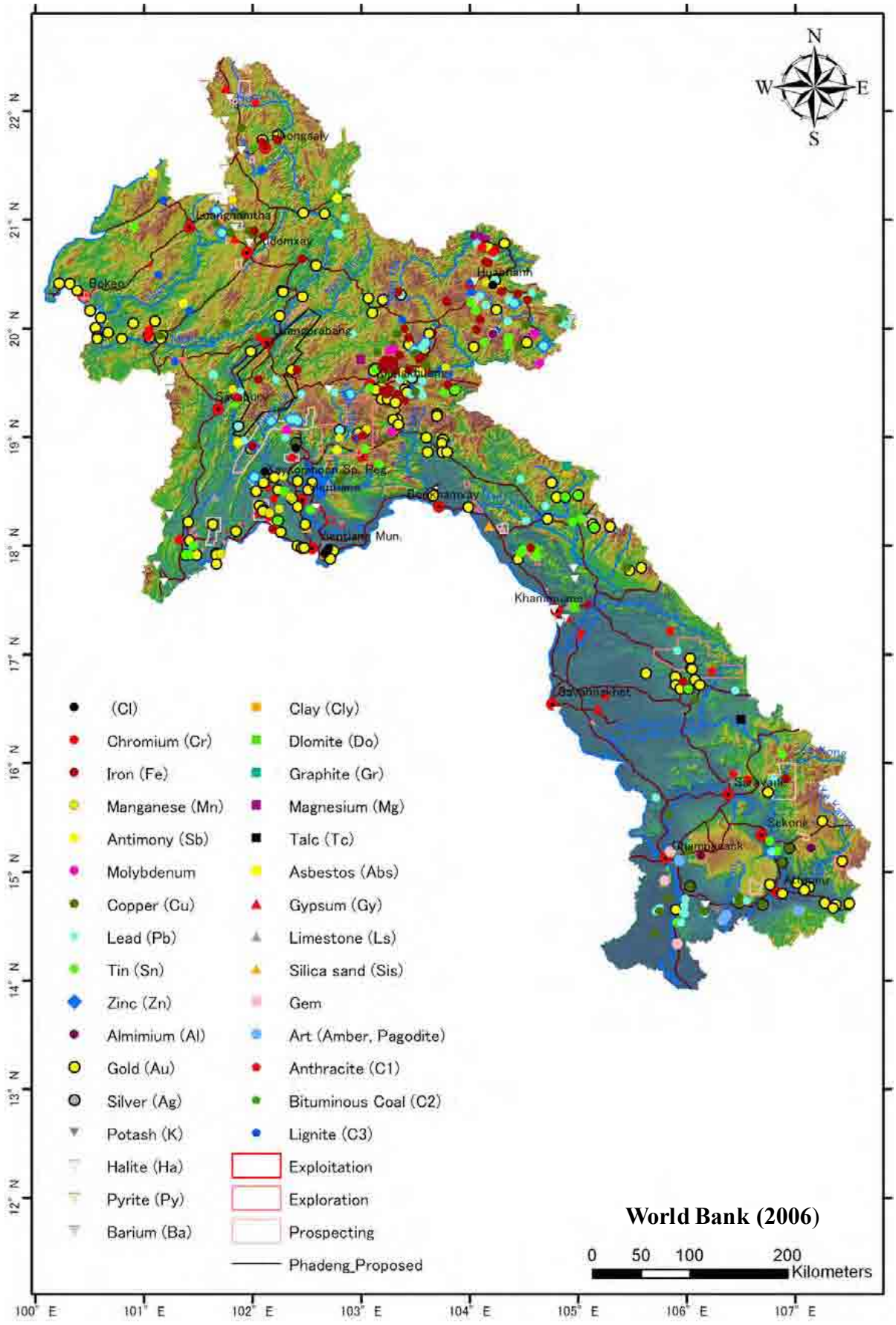


Figure 3.6.1 Location map of ore deposits and mineral showings