Chapter 4 Organizational Reform and Capacity Building

4.1 Current Status of the Organization of the GDMR and its Issues

4.1.1 Current Status of the Organization

(1) Overview of the Organization

The GDMR is one of general departments in the MIME along with the General Department of Industry, General Department of Energy, Departments of Administration and General Inspection. The GDMR plays two roles: as a promoter of mineral resource development and as a supervisor of development activities. Its ultimate objective is to develop and utilize Cambodia's mineral resources to maximize the well-being of the Nation taking into consideration social and environmental impacts caused by the development. The functions of the GDMR are as follows in the Prakas:

- Conducts and manages geological and mineralogical development
- Disseminates and enhances geological and mineralogical information
- Encourages the exploration, for potential evaluation and exploration of mineral resources, gravel, sand and construction materials
- Conducts and enhances geological surveys

More specifically, the GDMR:

- works out strategies, policies and plans for optimized development and utilization of mineral resources based on available geological information
- collects geological information on mineral resources and disseminates it to potential investors
- develops laws and regulations for fair and proper development and utilization of mineral resources in Cambodia
- issues licenses for exploration of mineral resources to investors
- issues licenses for exploitation of mineral resources to investors
- supervises and determines whether exploration and exploitation activities in Cambodia are fairly and properly executed by investors

The Minister governs and supervises the GDMR, which is an executive body that implements the Ministry's policies and strategies. As such, its authority to formulate budgets and recruit new staff is limited. GDMR submits its budget proposal to the Department of Finance under MIME. The department scrutinizes the proposal and, after The Minister's approval, informs GDMR of the results. Similarly, GDMR proposes the number of new qualified staff to be recruited in each year to the Department of Personnel under MIME. On behalf of GDMR, the department recruits new graduates from universities and elsewhere, and after the Minister's approval, assigns them to the GDMR.

While the GDMR is an upstream institution responsible for mineral resources development, the General Department of Industry has a closer relation with industries that use mineral resources. However, these two General Departments seem to lack close communication.

(2) Composition of the Organization

The GDMR is composed of four departments. They are the Department of Geology (DoG), the Department of Mineral Resources Development (DMRD), the Department of Mineral Resources (DMR) and the Department of Construction Material Resources (DCMR). These four Departments are supervised by a Director General of the GDMR. Deputy Director Generals support the Director General.

Until February 2009, the GDMR was comprised of the DoG, DMRD and DMR. In February 2009, however, the DMR was split into the DMR and DCMR. The reorganization was made in an effort to enhance the functions of the old DMR whose activities had recently been rapidly expanding.

Table 4.1.1 Characteristics and Activities of the Departments of the GDMR

Department	Main field	Activities	Inner organization	Remarks
DoG	Development	・Geological research ・Exploration for geological research ・Hydrogeology and Environmental Impact Evaluation	・Map Construction Office ・Geological Research Office ・Geological Environment Office ・Experimental Office	・Key actor in GDMR's competitiveness
DMRD	Planning/ Control	・Formulating plans, strategies and programs ・Evaluating investors' documents ・Managing revenue for GDMR	・Mineral Resource Development Office ・Cooperation Office ・Data Management Office ・Revenue Office	・Coordinating activities for the four departments (training needs, data management and international cooperation)
DMR	Customer management	・Supervision and inspection of investors' exploration and exploitation activities	・Metallic Minerals Office ・Non-Metallic Minerals Office ・Gemstone and Coal Materials Office ・Mining Inspection Office	・Regulator of mining companies
DCMR	Customer management	・Supervision and inspection of investors' exploration and exploitation activities	・Crushed Stone Office ・Sand Construction Office ・Clay Construction Office ・Administration Office	・Regulator to mining companies

Each department is managed by a Director, and Deputy Director or Chief Officer. Each Department has from 20 to 30 staff. Some DMR staff also work at the GDMR.

Table 4.1.1 shows the main fields and main activities of the four departments. Using a business metaphor, the DoG represents the product development and manufacturing department of a manufacturing company, while DMRD is the planning and control department and the DMR and DCMR are engaged in customer relations.

(3) Staff Arrangement

Although there are slight differences among departments, the main players at the GDMR, except top management, are younger people in their 20s and 30s. Around 40% of the staff joined the GDMR since the year 2000 and experience in the organization is not deep. Most of the geologists graduated from the Russian Institute of Technology. However, the geology department of the Institute was closed in 1999. Now, there is no organization to take the place of

the Institute. Since there is still many GDMR staff who had studied at the Institute in the past, there is no serious problem at the present time. However, looking ahead, there is a great concern that there will be a lack of geologists in Cambodia in the future. On the other hand, the number of GDMR staff who studied accounting, law and/or economics in universities is increasing. Variety in academic careers is a recent phenomenon.

(4) Changes in the Operations Environment to be noted

Work related to exploitation activities is increasing at a high pace year by year as is shown in Table 4.1.2. The table shows how the revenue from royalties from the construction materials has been increasing in the past several years. It is interesting that the countries of the registered companies are diversifying, and now include Vietnam, Korea, Japan, Australia, Thailand Singapore, UK and France. Exploration and exploitation of metallic minerals is expected to increase a diversification of mining operations.

Table 4.1.2 Trends in Royalties from Construction Materials, by Province

(Unit: US$)

Province/ Year	2004	2005	2006	2007	2008
Phnom Penh	5,135	31,375	28,250	10,500	107,311
Kandal	28,162	19,545	71,028	176,323	351,434
Kampong Speu	82,633	78,157	91,133	155,071	327,307
Kampot	8,264	14,728	28,010	18,150	50,727
Takeo	5,400	5,602	6,397	10,235	18,722
Prey Veng		2,050	6,886	30,898	7,100
Kampong Chhnang	2,940	2,434	2,700	7,111	7,145
Kampong Cham	26,154	57,236	20,325	27,270	40,551
Kampong Thom	2,262	4,086	4,956	6,000	14,886
Siem Reap	5,304	17,581	21,085	29,517	46,922
Pursat	8,000	4,467	8,469	6,000	9,947
Battambang	4,170	7,463	9,315	18,190	25,440
Banteay Mean Chey	18,142	24,952	26,998	32,180	72,793
Kratie	3,800	3,600	7,465	11,439	18,000
Preah Vihear		2,030	2,243	2,400	1,000
Pailin				1,600	1,992
Svay Rieng				300	
Stung Treng	230	684			
Odar Mean Chey			3,750	2,150	2,762
Koh Kong					11,096
Preah Sihanouk					14,410
Rottanakiri			1,487	1,026	7,686
Mondulkiri					1,000
Keb				1,500	2,600
Total	200,596	276,095	339,006	547,863	1,140,887

(Source: Royalty Inter-Ministry Committee, MIME)

4.1.2 Comments on the Current Situation

(1) An appropriate approach for the GDMR

The GDMR is a governmental / administrative organization which develops Cambodia's mineral resources wealth in the best way for their development to potential investors both inside and outside Cambodia. As such, the GDMR is required to be a fair and powerful promoter and regulator of mining development in Cambodia. In this regard, GDMR should do the following:

- Promote mineral resource development with the awareness that mineral resources in Cambodia are the Nation's valuable assets
- Act with a clear strategy on mineral resources development and utilization
- Expand its operations to meet increasing demands by customers
- Be a customer-friendly organization which can provide high quality service
- Be transparent to both customers and staff
- Have high accountability
- Create value for its customers

In this regard, the current GDMR has much room for improving and strengthening its operations in the following areas.

(2) Issues which GDMR Faces

1) Constructing a more strategy-conscious organization for daily operations

As a regulator of mineral resources development, the GDMR's primary responsibility is to ensure the appropriateness of development activities. However, as a promoter of mineral resources development, the GDMR has to pay attention to its development strategies. In this regard, the following two strategies are important. One is a strategy on maximum utilization of mineral resources in Cambodia between domestic consumption and export. The other is a strategy on how to invite quality investment considering that mineral resources will eventually be depleted.

In other words, they tend to manage GDMR without strategic thinking. As a result,

- They do not have enough time to consider exactly what management entails
- They do not have enough time to consider who their customers are, how to enhance their satisfaction, where high priority exists or how to follow strategic management

With respect to lack of strategic management, it seems that documents necessary for strategic management are not prepared in a useful way. Each department holds raw data which are useful for strategic management. However, neither staff nor managers realize how these data are valuable.

Table 4.1.3 shows a list of management data which are periodically produced. There is a possibility that they also hold other data and information useful for their strategic thinking. However, they may not be aware of their value and know how to use them.

The indifferent attitude towards strategic data and information can probably be traced to the following. First, a company registration system was not introduced until after 2004. Second, each set of data is kept by the department concerned. In other words, a data

management system is not yet well developed within the GDMR. Third but not least, management people and staff feel that the GDMR is only an administrative/executive agency, and differs from private companies where strategic management is far more important.

This lack of a sense of strategic thinking is also seen in middle management staff who will lead the organization in future. They do not care about the data and statistics which they compile. When asked why they compiled some data, they said that they compiled it at the request of top management. This shows how weak communication is between them and top management.

Table 4.1.3 List of Management Data

Department	Name of table / Database name	Frequency
DMRD	・List of staff ・List of staff attendance ・List of inventory: computers, desks, chairs, TV, etc ・Database system to manage and control registration of mining companies ・Database system to manage and control mining companies and their licenses/agreements ・ Database system to manage and control the payment of royalties and debts ・Database system to manage and control production of construction materials ・Money collected from companies -- Rental fee for land -- Official tax levies -- License fees	・Revised/ updated once a year ・Made and checked every day ・Made and checked once a year ・Data entered and checked every month ・Data entered and checked every month ・Data entered every day if any and checked monthly and yearly ・ Data (if any) entered every day and checked monthly and yearly ・Made and checked -- Once a year -- Two times per year -- Depend on application or renewal of license
DMR and DCMR	・List of staff ・List of staff attendance/absences ・List of inventory: computers, desks, chairs, TV, etc ・Database system to manage and control mining companies and their licenses/agreements ・Database system to manage and control production of construction materials	・Revised/ updated once a year ・Made and checked every day ・Made and checked once a year ・Data entered and checked every month ・ Data (if any) entered every day and checked monthly and yearly
DoG	・List of staff ・List of staff attendance ・List of inventory: computers, desks, chairs, TV, etc	・Revised/ updated once a year ・Made and checked every day ・Made and checked once a year

(Source: DMR, DMRD and DoG)

2) Strengthening flexibility to provide services which are necessitated by expansion of operations

In order to respond in a timely manner to the needs of operational expansion, it is necessary to increase the number of staff for current and new operations. However, under the current administrative system, staff increases are limited. The GDMR has been allowed to add only about 3-4 new staff in the past few years. Moreover, it is necessary to secure staff with new talents for new operation areas. To overcome these problems, the existing operational system should be streamlined, some staff should be reassigned from their current position to a new position, and training of staff for new operation areas should be accelerated.

3) Developing operations manuals for standardized operations and slim organizations

Although Prakas stipulate each Department's duties and responsibilities, their descriptions are not always clear. In addition, it is not clear what duties and responsibilities

each staff member has to undertake. As a result, staff members become frustrated. Furthermore, there are no operating manuals, so there is a lack of consistency, transparency and accountability in operational procedures. This impairs the organization's competitiveness.

4) Strengthening the management systems for enhancing the quality of daily operations

The GDMR faces three problems in enhancing the quality of daily operations

- Difficulties in communication

There are three main reasons for the lack of communication. First, while the DoG was required to maintain intensive communication with the other three departments, the DoG office was physically far from them. This led to a lack of inter-department communication. However, when the GDMR moved to a new office in June, 2010, the DoG was included in the relocation and the communication problems subsequently seem to be solved.

Second, it is said that Government officials in Cambodia need to work at another job in order to sustain their lives under the current remuneration system since their salary is low. This is said to be the situation in GDMR. As a result, some staff members leave their office earlier than the scheduled time or do not even show up due to their second job. Staff absences from the office are another reason for the lack of communication.

Third, quite a few staff members make frequent visits to mining sites at the request of investors, and some of these visits are not short. This situation also causes a lack of communication among staff and management people.

- Developing an IT system

The IT system in the GDMR is underdeveloped. There are not enough computers and networking is not yet developed. In addition, advanced computer technology has not been introduced. This underdevelopment at the DoG poses a particularly serious problem because its work is the main source of the GDMR's competitiveness. The DoG needs high-tech computer software such as GIS but due to budget constraints, it cannot acquire it. Under such circumstances, the DoG cannot produce high quality geological information and is viewed by investors in the mining sector as not being competitive.

Though the target for the development of Management Information System (hereafter, MIS) is focused on daily operations within the GDMR for the time being, when it is completed, computerization will have been expanded to the area of investment procedures. It is well known that streamlining investment procedures is as important as investment incentives for attracting investment. Therefore, a new system that allows investors to access the GDMR directly from their counties through the Internet, and finalize applications for investment should be constructed, even if it includes only some parts of procedures.

- Much room for awareness of customer satisfaction

It is not unusual for staff to have contacts with investors, but they do not care about customer satisfaction. Further, transparency in their contacts with customers is low.

It is important to recognize that the GDMR will survive only if its clients feel it

provides a valuable service.

5) Designing operating systems which place high priority on capacity building for staff

Most staff is not given jobs which fit their capability. Middle management people are also not so sensitive about the matter because they do not communicate with top management about it. In other words, top and middle management are not in the same boat regarding capacity building for staff.

The most serious matter for staff is that they are not given enough work to do each day, even though they are talented and have strong motivation. Top management already recognizes the problem, but they can not find a way to solve it. The issue should be seriously tackled by the GDMR with the highest priority. From the viewpoint of capacity development, it may be necessary to develop new business areas to provide new work for young staff. If it succeeds, it will bring about a new source of income and incentives for their hard work.

While top management's leadership is important for staff's capacity building, the key players may be middle managers who have daily contact with staff. The most important keys for successfully building the capacity of their subordinates are a strong commitment to capacity building and wisdom.

6) Enhancing geological research capability

The real source of the GDMR's competitiveness lies in its geological research. When it can develop and provide accurate geological information for potential investors, the GDMR can attract both local and foreign investors in mineral resources in which can in turn contribute to the economic development of the nation. However, the GDMR's research capability is weakening. Due to budget constraints, the DoG can no longer conduct first-class geological research.

To engage in first-class research, two conditions must be met. First, it is imperative for researchers to have access to high-tech equipment that can handle GIS and satellite analysis. However, the DoG cannot afford such equipment. Second, it is also necessary for researchers to be well trained in using such high-tech equipment. In this regard, too, staff at the DoG lacks opportunities for training due to budget constraints.

Another concern is lack of educational institutions for geology and mining in Cambodia. As was previously mentioned, since the closing of the Russian Institute of Technology, there is no place where Cambodian people can study geology and mining in their own country. Today, staff who graduated from the Institute in the past is supporting the DoG's operations. However, who will support its operations when these people retire? This is a serious issue that must be addressed. One idea is to open a similar institute to train a new generation of geologists. Since it will take several years before the first graduates from the new institute will be able to enter the DoG, the new institute should be established as soon as possible. Considering that the opening of a new technology institute will need substantial financial and human resources, it will be necessary for the Cambodian government to ask for international cooperation.

4.1.3 Strategies for Solving Issues

(1) Clarification of Prioritized Areas and Allocation of Human Resources to these Areas

Considering GDMR's functions and its current achievement level which is discussed in 4.1.2, it is necessary to assign staff to strengthen the following areas. A proposed organization for the prioritized areas is given in Paragraph 7.4.2 in Chapter 7.

1) Enrichment of overall strategic business planning for the GDMR

Even an administrative/executive organization such the GDMR needs to formulate an overall strategic business plan. For this purpose, an office has been set up to integrate the strategic business plans prepared by each department into an overall strategic business plan. In order to formulate this plan, the office conducts basic research on the mining industry in Cambodia as well as mineral resources development around the world. The main topics are as follows:

- Nationality and investment behavior of potential investors
- Potential minerals to be developed and their areal distribution
- Potential areas to be developed
- Prioritized R&D activities
- Human resources development
- International cooperation

Functions undertaken so far by the DMRD are to be transferred to the new department.

The following is priority work to be done by the newly created planning section.

- Analysis of the factors underlying stagnant mining investment and measures to accelerate investment

While mining investment is steadily increasing in the construction material sector, investment in other areas is stagnant. The factors underlying this trend should be meticulously analyzed and measures for acceleration should be taken. Only when investment in mining expands, can it be said that the mining sector is growing.

- Preparation of messages on management policy which are addressed to all staff of the GDMR by the Director General of the GDMR

The Director General is requested to inform all staff working for the GDMR about management strategies and policies. The newly created planning office is in charge of preparing the messages.

2) Development of new Laws and Regulations

Considering the increase in exploitation activities, it is necessary to develop new laws and regulations related to mine health and safety as well as environmental protection. The office of the DMRD is in charge of development. Two additional staff will be assigned to their development.

3) Environmental Impact Assessments

For the same reason stated in Development of New Laws and Regulations, demand

for environmental impact assessments will increase. While the assessments themselves will be carried out by private consultants, the GDMR's role is to check the results as a regulator. The work will be done by the DoG in collaboration with the Ministry of Environment. One new staff member will be sent to the Ministry of Environment when it is necessary to do so.

4) Strengthening of Management In formation Systems (MIS)

Plans call for assigning two IT specialists to enhance the efficiency of daily operations at the GDMR and to introduce a computer system into management. Their job will be to construct a new Management Information System (MIS). If it is necessary to do so, an IT specialist will be temporarily hired from some software company. By doing so, it will be possible to develop the system with only a few staff members.

Introduction of MIS will be limited to the GDMR's basic operations for the time being. When it is finished, its potential application to investment approval procedures will be investigated.

5) Assignment of a planning officer for personnel management

Capacity building for staff is one of the priority areas. A special officer is assigned to communicate with staff, give advice for their career development, and to plan capacity building for staff. It is important that he be independent from and not influenced by Technical departments. The officer will develop capacity development plans for staff including training programs inside and outside the GDMR.

The officer's main duties are as follows:

- Develop personnel files for all staff members
- Interview all staff on their expectations for assignments
- Ask all staff about their expectations for capacity development
- Develop a capacity building plan for all staff members

6) Public relations functions

In order to enhance capacity building at each staff level, it will be necessary to get support from the central government in addition to the direct support from the GDMR. For this purpose, it is necessary to communicate with the Cambodian people. The role of the public relations officer is to inform the Cambodian people about the kinds of mineral resources Cambodia is endowed with and how the GDMR is contributing to the economic and social development of the Nation through mining development. At the same time, the GDMR has to be more serious about accountability in its operations.

7) Coordinating functions

Development of mineral resources is influenced by industrial activities and foreign trade. The GDMR should be concerned about the current situation of industries that use and trade mineral resources. The newly assigned coordinating officer communicates with these industries.

The main activity is to exchange opinions on how the parties concerned can proceed with mineral resources development. The information collected through such dialogue will be used to help formulate development strategy. The pace of development is determined by the

availability of the mineral resources and user industries' demand for the resources.

8) New business development

The office's role is to develop new business based on its assets, know-how and information. Its main purpose is to develop the capacity of staff at the GDMR through the creation of new business. Another purpose is to expand the sources of its market-oriented revenue.

The following are some examples of their services to be provided by the new business:

- Special research on mining for investors
- Consulting services for foreign investors in the mining sector
- Educational services for universities and high schools
- Seminars on mining activities
- Lectures on mining and mineral resources development

The GDMR is an information provider for mineral resource development companies as well as a governmental and administrative agency which regulates the development of mineral resources in Cambodia.

9) Follow-up office

In order to ensure good governance of GDMR's operations, a new function of inspection for daily operations is being prepared. The results of inspections will be reported to the DGMR, and then there will be a follow-up.

(Duty)

Follow-up officers check whether staff undertakes their work in line with internal regulations set forth in the operations manuals, as well whether they make best efforts for capacity building. The most important task is to ascertain whether or not agreements with investors have been properly made.

(Areas)

- To inspect whether daily operations are performed in line with relevant regulations and operation manuals

The most important point is whether or not agreement between the GDMR and an investor in exploration or exploitation activities has made properly. This is crucial because mining licenses give the holders the right to develop the Nation's mineral resources; therefore, it is necessary to confirm that such agreements do not conflict with the Nation's interest. In addition, the office determines whether or not investment licenses have been properly issued according to procedures stipulated by the GDMR. Therefore, the first thing that should be done is to prepare operation manuals.

- To follow-up on whether an effort is being made to develop the capacity of each staff member.

In this inspection, priority is given to ensuring that management people are dedicated to developing staff members' capacity and treating them fairly and equally in their evaluations and assignments.

(Preparation)

The GDMR prepares the operation manuals for major tasks. The manuals cover the following areas.

- Registration of companies
- Determination of terms and conditions for issuing licenses
- Receipt of license fees
- Extension of exploration licenses
- Determination of terms and conditions of supports for investors
- Report on capacity building for staff
- Agreement with investors

The manuals include standard form of documents such as attendance lists and inventory lists of fixed assets, in addition to agreements with investors

(Follow-up)

Follow-ups are conducted once a year, and take around one month to complete.

(Report)

The results of the follow-ups will be submitted to the Director General of the GDMR. A summary of the results and recommendations will be given to the Director of each Department, as well.

(Follow-up officers)

Staff having experience with and knowledge of operations at the GDMR are assigned as officers.

(2) Restructuring of the DoG

It is necessary to allocate human and other resources to the Department in order for it to regain its competitiveness. In terms of number of staff, it is not so problematic though it is far from satisfactory. The main issue lies in deficiencies in equipment, which make it difficult to perform competitive research activities and train staff. In this regard, improvement is necessary in two areas. One is to renovate current facilities and replace old equipment with modern high-tech equipment. International cooperation will be needed to achieve this. The other is to enhance analytical capability in the Laboratory section through the introduction of advanced equipment and collaboration with other Departments. A new lab for analyses must also be constructed.

As a long-term strategy, it is necessary to start a new technological institute to take the place of the defunct Russian Institute. Since it is impossible for Cambodia to carry out projects with only its own resources, it will have to make every effort to obtain support from donor countries. However, in order to do so, the Government will have to make a long-term development plan for the mining sector of Cambodia and persuade donors why and to what extent the Government needs support. The Master Plan Study will help the Cambodian government to formulate a long-term development plan.

(3) Creating a more efficient operations system that makes the best use of Human Resources

Under the current administration system in Cambodia, it is difficult to recruit enough new staff for the above prioritized areas. Therefore, this issue is solved through efficient operations and enhancement of the current staff's motivation. Specifically, efficiency of operations is improved through the following.

- Preparation and use of operations manuals: streamlining and standardization of operations
- Introduction of MIS: quality improvement in operations
- Capacity building for each staff member: communication between a newly assigned planning officer for personnel management and staff

Details of the above programs are given in 7.4.3 in Chapter 7.

4.1.4 Resources for the Reforms

To implement the above reforms, it is necessary to secure two types of resources: 1) human resources, and 2) financial resources.

With respect to human resources, staff is required for three areas: management, customer service, and specialists in geology.

As for management staff, three sources seem to be available. The first is three to four freshmen who are assigned by MIME to the GDMR every year. The second is to reassign ten staff members to new positions to increase the efficiency of operations. Since staff members recruited in the past 2-3 years had experience in their current position, so long as they are placed at appropriate office and trained by chief officer at the new office, they will be able to handle their new assignment. Senior staff whose task is taken over by the above new staff is assigned to new and complex jobs in prioritized areas. The third is to accommodate 1-2 staff from international donor organizations.

As for staff assigned to customer services and geological work, a large number of staff may be needed depending on the scale of expansion of GDMR's activities. This is discussed in more detail in 7.4.4 in Chapter 7.

In regards to financial resources, the most desirable case is for the Department of Finance at the MIME to pay the full amount. However, it may be difficult, even if some portion of the funding could be prepared by clarifying the GDMR's business strategy. Therefore, in addition to the MIME's budget, two sources are being sought. One is support from international organizations. In this case, the support would be limited to the acquisition and installation of special equipment. The other is a training cost which is provided by investors under the Mineral Agreement concluded between investors and the MIME.

4.2 Current Situation of and Issues with Capacity Building

4.2.1 Current Situation

Capacity building in the GDMR has two components. One is related to the actual

development of mineral resources. The main beneficiaries are staff of the DoG and the DMR. The other is capacity building for all staff of the GDMR.

With respect to capacity building for resource development, programs developed by international organizations or an on-the job training (OJT) program should be available, as will be discussed in 4.3. However, this is far from satisfactory. With respect to capacity building for the entire staff, the GDMR has not developed a specific program.

Operations at the GDMR are currently undertaken by staff who studied geology and mining engineering at the Russian Institute of Technology. However, since the closing of that Institute, there is no organization in Cambodia which provides the necessary instruction in geology and mining engineering. Many people have expressed a desire for a similar facility to be established.

It is said that some countries have shown an interest in this. However, they would like for the Cambodian government to demonstrate a clear need for such an institute and to show what type of curriculum is needed by presenting an overall development plan for the mining sector in Cambodia. The Master Plan Study will serve to help meet these conditions.

4.2.2 Comments on the Current Situation: Issues and Countermeasures

Capacity building of staff will bear fruit only when the following 3 conditions are met: 1) the capabilities of individual staff members are strengthened, 2) the GDMR organization is strengthened, and 3) there is strong support from the Cambodian people.

(1) Capacity Building of Individual Staff Members

It is necessary to recruit people who have a strong desire for capacity development. However, the GDMR has to help the recruited staff polish the capacities (skills) that they have developed through their own efforts. There are two ways for the GDMR to achieve this. One is to train them through daily operations at the GDMR, that is, through on-the-job training. The other is to send the staff members to some specialized training course outside of the GDMR, that is, off-the-job training. Needless to say, on-the-job training would be the preferred method.

The issue is what kinds of programs would have to be developed for the two types of training. Even though the contents would differ according to the staff member's position, there would essentially be two types of training courses. One would be a course on general topics such as how to manage staff and to communicate with them and the other would focus on specific topics such as how to use advanced GIS.

Management people at the GDMR stressed that following areas are to be prioritized for training.

Department of Geology

- Geological survey skills for mapping
- Petrographic and mineralogical testing
- Application of Geophysics (Electric method)
- Advanced GIS
- Satellite image analysis

Department of Mineral Resources Development

- Mining policy
- Evaluation of mineral resources potential

Department of Mineral Resources and Department of Construction Material Resources

- Environmental management and engineering (Mining engineering and environmental restoration for abandoned mining areas and cost calculations)
- Mining management (Mineral economics and mineral tax regime)
- Mining management (Auditing accounts)
- Relationships and research (Advanced English)

Further, staff members who were interviewed suggested that they need training for the following areas to fulfill their duties as specialists. It should be noted that even the GDMR, an organization which has many specialists in mineral resources development, is strongly concerned about its deficiency of human resources.

- Specialist in GIS analysis
- Mineral resources economist
- Specialist in laws and regulations
- Specialist in corporate analysis
- IT specialist
- Specialist in environmental and community issues
- Specialist in environmental design
- Specialist in Environment Impact Assessment
- Specialist in mapping
- Specialist in geophysics
- Specialist in mineral testing
- Specialist in environment management and engineering
- Specialist in mining management (mineral resources economist, tax economist and auditor)
- English speaker

In addition to training staff, it is also necessary to arrange materials and equipment for daily operations. Following are some examples.

- High quality computer used for mapping

Table 4.2.1 shows the capacity development plan for 2008-2009 in the GDMR. It covers not only staff of the DoG but also staff of the DMRD, DMR and DCMR. It is costing around US$160,000 to implement the plan.

Table 4.2.1 Capacity Building for GDMR Staff（2008-2009）

No	Subject	No. of staff	Period (Year)	Cost (person/year) (US$)	Total (US$)	Training venue
Geology-Mining						
1	Mining engineering Environmental restoration for abandoned mining areas and Cost calculation	2	2	19,000	56,000	Abroad
2	Geophysical survey Satellite imagery Rock and mineral analyses	2	1	19,000	38,000	Abroad
Mineral economics and mineral taxation regime						
3	Mineral economics Mining taxation regime	2	1	19,000	38,000	Abroad
4(*)	Accounting and taxation system for mining and trading	3	1	400	1,200	Phnom Penh
Map						
5	Mapping	2	2	12,000	48,000	Phnom Penh
Foreign language						
6	Intermediate English	6	2	800	9,600	Phnom Penh
7	Advanced English	6	2	1,000	12,000	Phnom Penh
Total					159,600	

Note*: already done. (Source: DMRD)

(2) Strengthening the GDMR's Organization

1) Creating a "Good Organization"

Even if each staff member's capacity is strengthened as much as possible, there will still be limitations. What supplements each staff member's capability is the strength of the GDMR's organization. Under the "Good Organization" system, staff members' capability is strengthened further.

What exactly does "Good Organization" entail? The answers may vary but they generally include the following:

- A clearly defined corporate philosophy or management philosophy
- A strong guiding principle for the organization
- Performing tasks in accordance with the corporate philosophy
- A solid and transparent management system
- Clearly defined responsibilities and duties of each staff member
- Smooth communication between top management and staff

In order to establish a solid management philosophy, it is necessary to redefine "What the GDMR is". The following are examples of answers.

- An organization specializing in mineral resources development in Cambodia
- A one-stop service agency for local and foreign investors in development of mineral resources in Cambodia
- A strategic information organization for mineral resources in Cambodia
- A provider of information and network services for mineral resource development in Cambodia
- A capacity building organization representing Cambodia
- A strategic organization involved with mineral resources that are international

commodities

2) Strong leadership

Even if staff grow only when they make an all-out effort, it is necessary for management people to help and encourage staff to grow. The most important support is to show strong leadership. They should also let staff participate in "management" as much possible. By being active participants, staff will think deeply about what their organization is, what their responsibilities are, and how to manage their organization. During the course of this process, their capacity for problem solving will be enhanced.

For staff members to grow, support must be given by top management. The most important support is to believe in the staff members and to give them challenging but important work assignments. Staff can grow only when they are given difficult but important work.

3) Good communication

Good communication will help staff to grow. As stated above, communication within the GDMR has not always been good for several reasons. Some of these problems were solved by relocating the GDMR office and the four departments into the same building. It is also necessary for management people to make every effort to improve their communication. The following are some ways to improve communication.

- Top management meets and talks with as many staff members as possible even if though it is only for a few minutes
- Top management has a regular meeting with staff once a week

In this regard, one way to cope with the lack of communication caused by travel to mining sites and taking time off work for a side business would be to set an internal rule that every staff member would have to be in his or her office on the first and third Monday morning of every month.

It is also important and effective for good communication for top management to convey their strong message about management philosophy and daily operations. In this regard, many staff members said that they had never heard top management convey their philosophy. Top management surely has its own philosophy. The issue is how to convey it to staff. When it is not conveyed, staff members can not understand what top management thinks and where the organization is going. Communication not only among staff but also between staff and top management is important for creating and maintaining a competitive organization

(3) Support from the Government

In addition to strengthening individual staff members as well as the organization, capacity building also requires support from the Cambodian government. The government should send a message of strong commitment to mineral resources development to the people. Formulation of the Master Plan will give the Government a good chance to commit its support to the Cambodian people.

In addition, it is necessary for the GDMR to use every chance possible to discuss the state of the mining sector with other relevant parties such as the MIME and MoE through regular meetings.

4.3 Support for Capacity Development by International Organizations：Current status

(1) Past Examples of International Training of GDMR staff

Over the past several years, the GDMR has sent several staff members to overseas seminars, including the following:

- China
  In 2004: One-month course for software training. Two staff members participated
  In 2007: Two-week course for exploration technology: Two staff members participated
- Thailand
  In 2005: One-month course for infrastructure management: Five staff members participated
- Japan: JICA
  In 2007: Three-month course for sustainable mining development: One staff member participated

(2) International Training Plan at the GDMR

At present, two plans are under consideration. One is a course for improving English language proficiency. The course is given in Australia and eight staff members are scheduled to participate. The other is a plan to have two staff members take a training course in GIS technology, which would be administered by a private Cambodian company

As has been discussed above, capacity building has been attempted in technical areas, but not in management.

(3) Higher Mining Education in Cambodia

Since 1964, the Institute of Technology of Cambodia (ITC) has provided higher education up to the graduate level. Within its rural engineering department, there are two courses: *Water Resources* and *Geo-Techniques*. The *Geo-Techniques* course includes cement excavation, water control, soil testing and geologic structures & civil engineering, but there is no course or lectures on geology, mineral deposits, mining engineering and mineral resources development.

Through partner schools outside of Cambodia, the ITC is also able to offer Master's and Doctorate degrees in many of these subjects. The ITC is now largely supported by the French government. Since it started, over 4,000 graduates have advanced their careers in the service of Cambodia.

Partner organizations in the rural program include Action Nord Sud, Mekong River Commission (MRC), Mong Rithy Group, Muhibbah Engineering Company, Deutsche Gesellschaft fur Technische Zusammenarbeit (GTZ), the Research and Technology Exchange

Group (GRET), Water Utilization Program-Finish Environment Institute SYKE (WUP-FIN), MAEDA, South-East Asian Community Access Program (SEACAP), ILI Consultants and the MIME.

Chapter 5 Geology and Mineral Resources

5.1 Present Condition of Information on Geology and Mineral Resources

Since the latter half of the nineteenth century, geological studies and mineral investigations have been carried out by French, Chinese, Vietnamese and Cambodian geologists from time to time. However, many of those studies were lost during the civil war of the 1970's, and there are still no archives or libraries that have been established for existing data in Cambodia.

In 1993, the ESCAP compiled the existing data at the time into the Atlas of Mineral Resources of the ESCAP Region, CAMBODIA, which includes an explanatory booklet, a geological map and a mineral resources map at the scale of 1:1,500,000.

In 1999, a 1:750,000 mineral resources map was compiled by the Department of Geology (DoG) using the information from a 1:1,000,000 mineral resources map made by French geologists, an ESCAP 1:1,500,000 mineral resources map, survey reports from 1989 to 1997 of DoG and companies' reports from 1993 to 1997. An explanatory booklet titled "Mineral Deposits in Cambodia" was published by GDMR in 1999. The booklet is a kind of revised edition of ESCAP's explanatory one.

French geologists published 1:200,000 geological maps and explanatory booklets in 1972 and 1973. The maps are reliable, but there is only sketchy information about eastern Cambodia (due to the lack of surveys during the Vietnam War) and about the Cardamom Mountains area. The present 1:200,000 geological maps of eastern Cambodia, especially Rattanakiri province, were revised based on the results of Vietnamese and Cambodian surveys conducted in 1988. All 1:200,000 geological maps were digitized; and a 1:500,000 scale geological map was compiled based on those previously cited maps.

After the Vietnamese survey in 1988, geological surveys and mineral exploration have been done by private sector companies for their own concessions. Private companies submit exploration reports to the GDMR, but they are not disclosed. Information on mineral resources published after the release of the ESCAP atlas, are GDMR's 1:750,000 mineral resource map and the booklet of 1999, and the partly revised 1:200,000 geological maps mentioned above. Obtainable primary documents are listed in Table 5.1.1, and an index map of existing geological map is shown in Fig. 5.1.1.

Table 5.1.1 Primary Existing Documents on Geology and Mineral Resources in Cambodia

TITLE	SCALE	YEAR	EDITOR	NOTE
Geological maps and notes in French	1:200,000	1972 - 1973	BRGM	14 sheets cover whole territory
Geology of Kampuchea, Laos and Vietnam	1:1,000,000	1991	Geological Survey of Vietnam	2nd Edition is available
Atlas of the Geological resources of the ESCAP region	1:500,000	1993	ESCAP	Geology and Mineral Resources
Mineral deposits in Cambodia	Booklet only	1999	GDMR	No attached map
Geological Map of Cambodia	1:1,000,000	2003	GDMR	Digital version

BRGM: Bureau of Geological and Mining Research,
ESCAP: Economic and Social Commission for Asia and the Pacific

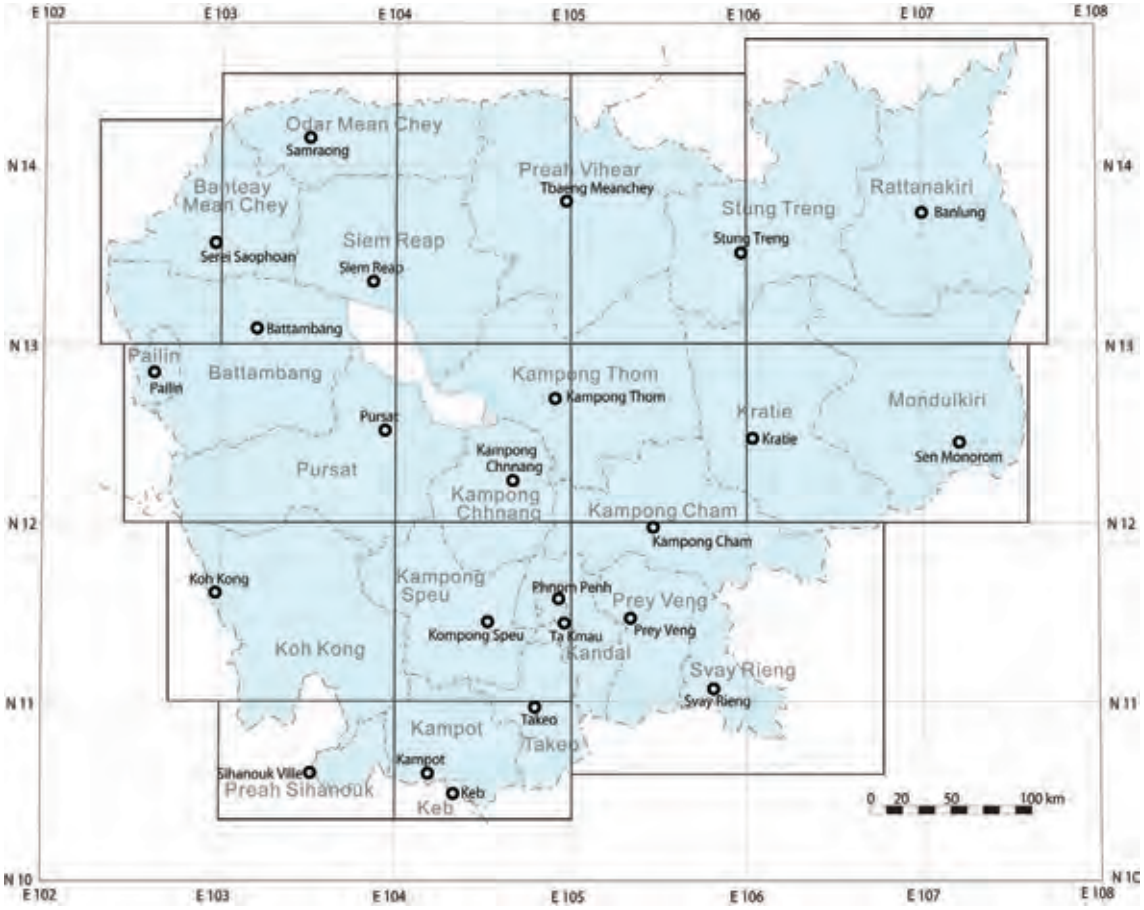


Fig.5.1.1 Index Map of Existing Geological Maps

5.2 Geology and Mineral Resources of Cambodia

5.2.1 Geology and Tectonic Setting

Cambodia can be divided into three geological regions. They are the Northeast (NE), Middle and Southwest (SW) regions. The NE and SW regions are comprised of metamorphic, sedimentary, volcanic and intrusive rocks dating from the Precambrian and Mesozoic as basement, plateau basalt and soft sediments of the Neogene and Quaternary. The Middle region is the Tonle Sap – Mekong Plain, widely covered with Quaternary sediments with isolated hills of basement rocks. Paleogene features are occasionally seen on the surface. A geological map of the country is shown on Fig.5.2.1. Information on stratigraphy and mineralization is compiled in Table 5.2.1.

Cambodia belongs to the Indochina Block together with the southern part of Laos and Vietnam. The Indochina Block is bounded on the north by the South China Block and on the west by the Shan – Thai Block. The boundary areas of each Block are Fold Belts with accompanying intensive folds, faults and intrusive bodies. The Middle and SW regions coincide with the Indosinian Fold Belt (Permian to Triassic) between the Indochina Block and the Shan – Thai Block. Distributions of the tectonic blocks are shown in Fig.5.2.2.

5.2.2 Mineralization

Metallic mineral resources of Cambodia include antimony, chromium, iron, manganese, molybdenum, tungsten, aluminum, copper, lead, zinc, tin and gold. Rare earth elements have so far not been found. Mineralization of these minerals was accompanied by igneous activities (e.g. intrusion of granitoids and basalt extrusion). Four main series of granitoid activities are recognized: the Early – Middle Paleozoic, the Permian – Triassic, the Late Triassic – Jurassic and the Cretaceous – Paleogene. The Precambrian orthogneiss suggests that there was igneous activity in the Precambrian era, but the details are unknown. All-granitoid activities would accompany mineralization. The Late Triassic – Jurassic mineralization in the NE region is the most dominant (Table 5.2.1). The Neogene – Quaternary erosion of primary deposits made small scale placer gold or tin deposits. Intensive erosion and deposition occurred during the Indosinian era and the Cretaceous, but no placer deposits from this era have been discovered yet.

The Neogene – Quaternary basalt covers a vast area of land in the NE region and part of the SW region. Bauxite deposits were formed by weathering of the basalt. Corundum, Zircon and Garnet crystals were blown out with basalt eruption, and deposited in tuff beds. The tuff beds are the source of placer gems.

Fig.5.2.3 shows the distribution of mineral resources in Cambodia. A list of mineral deposits and occurrences is given in Appendix V-1.

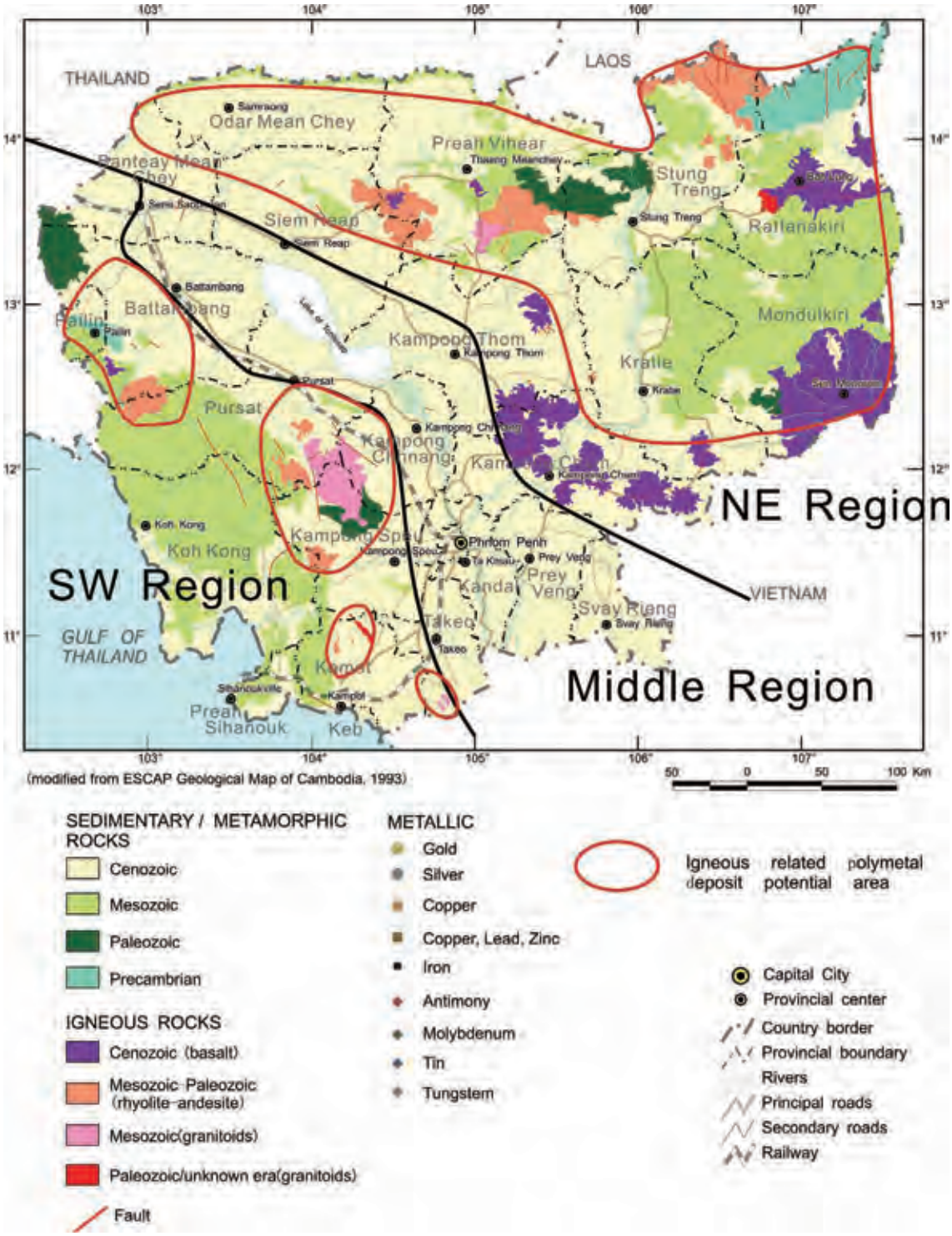
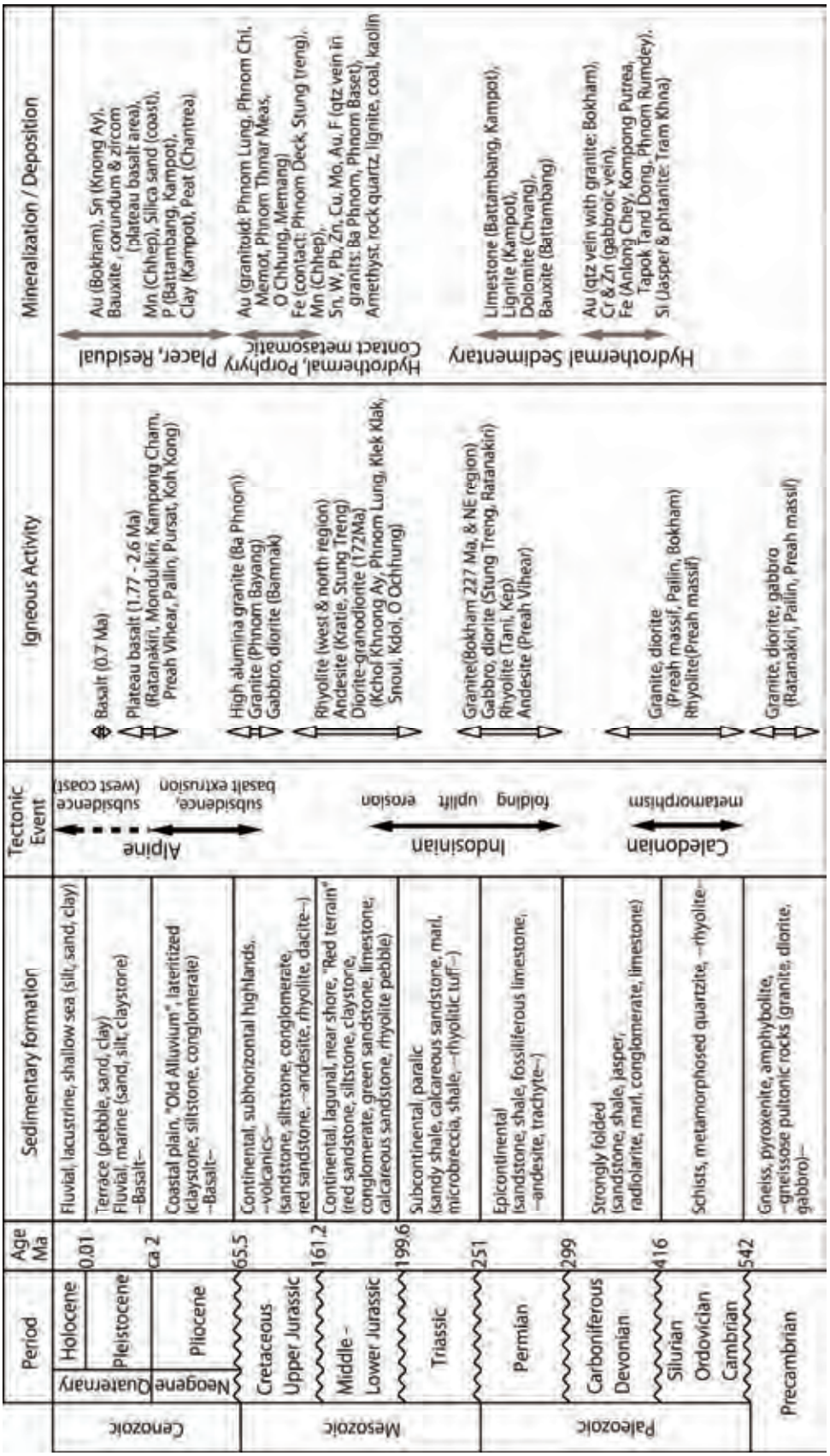


Fig.5.2.1 Geological Map of Cambodia

Table 5.2.1 Geology and Mineralization of Cambodia



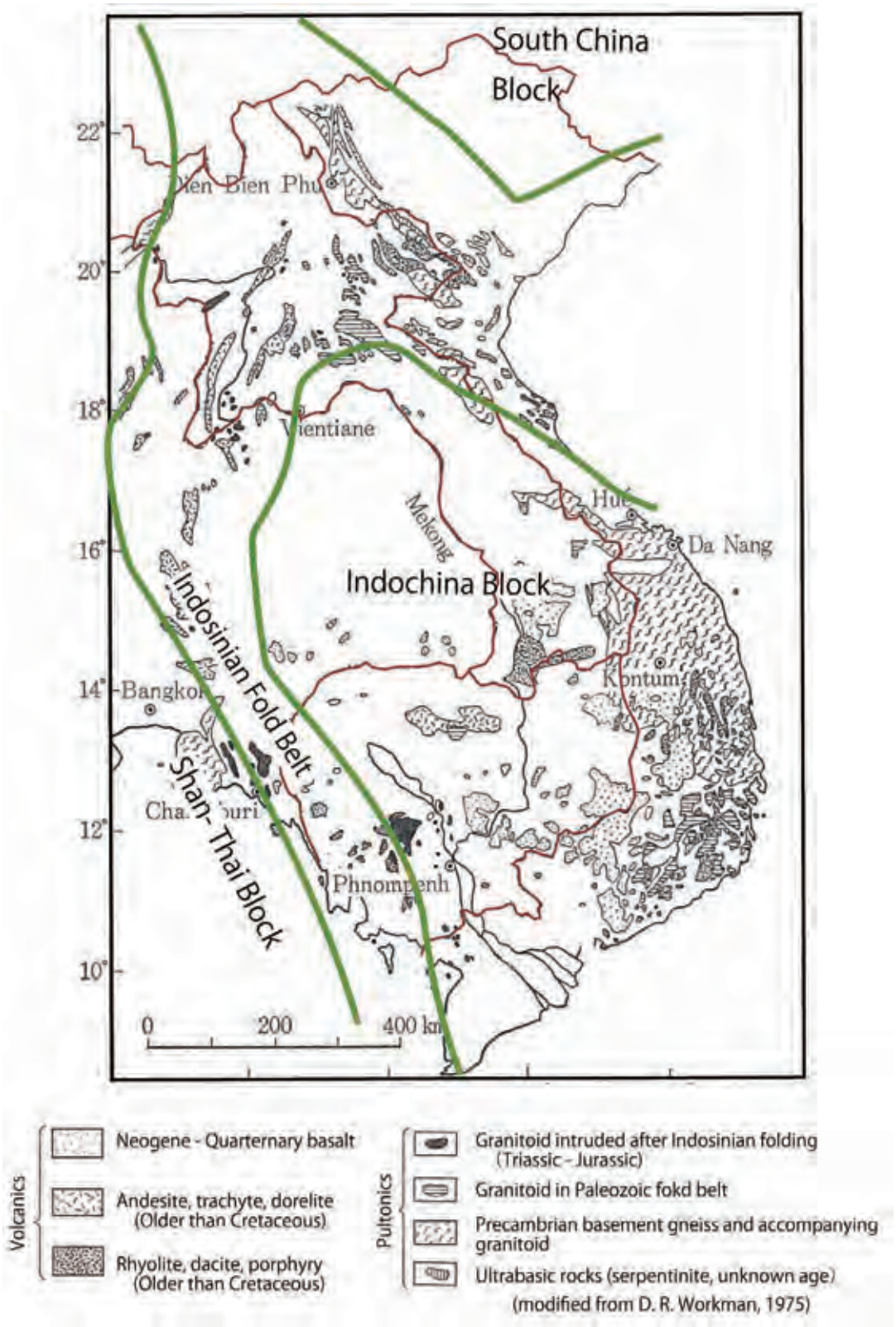


Fig.5.2.2 Tectonic Setting of the Indochina Peninsula

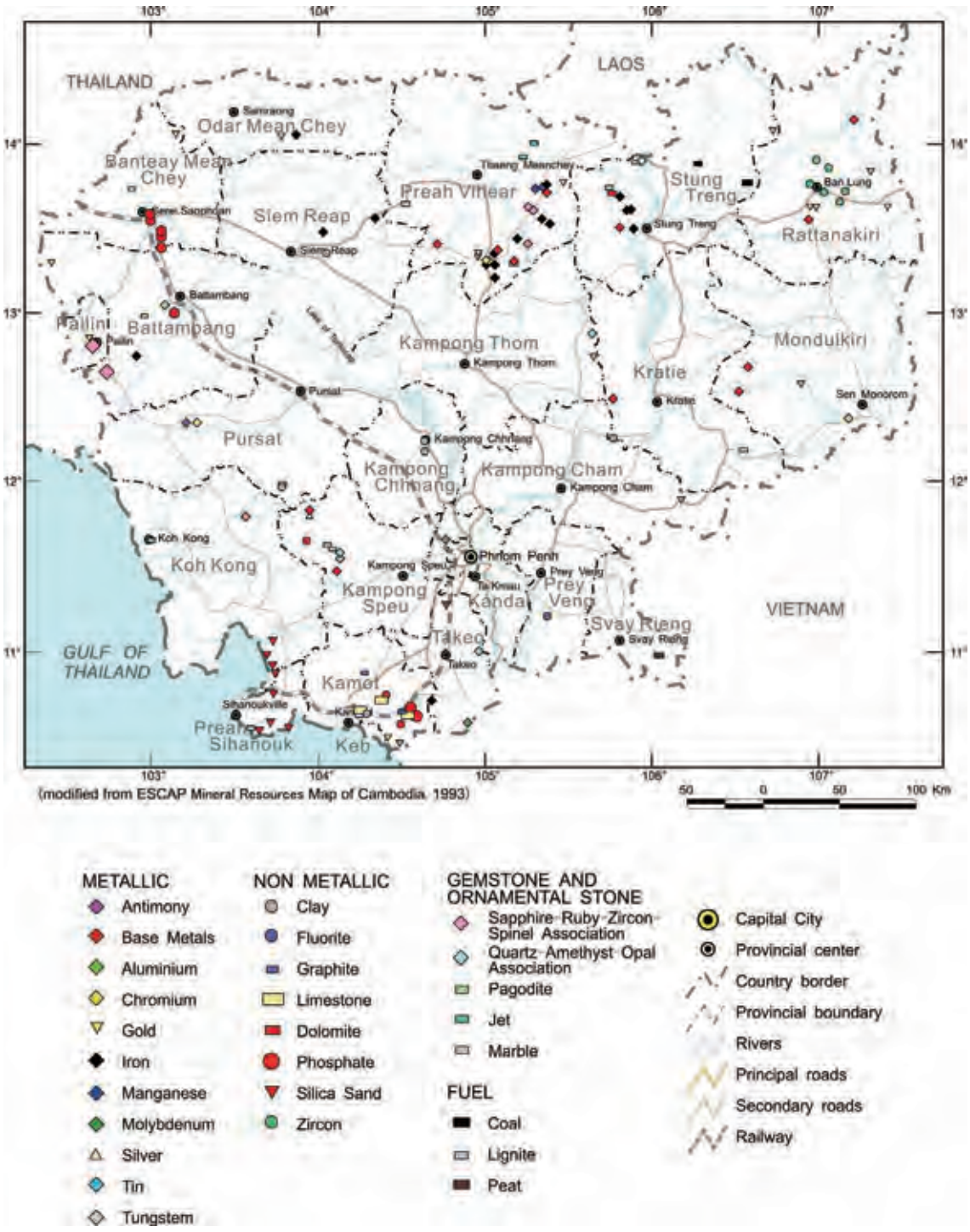


Fig.5.2.3 Mineral Deposits and Occurrences of Cambodia

5.3 Satellite Image Analysis

5.3.1 Utilized Data and Processing

Roughly 66% of Cambodia is covered by forest, and outcrops are limited. In addition, there are both rainy and dry seasons, and it is difficult to get satellite images of the whole country on relatively cloudless days. First, we examined existing satellite images and searched for the satellite images required for mineral classification and geological interpretations from distributing organizations such as ERSDAC and JAXA. Then we created a list of the satellite images of Cambodia that are currently available for use.

Existing data include ALOS, LANDSAT and SOPT images owned by JICA, which are summarized in Table 5.3.1. These data do not cover the entire country, and the low number of bands (one or four) is not adequate for classifying minerals. Therefore, for the present analysis we attempted to acquire ASTER images for nearly the entire country that were obtained on days of 20% or less cloud cover. Although plans had been made to use ALOS PALSAR data for the geological interpretations, very few of these images have been taken of Cambodia, so instead we acquired HH polarized regional radar images.

In satellite image analysis related to mineral resource exploration, spectral analysis is usually used to classify minerals. However, for a heavily vegetated area like Cambodia, it is probably too difficult to conduct a spectral analysis. Therefore, it is necessary to investigate methods for mineral exploration that can even be used for tropical rainforest, and verify their applicability to Cambodia.

Satellite image analysis requires the use of specialized software. In order to promote the transfer of satellite image analysis technology to counterparts at the DoG, a technical software training seminar was held. The counterparts practiced with actual data that they had compiled for ASTER and ALOS PALSAR until they were able to handle satellite image data. .

Table 5.3.1 Overview of Existing Satellite Images Provided by JICA

Sensor name	No. of scenes	Product	No. of bands	Processing level	Resolution (m)	Notes
ALOS AVNIR	31	VNIR	4	1B2	10	GeoTIFF
ALOS AVNIR	13	VNIR	4	1B2	20	GeoTIFF
ALOS PRISM	15	DEM	-	1B2	2.5	GeoTIFF
SPOT5	15	SPOT	-	-	2.5	GeoTIFF

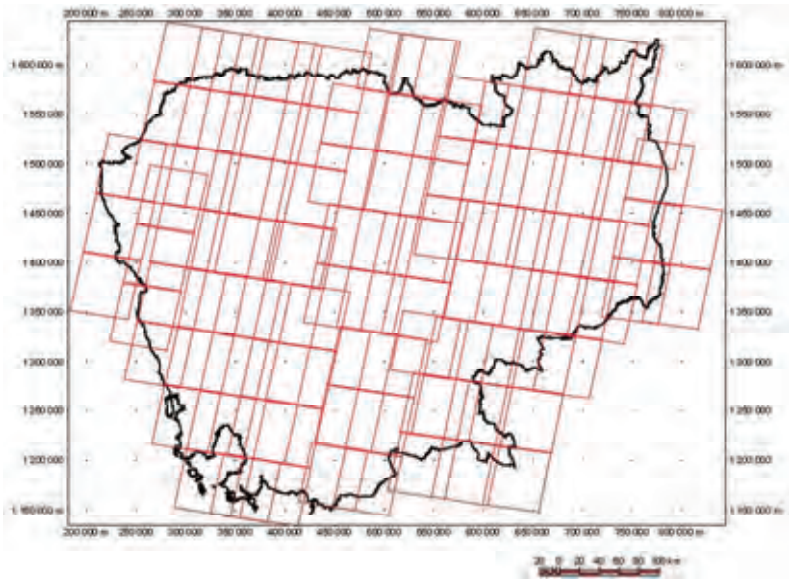
An overview of the newly purchased satellite images (utilized data) is shown in Table 5.3.2. Index maps of ASTER and PALSAR images are shown in Fig.5.3.1. Scenes from ASTER109 and PALSAR28 were purchased and subjected to mosaic processing. Details of these data are given in Appendix V-2 and V-3.

ASTER false color images, DEM shaded relief maps, and PALSAR radar images are shown in Figs.5.3.2, 5.3.3 and 5.3.4, respectively.

Table 5.3.2 Overview of Satellite Images Purchased by This Project

Sensor name	No. of scenes	Product	No. of bands	Processing level	Resolution (m)	Notes
ASTER	109	VNIR,SWIR,TIR	14	3A01	15,30,90	EOS Advanced Spaceborne Thermal Emission and Reflection Radiometer format
ASTER	109	DEM	-	3A01	15	EOS Advanced Spaceborne Thermal Emission and Reflection Radiometer format
ALOS PALSAR	8	HH	1	1.5	5～50	Radarsat CEOS radar format
ALOS PALSAR	20	HH & HV	2	1.5	5～50	Radarsat CEOS radar format

a)



b)

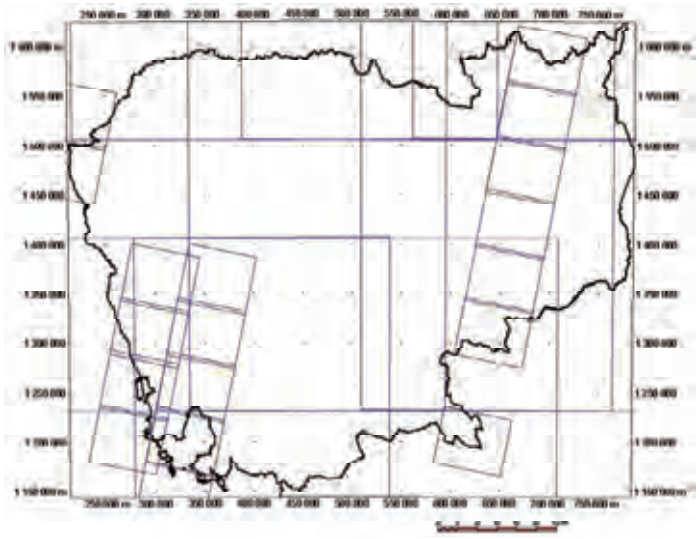


Fig.5.3.1 Index Maps of Satellite Images
a) ASTER images, b) PALSAR images

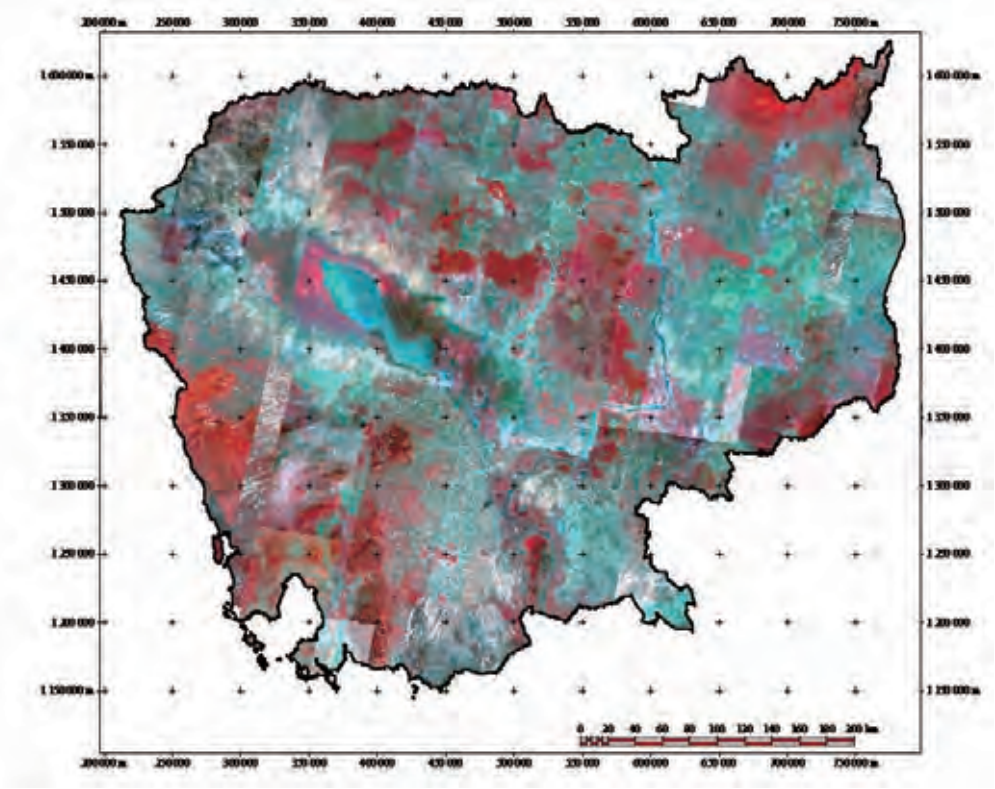


Fig.5.3.2 ASTER False Color Images (RGB=VNIR3,2,1)

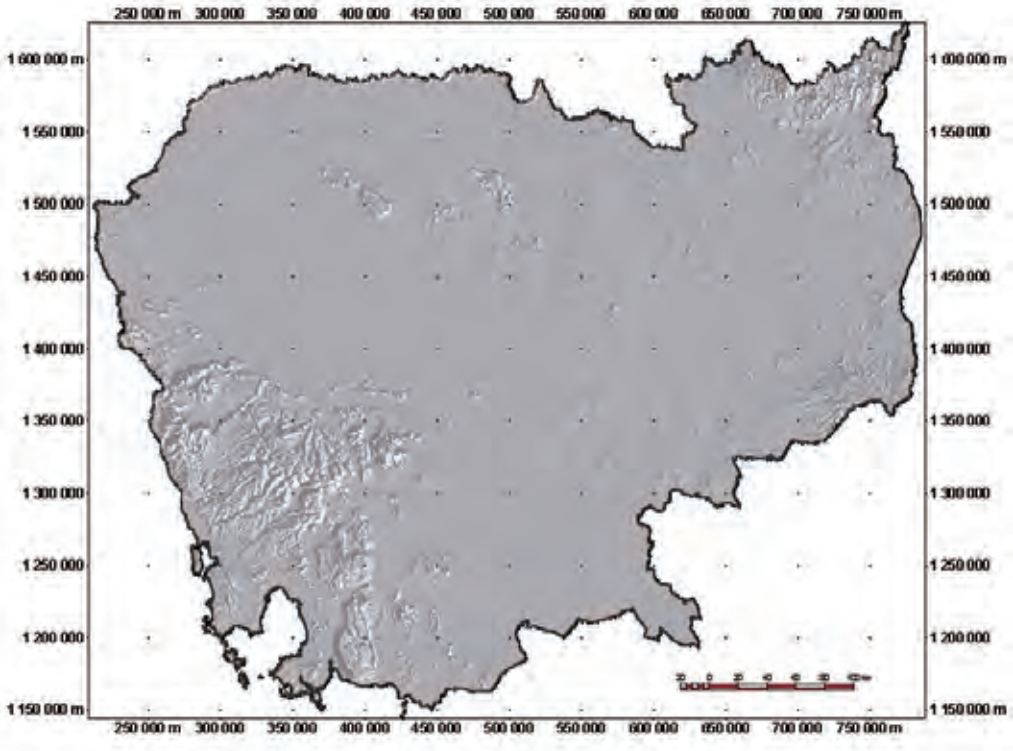


Fig.5.3.3 DEM Images Based on ASTER (grid size: 30m)

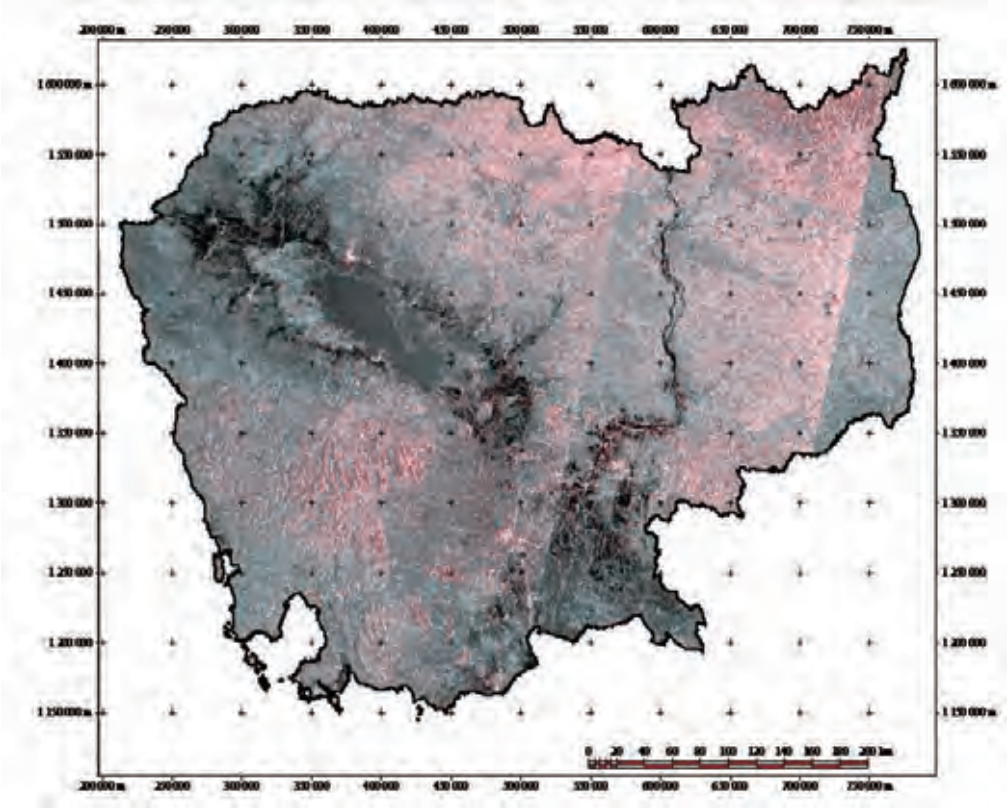


Fig.5.3.4 PALSAR Radar Image (HH polarization)

5.3.2 Image Analysis

When conducting analyses of tropical rainforest areas, vegetation and cloud cover can pose a problem. In addition, geological data indicate that deposits in Cambodia have often been formed by alteration processes that accompany rock intrusion. Therefore, we attempted to identify promising areas by analyzing the distribution of igneous, intrusive, and other types of rock from images.

First, in order to investigate deposits and tropical rainforest vegetation from satellite images, we selected the Sepon Mine in neighboring Laos as a training site, and analyzed images from the vicinity of the mine. The information that was obtained therefrom was applied to satellite image analysis of Cambodia.

(1) Method for identifying promising areas

An overview of the method for identifying promising areas is shown in Fig.5.3.5. The satellite image data utilized here were all 14 bands of ASTER L3A products and DEM data. There were also ALOS PALSAR regional radar images and HH and HV polarized radar images. The analysis was conducted in the following order:

1) Confirm the state of vegetation
2) In areas around deposits that were not heavily vegetated, promising areas were identified from spectral analysis using all ASTER bands.
3) In areas around deposits that were heavily vegetated, promising areas were narrowed down using a combination of ASTER TIR band analysis, topographical characteristic

analysis, and geological interpretations of radar images.

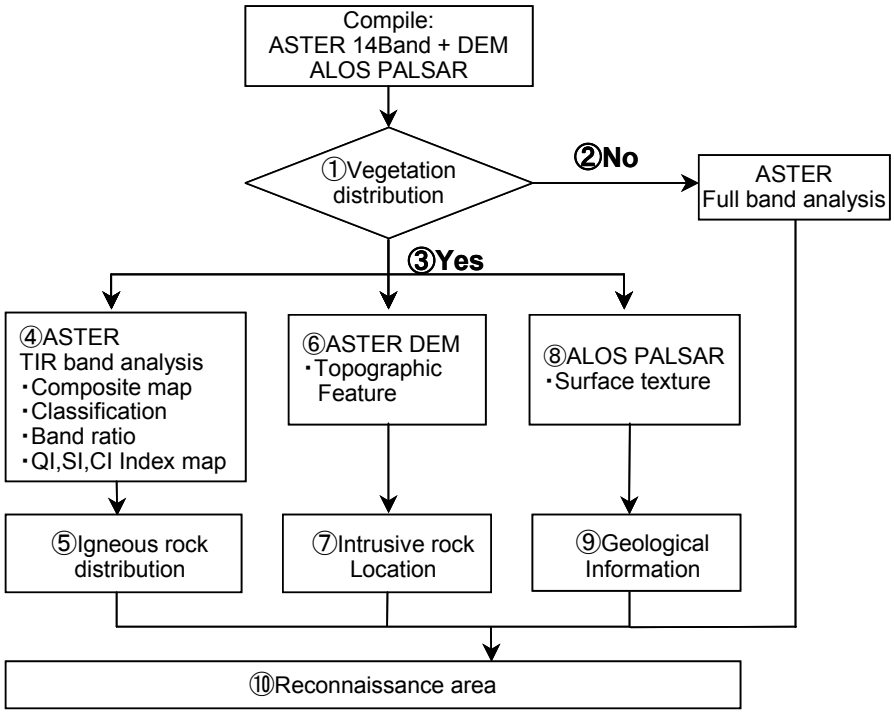


Fig.5.3.5 Flow Chart of the Method for Identifying Promising Areas

4) & 5) The distribution of igneous rocks was determined from composite images made using TIR band data, automatic class separation, and Ninomiya et al's (2002) Quartz Index (QI), Carbonate Index (CI), and SiO_2 content Index (SI).

6) & 7) Topographical characteristics were quantified and analyzed using DEM data to determine the locations of intrusive rock.

8) & 9) Textural changes in radar images were used as materials for geological interpretation.

10) Promising areas were identified using the results of 4) to 9).

(2) Verification of the area around the Sepon Mine in Laos

Fig.5.3.6 shows the location of the Sepon Mine in Laos. Gold and copper deposits were formed at this mine by intrusive rock (copper reserves of 14.8 million tons with 4.9% Cu, and gold reserves of 3.9 million tons with 1.6 g/t Au). In the ASTER color composite images in Figure 5.3.6 (RGB=3,4,5), we can see that there is much vegetation cover, which is shown in red, around the mine. Therefore, starting with Step 3) in (1) above, an analysis was made of the Sepon Mine.

(Source: Oxiana's HP)

Fig.5.3.6 Location of the Sepon Mine, Laos

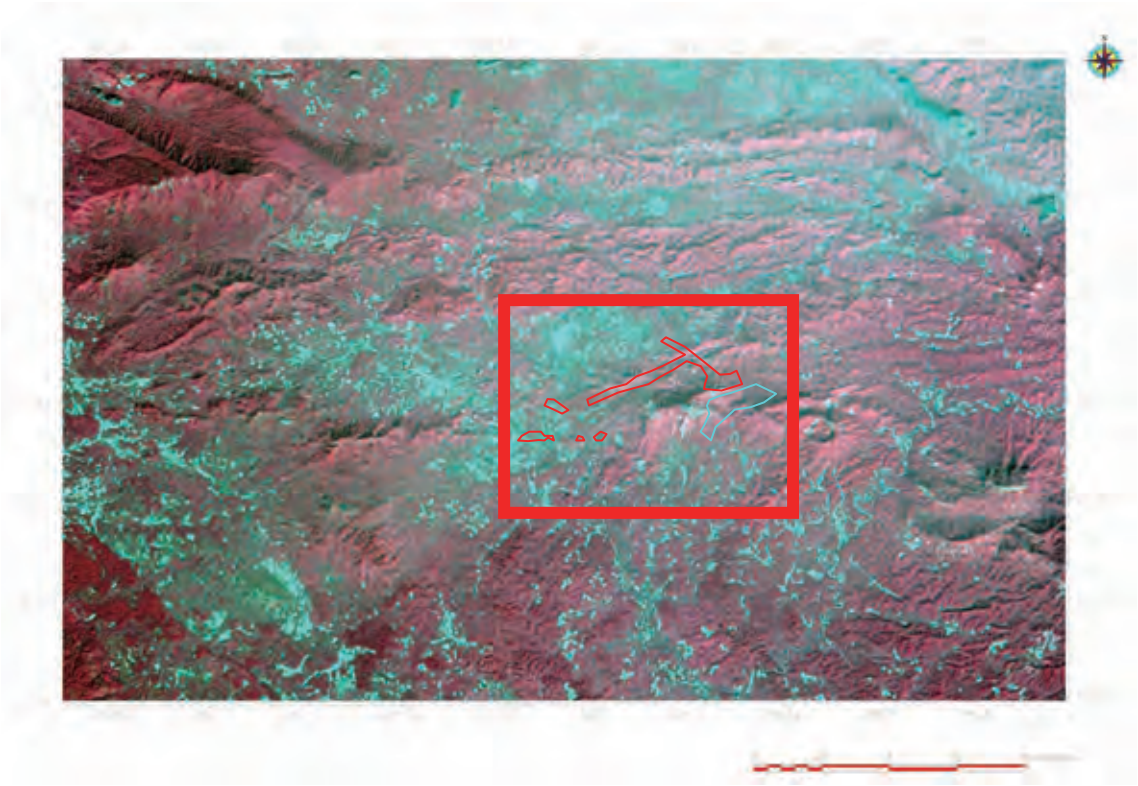


Fig.5.3.7 ASTER Color Composite Image (RGB=VNIR3,4,5)
of the Area around the Sepon Mine (outlined in red)

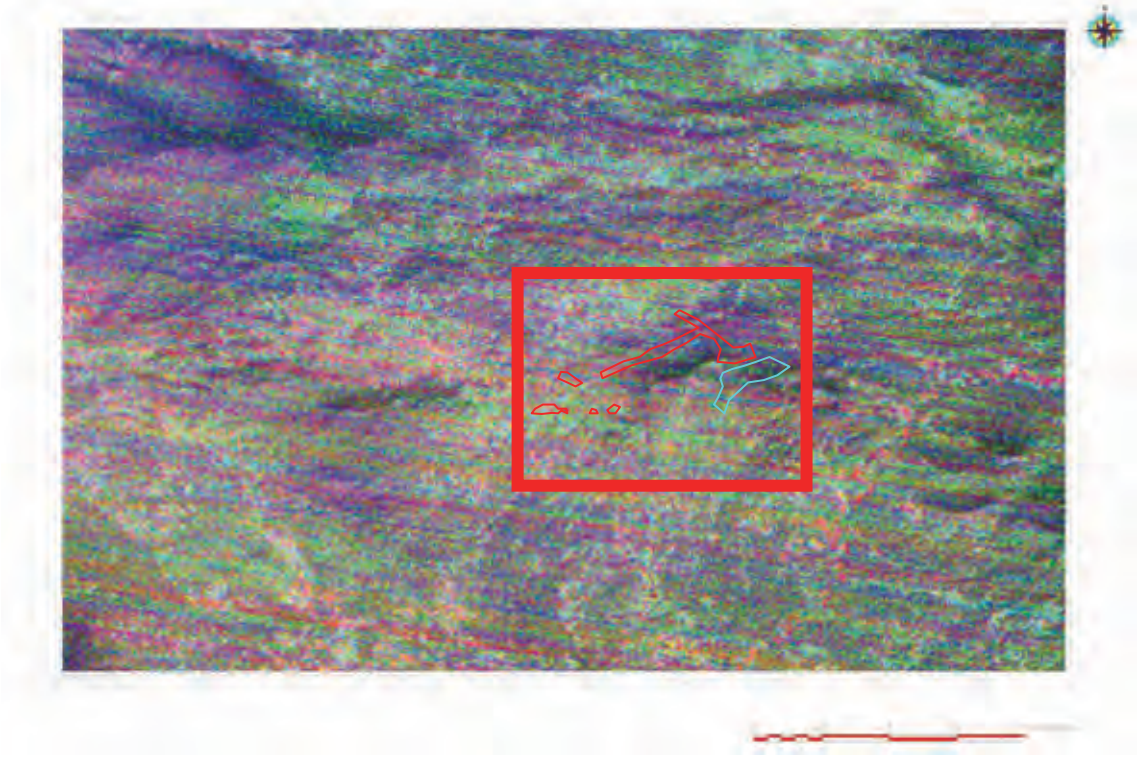


Fig.5.3.8 Non-correlated Stretch Image Using ASTER TIR Bands 10, 11 and 12 (RGB=TIR10,11,12). The Sepon Mine is outlined in red inside the red box.

Steps 4) & 5): Fig.5.3.8 shows a non-correlated stretch image made using ASTER TIR bands 10, 11 and 12. The sections shown in simple red in the false color image are expressed with multiple colors here, so the analysis was carried out using the TIR bands.

In the automatic classification results (Fig.5.3.9) of 20 classes using all 14 ASTER bands, the area around the Sepon Mine (outlined in red in the figure) was classified into several types of blocks. The sections shown in bluish yellow correspond to intrusive rock, and the vicinity was classified as Yellow-Brown 17. The areas around the gold deposits (thin red lines) were classified as Purple 14, Light Blue 3, and Dark Blue 20.

The composite map (RGB=QI,CI,S I－0,3) incorporating Ninomiya et al's (2002) indexes (QI,CI,SI) that was made to determine the distribution of igneous rocks is shown in Fig.5.3.10. The SI Index for expressing silicate rocks (igneous rocks) becomes bluer as the index value increases, while the QI index for expressing silicified rocks becomes redder as the index value increases. We can see that the two colors meet to become blue to purple in areas around the intrusive rocks.

Steps 6) & 7): Fig.5.3.11 shows a shaded relief map (light source coming from NE) of the Sepon Mine vicinity that was made using ASTER DEM (elevation data). There are intrusive rocks that are centered around the mine, and north of that an ENE-WSW-oriented lineament can be confirmed. The gold deposit occurs along the lineament, while the copper deposit occurs on the south-facing slope of the intrusive rock body.

Fig.5.3.12 shows the slope angle in the topographic features expressed by colors (Blue 0° ～ Red 90°). Near topographical transition points such as intrusive rock and lineament structures, slopes become steep, and their topographical patterns are shown with "warm" colors. We can see that gold deposits are distributed along the length of the lineament.

Step 8): This step was omitted because we were not able to obtain ALOS PALSAR radar images.

Step 9): We referred to existing geological maps and reports put out by Oxiana Company.

Step 10): Analyses were conducted of the categories using ASTER TIR band data and DEM data.

The results were as follows:

a) We were able to learn much about the distribution of igneous rock using the composite map compiled with all three indexes (QI, CI, SI).

b) We could interpret areas of igneous rock based on topographic features of DEM.

Analyses in a) and b) led to the identification of intrusive rock. Areas where the SI index was high were selected as candidates for promising areas.

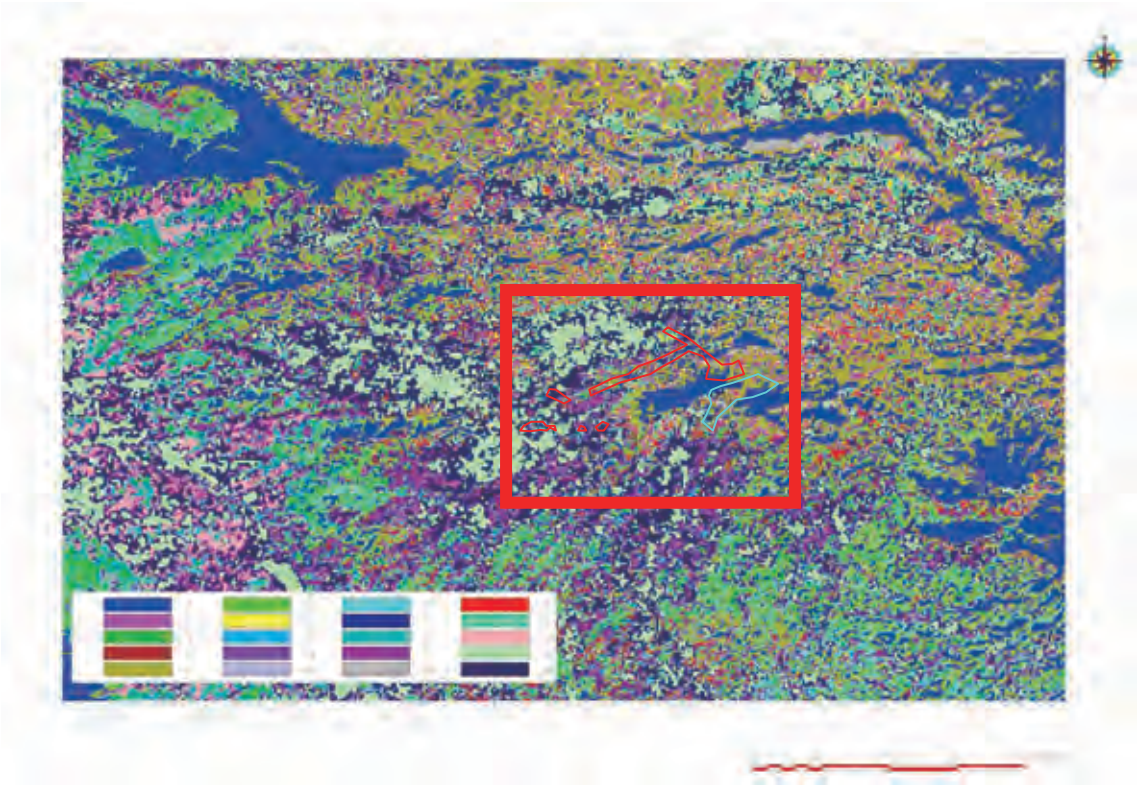


Fig.5.3.9 Results of Automatic Classification Analysis using ASTER 14-Band Data.

The Sepon Mine is outlined in red inside the red box.

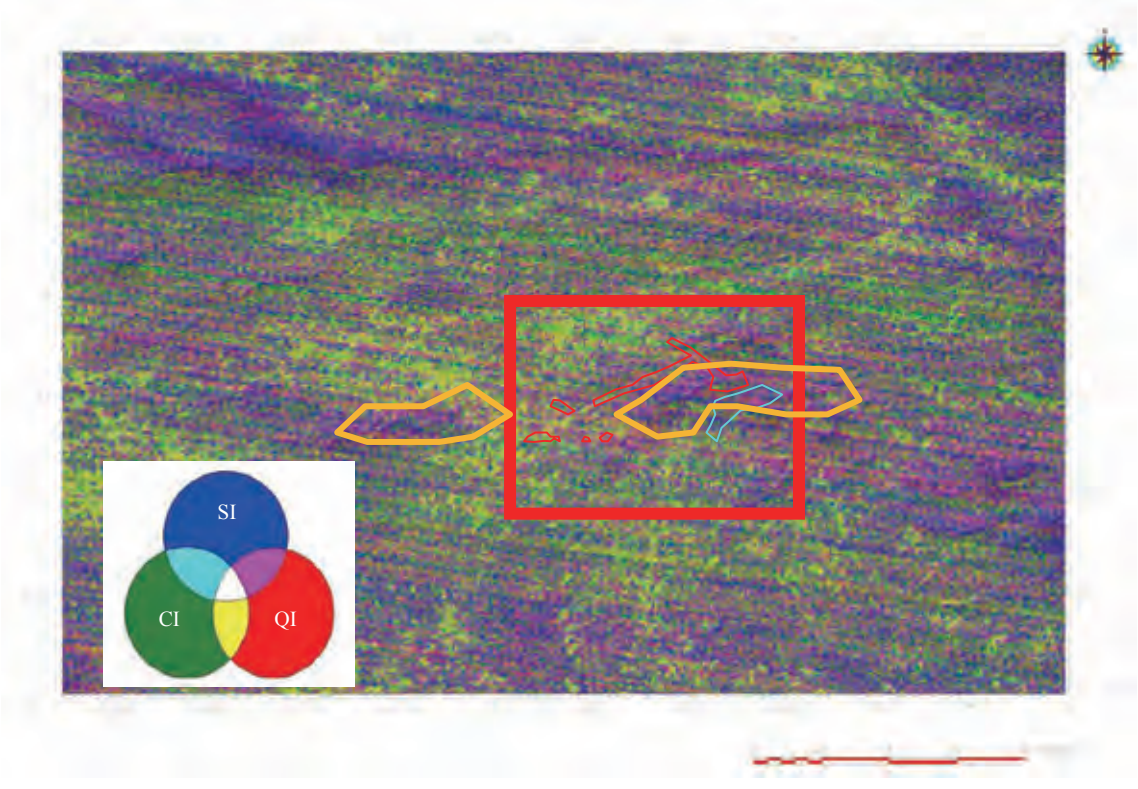


Fig.5.3.10 Composite Image made of the QI,CI, & SI Indexes (R:QI, G:CI, B:$SI^{-}_{0,3}$).

The Sepon Mine is outlined in red; areas outlined in orange show high potential for igneous rocks

Fig.5.3.11 Shaded Relief Map of the Vicinity of the Sepon Mine (outlined in red)

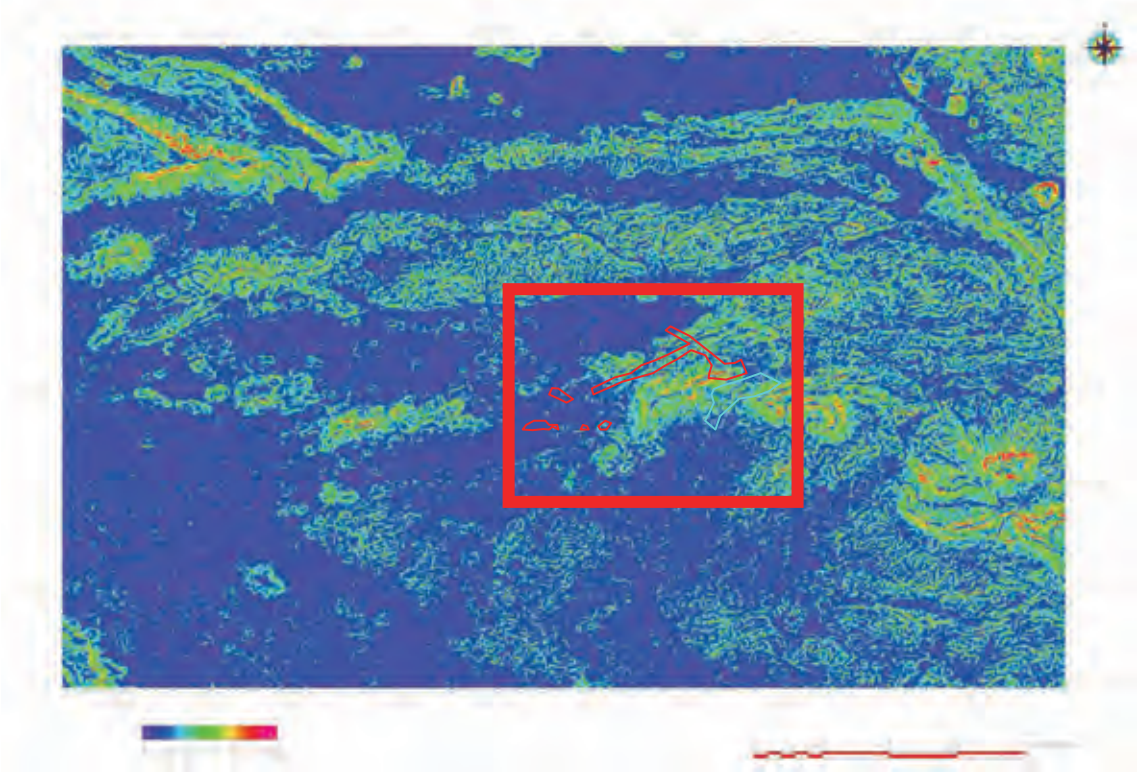


Fig.5.3.12 Results of Topographic Feature (Slope Angle) Analysis
"Warm" colors show steep slopes

(3) Objectives of satellite image analysis

Deposit types that were subjected to image analysis: Igneous rock and surrounding metamorphic belt. The area that has been subjected to metamorphic processes in conjunction with intrusive rock, such as at the Sepon Mine, was the target of the analysis. This type of deposit is characterized by mineralization belts centered on igneous (intrusive) rock that spread out in concentric circles.

Objectives of analysis: Conditions such as frequent cloud cover and lush vegetation exist, making it difficult to classify clay minerals with VNIR and/or SWIR bands, which are used for dry or exposed areas. Therefore, a combination of several analytical methods, including rock facies indices (QI, CI, SI indices) based on TIR bands, topographic feature analysis based on DEM, etc., are integrated with the results of intrusive rock evaluations to identify promising areas.

Following the procedure in (1), 109 ASTER images, and 28 ALOS PALSAR images were prepared.

While there is some bias in Cambodian vegetation depending on the region, in the VNIR image in Fig.5.3.2, Band 3, which included vegetation data, shows vegetation in red, and we can conclude that it is concentrated around hilly areas. In addition, because existing materials indicate that there are many mineral occurrences in hilly regions, it was decided to identify promising areas according to the analytical procedure based on TIR band data that was applied to the Sepon Mine. ASTER analyzed images consisted of composite images, band ratio images, and SI index images of the VNIR, SWIR, and TIR bands. We also carried out the topographic feature analysis based on DEM data. However, because there were few PALSAR images available, it was decided to use them for making supplementary geological readings.

In order to verify the conditions in regions that were determined to have vegetational cover based on the satellite images, visual observations were made of the land surface in the hilly area around the Pousat area. Fig.5.3.13 shows ASTER false color images (RGB=321) of the visually observed area. The photograph was taken north of the point denoted by the circle, and the mountain peak in the background is the mountain shown by the arrow in the image. In the ASTER image, we can see that there is little vegetation in the area around the peak (green thread), while the vegetated (red) areas spread out from the hillsides.

Therefore, the visual observations indicate that there are many trees 10m or taller, so it was determined that it would be difficult to classify minerals based on visible light bands in such areas.

Regarding the igneous rock, ASTER images were integrated with an existing geological map to create the distribution map shown in Fig.5.3.14. Color was added to the map to show igneous rock types.

From the images, we can see that there are numerous occurrences of igneous rock in areas shown as having convex terrain in the DEM images, while other areas are largely dominated by sandstone. In the DEM images, even places that are covered by Quaternary layers can be interpreted as having topography indicative of intrusive rock, so it is possible that

igneous rock types exist even in places where the ground surface cannot be confirmed.

The topographic feature analysis based on the DEM data makes it possible to interpret intrusive rock, as shown in Fig.5.3.15, and it is possible to obtain information even on geological boundaries that cannot be interpreted with existing geological maps. This feature can be particularly utilized for classifying sedimentary layers of the Quaternary.

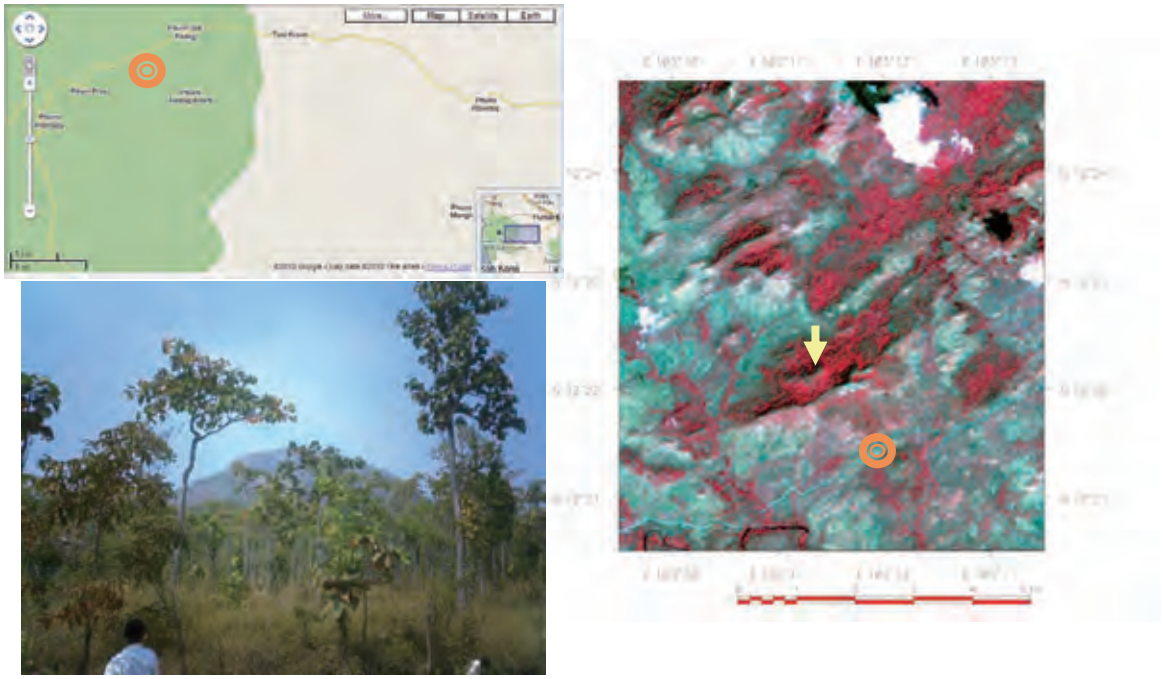


Fig.5.3.13 Visual observation point (upper left), photographic view of the area (lower left) and ASTER composite image (RGB=321)

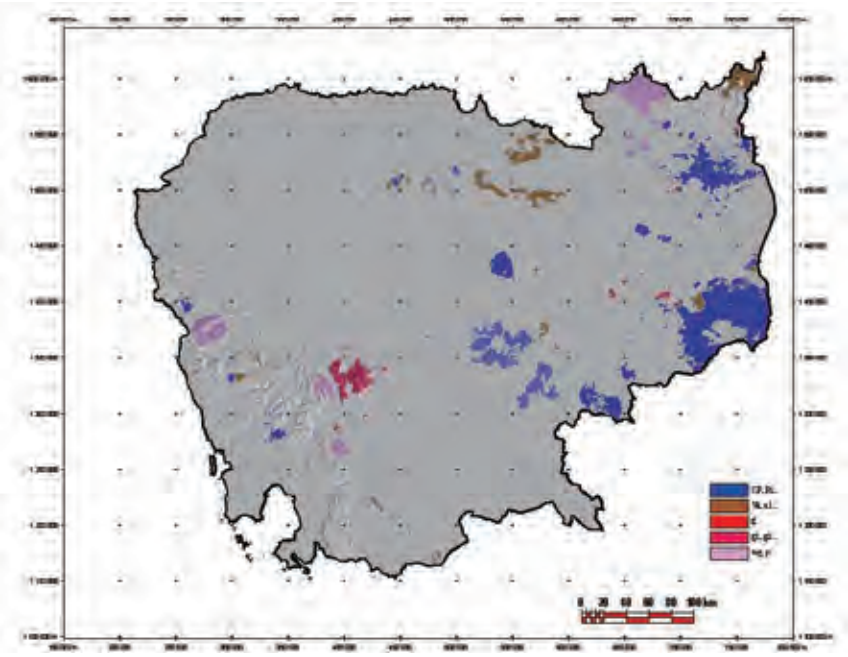


Fig.5.3.14 Distribution of Igneous Rocks

(This image shows igneous rock distribution juxtaposed on a DEM image.)

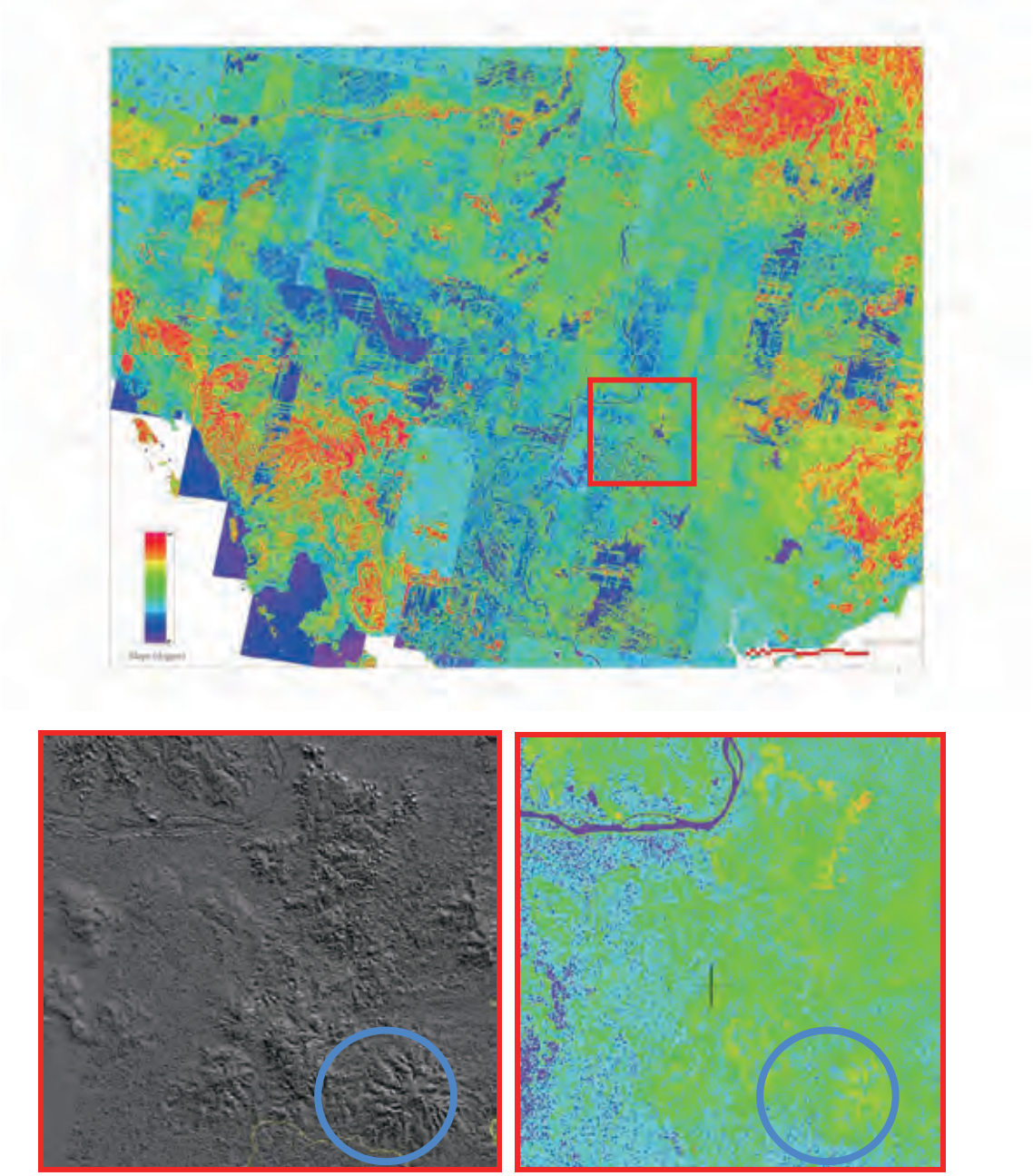


Fig.5.3.15 Results of Topographic Feature (slope angle) Analysis (top)
Corresponding to the area in the red box in the upper figure are DEM data (lower left), and topographic features (lower right)

5.3.3 Results of Satellite Image Analyses of Cambodia

In order to corroborate the results of the satellite image analysis, surface geological mapping was conducted concurrently with a geological survey. The details of the survey periods are given in 5.5 of Chapter 5. The geological mapping area did not include areas that were inaccessible by motor vehicle or areas for which concessions had already been established. With the standard being areas around mineral occurrences and places with distributions of igneous

rocks, 10 areas were selected. These 10 areas are denoted by the green boxes in Fig.5.3.16.

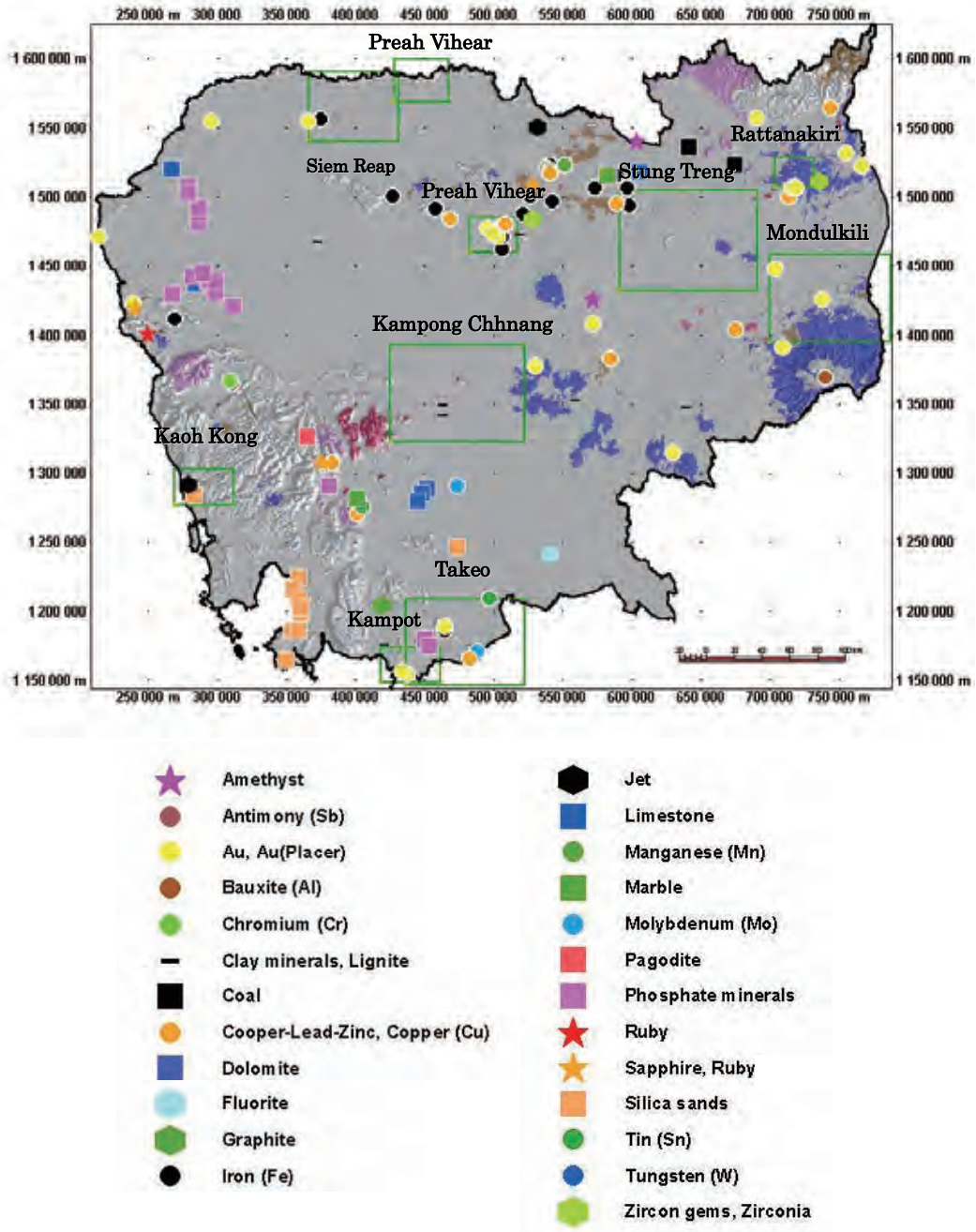


Fig.5.3.16 Mapping Areas (green boxes)

(The areas were selected by adding conditions such as infrastructure, concessions, etc., to a base of topographic feature analysis and igneous rock distribution.)

In these mapping areas, observations were made of surface geology, topography, vegetation, etc., and the results were used to interpret features appearing in the images. The actual mapping routes are shown in Fig.5.3.17. Travel was usually by car or boat. However, there were some zones that were accessed on foot because the roads were difficult for

automobiles to travel on.

In the ground truth, portable GPS (accuracy to within 10m) was used to save location information about routes and observation points, and a digital camera whose clock was synchronized with the GSP clock was used to record conditions on the ground. Afterward, these recorded times were used to match up photographs with the places where they were taken.

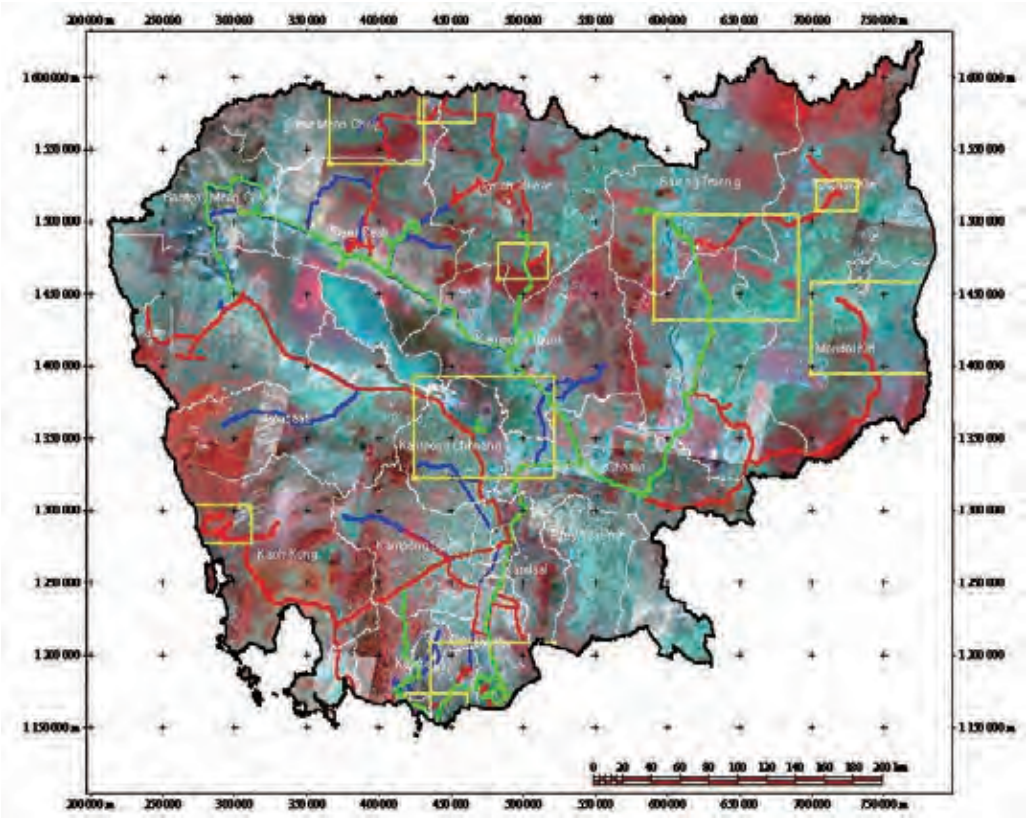


Fig.5.3.17 Route Map for the Ground Truth Survey
(The red, blue and green lines show survey routes.)

Here, we will examine results of interpretations of three (3) areas: Stung Treng, Takeo, and Kampong Chhnang.

(1) Stung Treng Area

The Stung Treng area is located in northeast Cambodia. The mapping study area here was bounded on the west by the Mekong River, while an expansive sandstone area spread out on the eastern side. Fig.5.3.18 shows a map, and the area of the ground truth (red box).

In addition, Fig.5.3.19 shows an image which confirms the vegetation in this region. In the RGB image, the vegetational index NDVI was assigned to R, so the areas that appear Red are those containing a lot of vegetation. In the photograph of the site shown in Fig.5.3.20, the vegetation in low areas along roadways appears to be undergrowth, but this turns into jungle in the hills and uplands. It corresponds well with the vegetational index image.

The igneous rock in this area occurs from the center toward the east. In the figure (Fig.5.3.21) synthesized with the results of automatic classification of the TIR band,

classification results identical with the igneous rock distribution were obtained for an area extending in a NW direction. To verify this, an image of an intrusive rock index (Fig.5.3.22) was created.

In the ASTER TIR band, the Quartz Index (QI), Carbonate Index (CI) and SiO_2 content Index (SI) derived from ratioing are generally shown as follows:

QI = (B11×B11)/(B10×B12)

CI = B13/B14

SI ＝ B12/B13

Fig.5.3.22 is a composite of these indices.

By making a comparison with existing images of locations of igneous rock occurrence, we can see that the analytical results indicate what looks to be intrusive rock extending in a NW direction (the yellow broken line box in the image). In the present ground truth, it was not possible to physically enter this area, but by examining combinations with the results of the geological survey, it is possible to obtain new information.

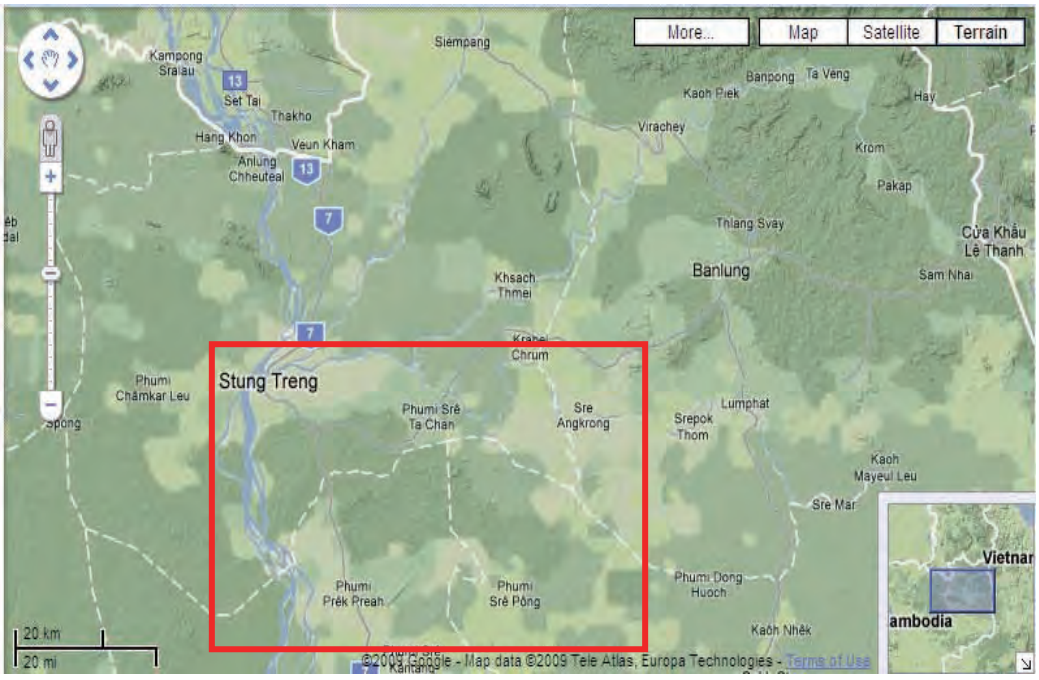


Fig.5.3.18 Location of the Stung Treng Area (red box)

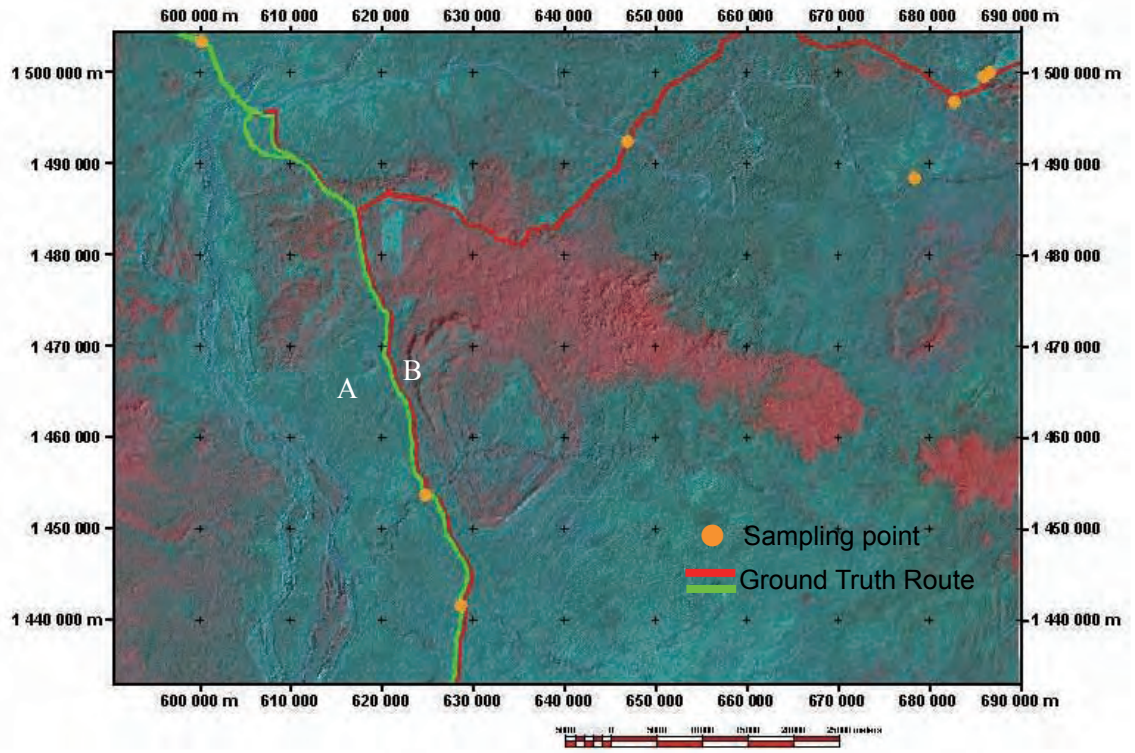


Fig.5.3.19 Vegetational Index Image (RGB= Band NDVI 4 6)

(The vegetational index NDVI shows (B3-B2)/(B3+B2). Points A and B show sites where photographs were taken.)

Fig.5.3.20 Photographs of the Stung Treng Area

(The left photograph was taken at Point A in Fig.5.3.19, while the right photograph was taken at Point B.)

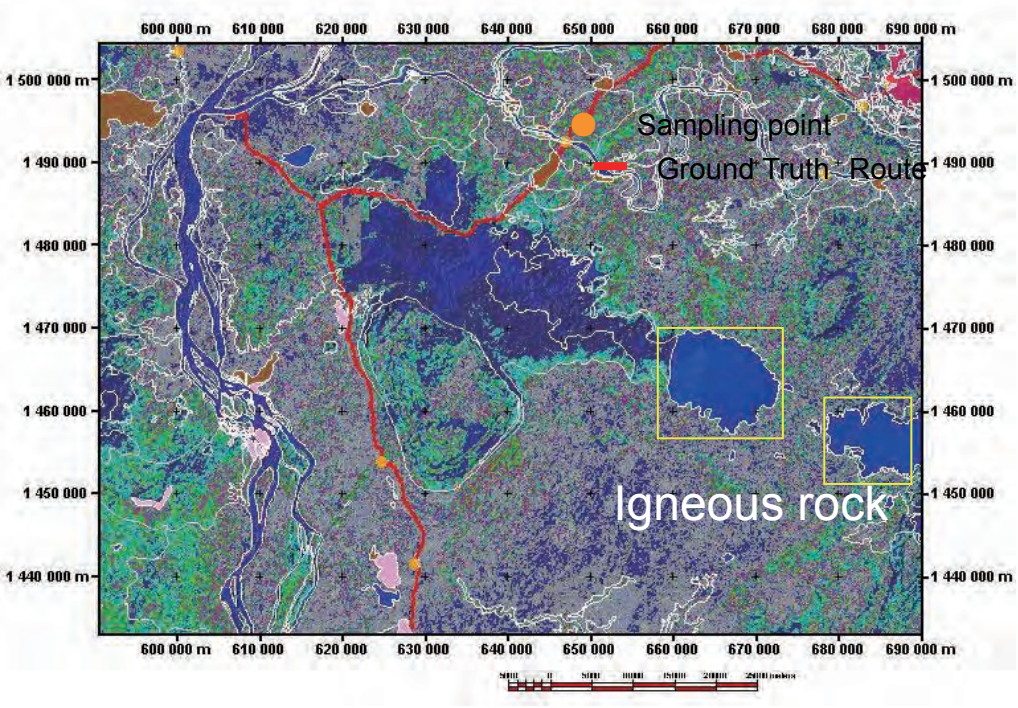


Fig.5.3.21 Automatic Classification Map made with ASTER TIR Bands

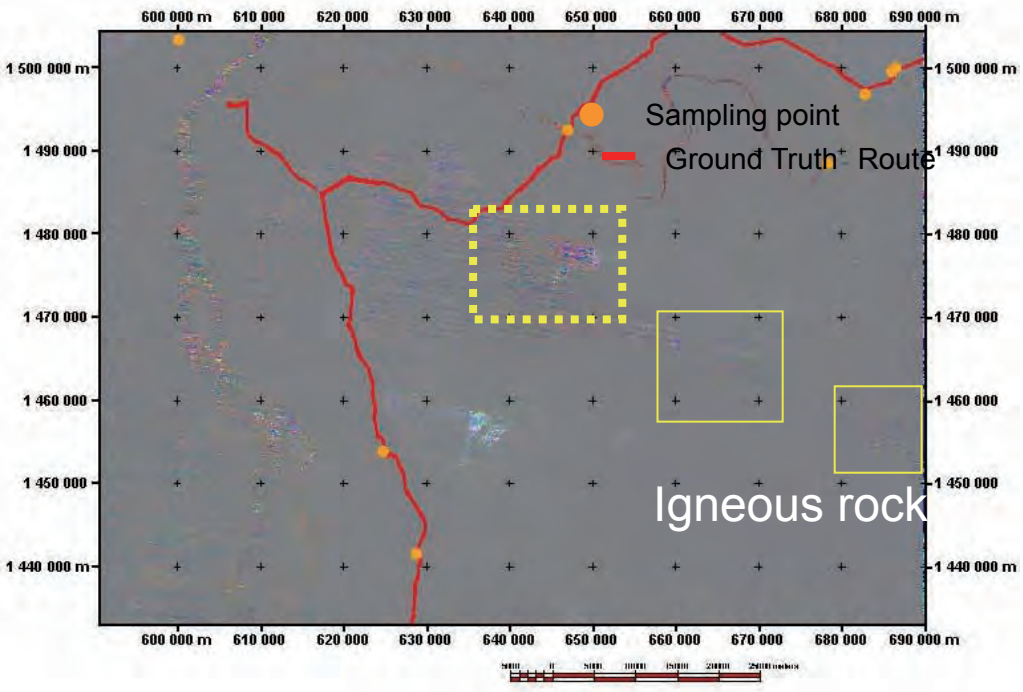


Fig.5.3.22 Igneous Rock Index Map (RGB = QI,CI,SI)

QI : quartz index, CI : carbonate inde, SI : SiO_2 content index

(2) Takeo Area

Fig.5.3.23 shows a map of the Takeo area and ground truth area (red box). This area is in southern Cambodia, near the border with Vietnam. Near the central part of the image, intrusive rock bodies align in a NW-SE direction. The lowlands of the mapping area are mainly an expansive pastoral zone, with residences and roads concentrated around these rock bodies. There are also scattered quarries in this rock body zone.

Fig.5.3.24 is an image that confirms the vegetation in this area. As in the previous section, the NDVI vegetation index in the RGB image was allocated to R, so the Red sections indicate areas where there is a lot of vegetation. The lowlands around the rock bodies are pastoral areas of sparse vegetation. In addition, as shown by the photograph of the site in Fig.5.3.25, there is little vegetation in areas where granite is exposed, and there is little red even in the vegetational index images.

We can also see from the image of the igneous rock that occurs in the central part of this area that there is little vegetation here. Therefore, for this area, SWIR band data were also used to conduct image analysis. Because rock containing much iron was seen at this site, an image was created using the oxidized iron index. The color allotted to the oxidized iron index B4/B3 in the image was Green.

Fig.5.3.26 is a composite image of the oxidized iron index and the existing igneous rock distribution. The area shown here corresponds to the section enclosed in the yellow box in Fig.5.3.24. The sections shown by the magenta polygons are the granite that is seen in the photograph in Fig.5.3.25.

Fig.5.3.23 Location of the Takeo Area (red box)

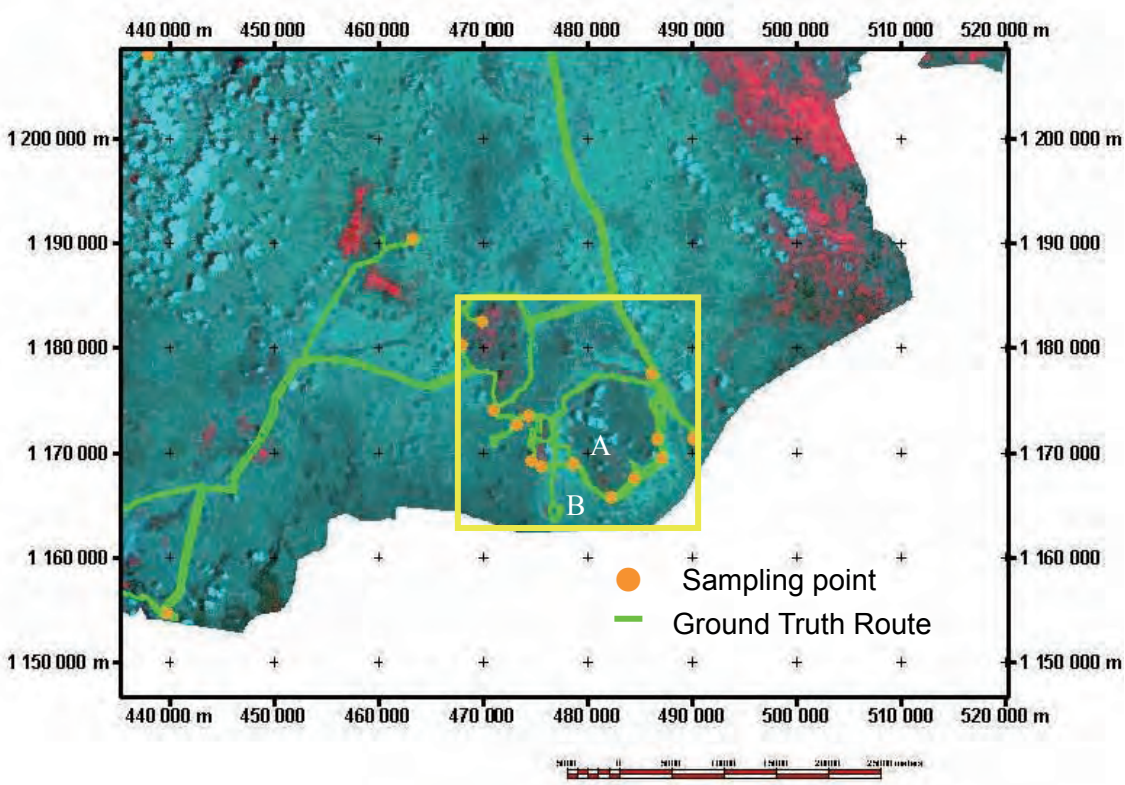


Fig.5.3.24 Vegetational Index Image (RGB= Band NDVI 4 6)

(The NDVI vegetational index is (B3-B2)/(B3+B2). Points A and B show sites where photographs were taken. The yellow boxes show areas of detailed analysis.)

Fig.5.3.25 Photographs of the Takeo Area

(The left photograph was taken at Point A in Fig.5.3.24, while the right photograph was taken at Point B.)

Fig.5.3.27 is a composite image of the oxidized iron index and DEM. The rock bodies in the NW part of the figure and contained in the red circle appear to be the same type of intrusive rock, but because the surface geology is different, the coloring is different: red lines are strong on the NW side, while green lines (oxidized iron) are strong inside the red circle. Because the rock samples collected at the sites contain much iron, we can say that these results are consistent with the results of the image analysis.

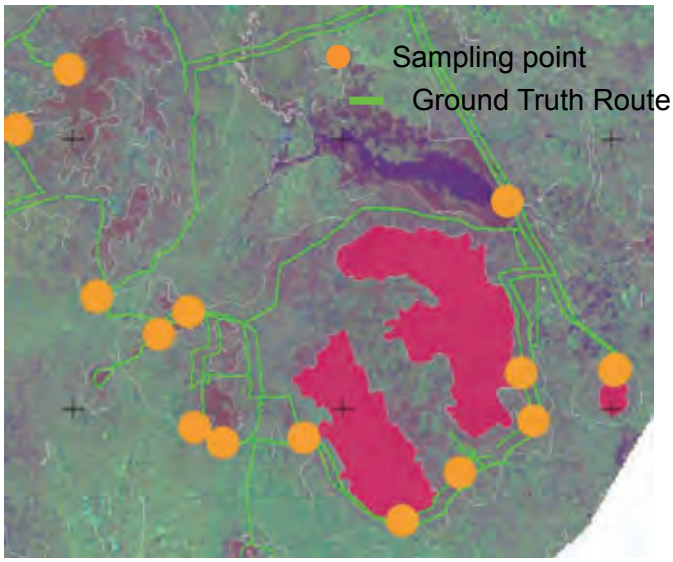


Fig.5.3.26 Composite Image of Igneous Rock Distribution (magenta polygons) and the Oxidized Iron Index (RGB = 4/7 4/3 2/1) in the Yellow Box shown in Fig.5.3.24.

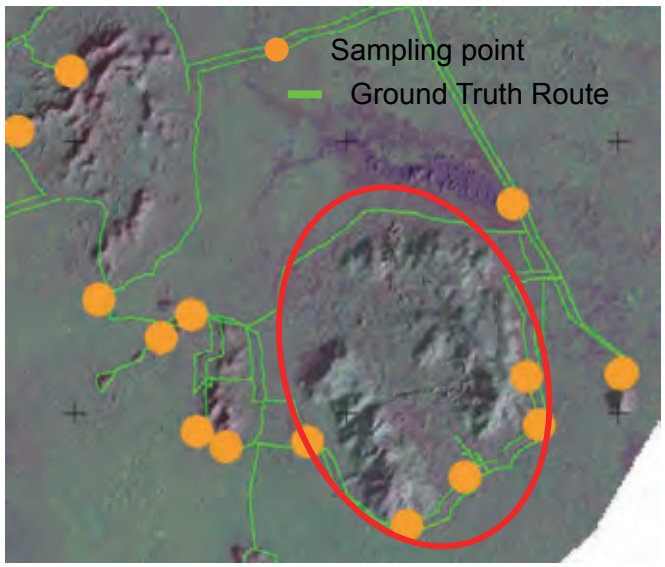


Fig.5.3.27 Composite Image of DEM and the Oxidized Iron Index (RGB = 4/7 4/3 2/1)

(3) Kampong Chhnang Area

Fig.5.3.28 shows a map of the Kampong Chhnang area and the ground truth area (red box). This area is in the central part of Cambodia, near the southeastern shore of Lake Tonle Sap. Igneous rock bodies occur in the central part of the image.

Fig.5.3.29 is an image that confirms the vegetation of the area. In this RGB image, the NDVI vegetation index was allocated to R, so the Red sections indicate areas where there is a lot of vegetation. Intrusive rock bodies are shaded red, indicating trees of a height of about 2m (Fig.5.3.30).

Fig.5.3.31 is a composite image of DEM and igneous rock distribution. The area shown here corresponds to the area in the yellow box in Fig.5.3.29. We can see that the convex sections of DEM in this area are igneous rock.

Fig.5.3.32 is a composite image of decorrelation stretch images of the TIR bands 13, 12, 10 and the geological boundaries. The decorrelation stretch image shaded within the red line corresponds well with the geological boundaries.

Because it was difficult to access this area, satellite images should be used in the interpretation work when the geological map is updated.

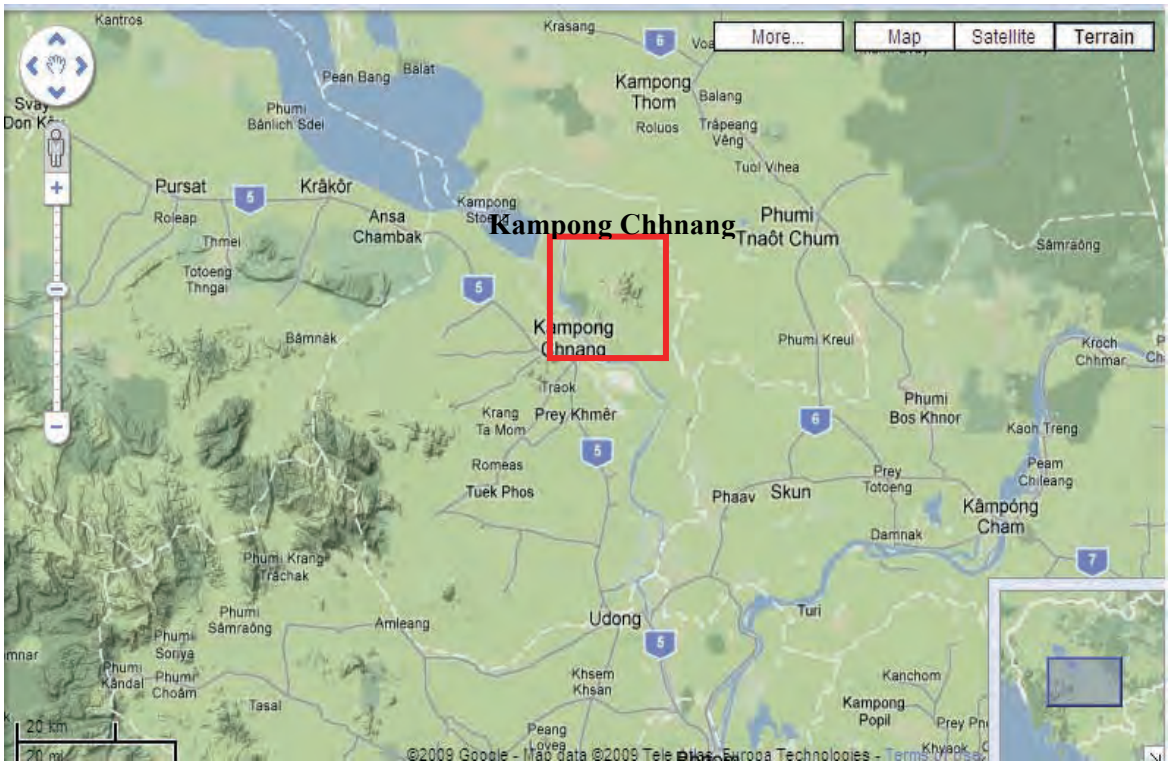


Fig.5.3.28 Location of the Kampong Chhnang Area (red box)

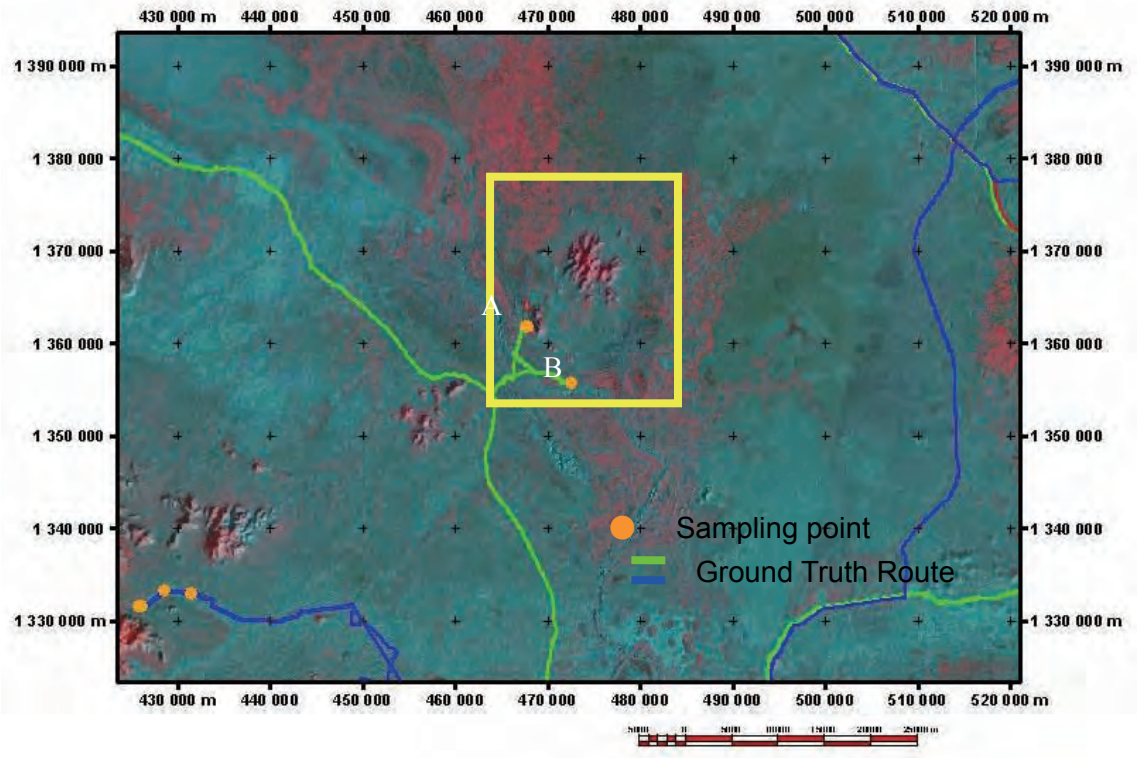


Fig.5.3.29 Vegetational Index Image (RGB= Band NDVI 4 6)

(The vegetational index NDVI shows (B3-B2)/(B3+B2). Points A and B show sites where photographs were taken. The yellow box shows the area covered by the detailed analysis.)

Fig.5.3.30 Photographs of the Kampong Chhnang Area

(The photo on the left was taken at Point A in Fig.5.3.29, while the photo on the right was taken at Point B.)

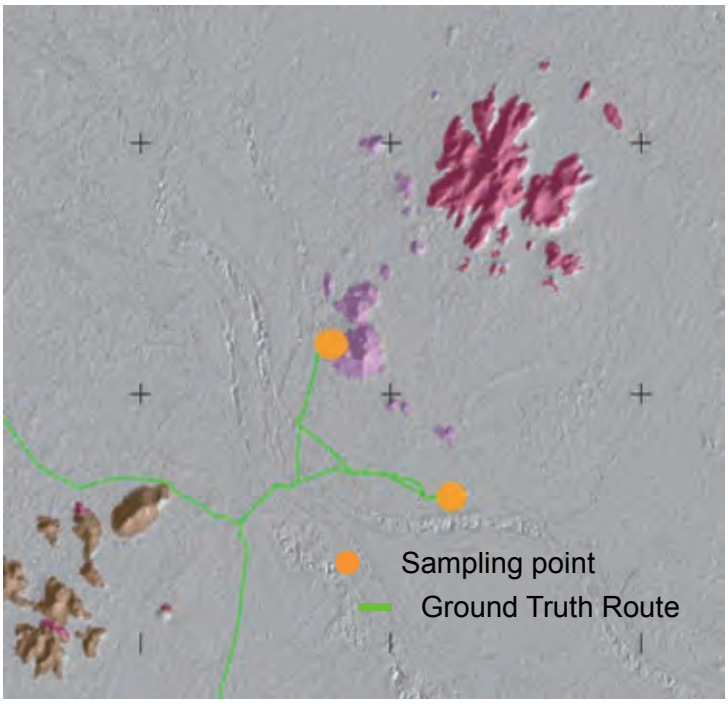


Fig.5.3.31 Composite Image of DEM Image and Igneous Rock Distribution

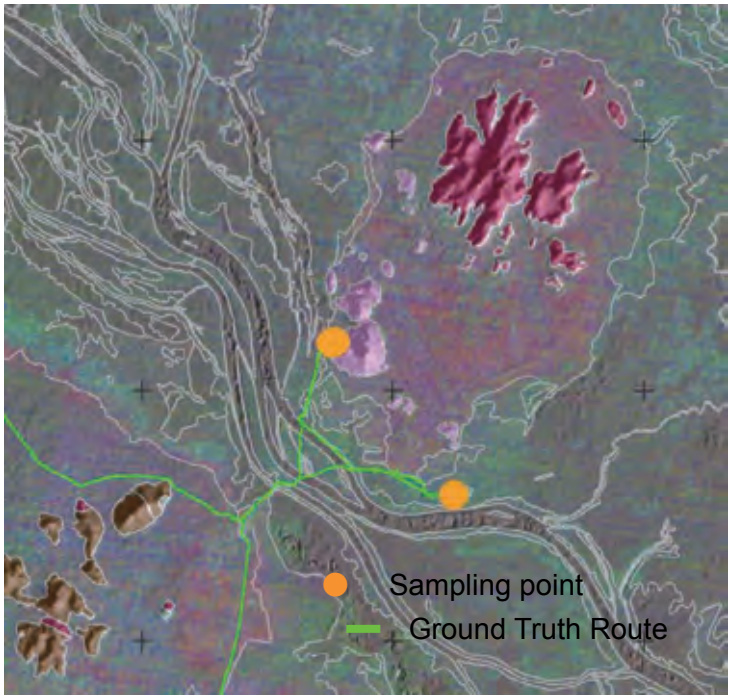


Fig.5.3.32 Decorrelation Stretch Image of TIR Bands 13, 12 and 10

5.3.4 Technology Transfer

We interviewed the Director of DoG and confirmed the equipment and human resources that could be used for image interpretation. During the survey period, there were two assigned counterparts who participated in a series of tasks related to satellite image processing, including satellite image processing, analysis, interpretation and ground truth, and subsequent tuning.

Although the staff had no knowledge of satellite image processing, they were creating geological maps as part of their work, so they were able to begin from classes about image analysis software. Although their equipment (PCs, etc.) was old, it appears at this point in time that it will not hamper analysis. However, there is a problem in that the hard disk drives used to store data have a very low capacity.

In order to proceed smoothly with satellite image processing, two technology transfer seminars were held in the DoG director's office, on 13-15 October, and 27 October, 2008. The courses provided explanations about basic processing of ASTER and ALOS images, and included training using image processing software (Appendix I-6).

5.4 Potential of Mineral Resources

Despite the insufficient amount of exploration, it is known that there are many mineral deposits and occurrences in Cambodia. They include antimony, chromium, iron, manganese, molybdenum, tungsten, aluminium, copper, lead, zinc, tin and gold as metallic minerals; limestone, sandstone, silica sand, phosphate and other rocks or sediments as industrial materials; and gemstones like ruby. The number of known metallic deposits and occurrences is 26 for iron and ferro-alloy metals, 15 for base metals, and 21 for gold. Artisanal miners have been mining those known deposits, particularly gold and gemstones, for many years.

Today, most deposits and occurrences have been covered with tenements (concessions) by private companies, and exploration projects are in progress. Private companies' exploration work is still mostly at the drilling survey stage or surface survey stage like geochemical survey or trenching, but some of these surveys have found ore bodies. Some examples are as follows.

- Trenching at the Phnom Khtong tenement of Southern Gold in Kratie province shows 32 meters in width at 2.4g/t or 4 meters in width at 15.8 g/t of gold.
  (Southern Gold Limited's website;
  http://www.southerngold.com.au/cambodia_projects.php)
- Trenching at the Okvau tenement of OZ Minerals in Mondulukiri province shows 14 m at 6.5 g/t of gold.
  (OZ Minerals Limited's website;
  http://www.ozminerals.com/Operations/Exploration.html)

Most metallic mineral deposits of Cambodia were formed by igneous activities, so mineral occurrences on the surface will extend underground along igneous bodies or related veins, and have potential to be larger deposits in deeper places.

5.4.1 Identification of Potential Mineralization Areas

Many igneous bodies are thought to be hidden under the Neogene – Quaternary sediments. Especially in the central part of the Middle region, the Tonle San River area of Ratanakiri Province and the Ratanakiri – Mondulkiri provincial boundary area, isolated igneous rock hills are located in Neogene – Quaternary sediment land. These areas have high potential for discovering new igneous bodies and related metallic deposits. High potential areas of igneous bodies are shown in Fig.5.2.1.

The Cardamom Mountains of the SW and Middle regions are situated in the Indosinian Fold Belt. A Gold – Copper ore zone is located along the Indosinian Fold Belt (Sepon and Phu Kham Au – Cu mine in Laos, Phu Hin Lek Fai Cu mine and Chatree Au mine in Thailand). In the southern extended area of the Gold – Copper ore zone, the Phnom Basset Cu-Mo deposit in granodiorite and the Phnom Prak hydrothermal Au-bearing Pb-Zn deposits are located in Cambodia. There is potential for discovering Phnom Basset- or Phnom Prak-type deposits in the Cardamon Mountains. Location of ore zones are shown in Fig.5.4.1.

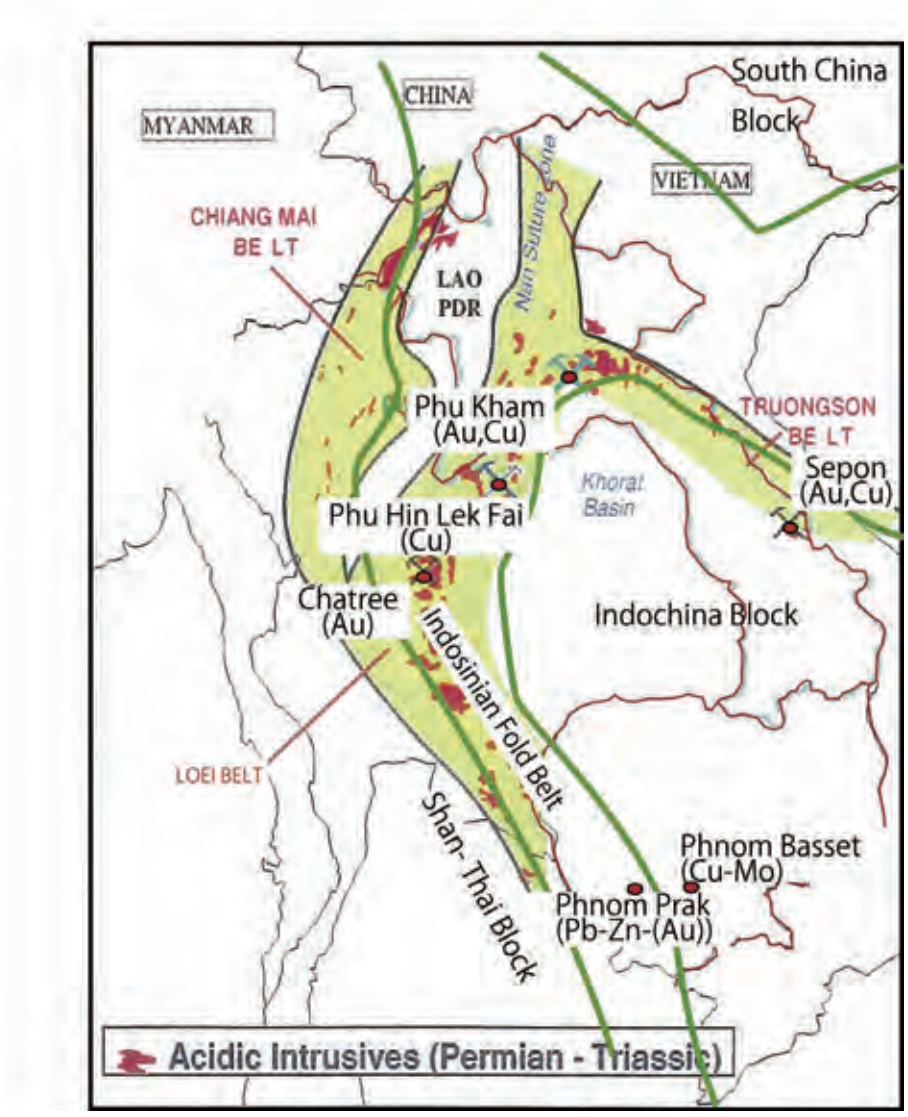
The following are deposit types that likely exist in Cambodia.

- The NE region: mainly Mesozoic terrestrial sandstone, mudstone, limestone, many small Jurassic granodiorite stocks, Cenozoic plateau basalt, partly Precambrian and Paleozoic metamorphic rocks

  > Igneous related Au-poly metal veins / metasomatic / hydrothermal / porphyry, Mississippi valley type, U in terrestrial sandstone
- The Middle region: Quaternary cover

  > Blind deposits (Igneous related Au-poly metal veins / metasomatic / hydrothermal / porphyry), sedimentary industrial materials (e.g. clay)
- The SW region: mainly Mesozoic terrestrial sandstone, mudstone, Triassic or Post Triassic granodiorite batholiths and stocks, partly Precambrian and Paleozoic metamorphic rocks

  > Igneous related veins / hydrothermal /, U in terrestrial sandstone, sedimentary industrial materials (e.g. silica sand)



(modified from the presentation of the Lao PDR mining master plan, JICA 2008)

Fig.5.4.1 Indosinian Fold Belt and Metallic Deposits

5.4.2 Geological Survey Plan

Potential areas for discovering igneous bodies are shown in Fig. 5.2.1. In many parts of these areas, the distribution of basement rocks and igneous rocks is still relatively unclear due to the cover of Neogene – Quaternary sediments. Basement rock structures under the cover sediment are seen as micro topography on a newly processed Satellite DEM image. Site survey areas were selected by identifying possible areas of igneous rock distribution in the image.

It is necessary to determine whether the structure on the image is igneous rocks or sedimentary basement on site. If there is no outcrop at the site, weathered soil or stream sediments will be collected and analyzed to assess mineralization; however, this would not be able to confirm the distribution of igneous rocks.

To identify promising areas of mineralization, it is necessary to visit as many potential

igneous areas as possible. Site surveys have two steps. The first step is conducting reconnaissance in a wider area to find igneous bodies and related mineralization. The second step is conducting a detailed survey to identify promising sites within the reconnaissance area.

5.5 Results of Geological Survey

5.5.1 Geological Survey Contents and Periods

The geological survey periods for the present study and the number of collected samples are listed in Table 5.5.1. Survey routes and sampling locations are shown in Fig. 5.5.1. Contents of laboratory tests and their results are listed in Table 5.5.2 and Appendixes V-5 to V-10. Thin sections and hand specimens prepared in the laboratory tests had been submitted to the DoG with the observation results.

Table 5.5.1 Geological Survey Periods

	2009	Samples
Reconnaissance 1	4 – 17 Jun. (14 days)	Geochemical sand: 54 Rocks: 32
Reconnaissance 2	6 – 23 Aug. (18 days)	Geochemical sand: 41 Rocks: 18
Detailed survey	10 – 20 Nov. (11 days)	Geochemical sand: 4 Rocks: 24
	43 days	Geochemical sand: 99 Rocks: 74

Table 5.5.2 Contents of Laboratory Tests

Item	Quantity
Rock samples (74samples in total)	
Thin Section preparation and observation	36
Polished Thin Section preparation and observation	9
Whole Rock Chemical Analysis	20
ICP Multi-Element Analysis (36 elements)	51
Sand samples (102 samples from 99 sites)	
ICP Multi-Element Analysis (36 elements)	102

5.5.2 Results of the Geological Survey

The results of the geological survey can be summarized as follows and are listed in Table 5.5.3. Photographs of field occurrences of rocks are shown in Appendix V-4.

- In the potential areas identified based on existing documents and satellite image analysis, some occurrences, which suggest possible mineralization, were identified (see Table 5.5.3). Further field surveys around those occurrences are expected to confirm mineralization.
- Some isolated hills of basement rocks show mineral occurrences in the Middle region; however, the region, which includes the Tonle Sap – Mekong Plain, is covered by Quaternary sand and mud. In Phnom Kraom to the north of the region (Fig. 5.5.1),

limonite gossan occurring along fissures in sandstone was observed in the survey. Angkor Borei (number 8 in Fig. 5.5.1) in Takeo province in the southern part of the region is known to have tin occurrences.

- Private companies' explorations have proven the known occurrences to be ore bodies. At the same time, the identified potential areas also have been proven to be metallic mineral potential areas, as noted above.
- Future exploration for finding new mineral deposits will involve geological traverse and geochemical surveys in areas where igneous rocks are known or suspected to occur; however, not all deposits are igneous related.
- Many new outcrops are being exposed in civil engineering projects all over the country. This is providing opportunities for conducting geological surveys now. For example, work roads for dam construction have recently been built in the Cardamom Mountains.

The following areas were not surveyed due to bad road conditions, etc.

(1) Cardamom Mountains
(2) Virachey National Park
(3) Boundary area between Rattanakiri province and Mondulkiri province
(4) Boundary area between Kratie province and Kompong Thom province
(5) Eastern slope of the Cardamom Mountains in Pursat province and Kompong Speu province

(1) and (2) have not been surveyed since the independence of Cambodia, and there is still no motorable road. Most of (2) has been registered as a private company's tenement. (3), (4) and (5) have also been identified as potential areas. These areas are future exploration targets.

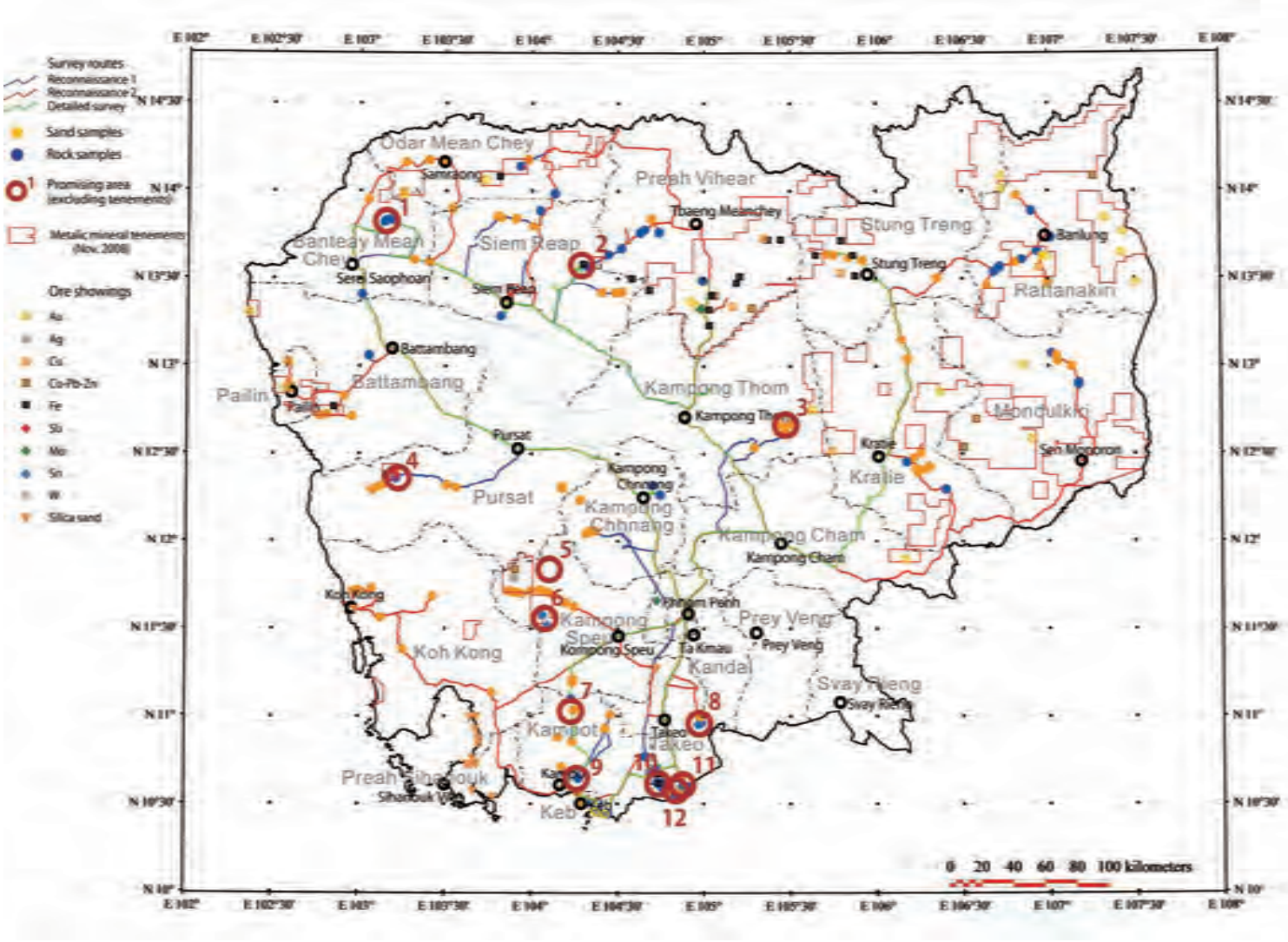


Fig. 5.5.1 Geological Survey Routes and Sample Locations

Table 5.5.3 Results of Geological Survey

No.	Reconnaissance	Detailed survey	Photo App.	Accessibility
1	Andesite distribution has been known. A few sporadic metallic minerals have been observed in andesite or silicified sedimentary rock.	Three hills located in this area of 5km (E-W) by 2km (N-S). Small pyrites occur in all of those hills. Assay results of rocks show no anomalous values.	1	Comparatively good. 30 km N of Prey Moan on the N6 road between Serei Saophoan and Siem Reap.
2	This site is located at the western margin of known occurrences of gold, copper and iron accompanied by intrusives, andesite and basalt. Silicified and sericitic altered volcanic rock has been observed. This suggests the possibility of mineralization.	Small sphalerites and pyrites occur in silicified lapilli tuff. Assay results of those rocks show Au content of 0.038 ppm and S content of 0.36 %.	2 3	Comparatively good. 50 km NE of Dam Daek on the N6 road.
3	Isolated hills indicate hidden igneous rocks. Silicified rock with limonite gossan was observed at the foot of a hill.	(Detailed survey has not been done due to a lack of outcrops. Assay results of samples taken during the reconnaissance show no anomalous values.)		Comparatively good. 40 km NE of Yeay Tleng on the N71 road.
4	Peripheral area of antimonite occurrence related to rhyolite body. Serpentinite was observed in a company's exploration trench. There is a huge variety of igneous activity in this area.			Comparatively good. 80 km WSW of Pursat on the N5 road. The site area is a mine field.
5	Granite batholith is homogeneous and fresh, no mineralization was observed. The area has more granitic bodies, and they are future exploration targets.			Difficult. 45 km W of Ou Ruessei on the N5 road, which is in bad condition.
6	Small bodies of granites and rhyolites are located near a known Cu-Pb-Zn deposit. The deposit is a company's tenement. The surrounding area is future exploration target.			Comparatively good. 40 km WSW from Kompong Speu.
7	In a road side pit (5m x 45m), argillized rock with limonite gossan is observed. Granites distributions have been known in surrounding area.	No outcrop other than the pit. Argillized sandstone from the pit shows Cu content of 383 ppm. An igneous rock hill is located 2 km to the west.	4	Comparatively good. 20 km S of Traeng on the N4 road.
8	Phnum Angkor Borei in Takeo province is known as a tin occurrence. Another granite hill, called Phnom Dar, 3 km NE of Phnum Angkor Borei, has quartz vein nets. This suggests the possibility of mineralization in the area. River sand at Angkor Borei show Au content of 0.064 ppm.			Good up to Phnom Dar. 34 km SE of Chambak on the N2 road. A boat is needed to get to Phnom Angkor Borei in the rainy season.
9	Quartz veinlets with limonite have been observed in conglomerate. Igneous rocks have been found in the area.	(Detailed survey has not been done due to a lack of outcrops)	5	Good. 5.5 km S of Prey Thnang on the N3 road.
10	Known iron occurrences in low hills in the southern part of the Mekong lowland. Two types of occurrences have been observed. One is a low-grade Fe-Mn vein with quartz and the other is a nodule layer which is concordant with host shale bedding.	Iron occurrences are distributed in an area of 15 km in length in the NNW-SSE direction. Fe-Mn nodule layers are intercalated. Assay results are as follows. Fe: 28.4%, Mn: >5%, Ag: 5.4 ppm, Co: 364ppm, Cu: 350 ppm, P: 4660 ppm, Zn: 406 ppm.	6 7	Good. 15 - 20 km W of Kirivong on the N2 road.
11	Known molybdenum occurrence in an isolated granite hill. Large outcrop of ex-quarry is 70 m in width. Dissemination is 40 m in width, weak intensity, and composed of molybdenite, chalcopyrite and pyrite.		8	Good. South side on the N2 road. 2 km to Cambodia - Vietnam border.
12	Skarn with arsenopyrite has been observed in hornfels of shale in contact with granite batholith.	Skarn with arsenopyrite is distributed in hornfels along with granite in a 7 km-long area. Assay results are as follows. Cu: 412 ppm, As: 2780 ppm, S: 1.35%, W: 130 ppm.	9 10	Good. 6 - 10 km S of Kirivong on the N2 road.

Chapter 6 Compilation of Digital Spatial Datasets and Information Disclosure

6.1 Status of the Current GIS Database

(1) Geological and Mineral Resource GIS datasets

In the GDMR, the DoG ordinarily manages GIS datasets for geology and mineral resources mainly, and DMR handles concession GIS datasets.

The current mineral resource information was mainly taken from the ESCAP (1993) which includes geological maps and mineral deposits and occurrences in Cambodia, and partially supplemented with the following results from the GDMR (1999) and company reports. Basic spatial datasets such as administrative boundaries and road networks have also been added.

Geological maps of 1:200,000 in scale covering the whole country were compiled by the BRGM in the 1960s (published in 1972 and 1973), which resulted in 14 sheets. However, there is a lack of geological information about the northeastern part of Cambodia. Subsequently, a 1:1,000,000 geological map has been compiled with the cooperation of the Department of Geology and Mineral Resources of Vietnam, Department of Geology and Mine of Laos, and the Department of Geology and Mines of Cambodia (first edition in 1988, second edition in 1991, updating for third edition as of August 2010). The geological maps compiled in Vietnam were not converted from paper geological maps to digital GIS datasets. In the DoG, 1:200,000 geological maps were digitized in 1996 and 1997 using ArcInfo, the world standard GIS application developed by ESRI (United States). Furthermore, the "Study on the Establishment of GIS Base Data for the Kingdom of Cambodia" undertaken for the MPWT and financed by JICA produced fundamental GIS datasets in 2003. Five geological engineers from the GDMR participated in the project to revise geological GIS datasets based on the BRGM's geological maps and compile other geographic datasets.

(2) Concession Management GIS Datasets

Concession datasets are comprised of three categories, i.e., mineral resources, rock, and sand for construction materials, which are stored as polygon or line vector data in GIS, and are managed in the concession room of the DMR. The data is integrated with scanned topographic maps and related backdrops to enable visualization of proposed concession locations with topographic maps. Concession data generally consist of title holder, license number, commodities, due date, agreement date, expiration date, description of the place, the area, the person in charge, and other attribute information. Current concession GIS datasets for mineral resources face several issues for management, including unstructured attribute fields for GIS data, which will be described later.

(3) Use of GIS Datasets in the Departments of the GDMR

Implementation of GIS data sharing in the country is remarkably delayed and the GDMR is no exception. For instance, geological data is stored in the DoG and concession data in the DMR, without any data exchanges, which impedes the coordination of efforts by these organizations. The following sections are overviews of three departments of the GDMR that use GIS datasets, and their current IT circumstances (Table 6.1.1).

Department of Geology

Geology and mineral resources information in the DoG is managed using ArcView and the ArcMap, GIS software programs made by ESRI which have been gradually updated by the director and some staff members. There is no local area network (LAN) in the office, and no Internet access. For input and output peripherals, there are only a digitizer and seven laser jet printers, and it is impossible to print large-size materials.

Department of Mineral Resources Development

The staff of the DMRD only handle GIS datasets for deposits. The locations of deposits and occurrence information are taken from the ESCAP (1993), Mineral Resource Report (1999), and partially from annual company reports. However, there has been no data entry, especially for deposits discovered in southern and southeastern Cambodia, since the mineral resources report was submitted in 1999.

The mineral resources datasets were digitized separately from those at the DoG. The concession datasets are kept in stand-alone PCs, which are not connected to the Internet. They have an A0-size plotter and seven A4 size printers.

Department of Mineral Resources

The concession room of the DMR manages concession datasets, mineral resources, rock, and sand for construction materials with scanned topographic maps and backdrops using ArcView. The concession areas are stored as polygon or line (sand dredging along river streams) features in GIS. Here as well, there is no LAN and no Internet access in the office. There is one A4-size scanner, and three A3 or A4-size printers.

Department of Construction Materials Resources

The DCMR now has a GIS database based on ArcView 3.3 which is being utilized to manage licensed quarries. Although four offices in the DCMR need at least 5 GIS operators at this moment, the department, which was established in 2009, has only one GIS and database operator. The department has four A4-size B/W printers and one color printer, but they are not able to print out large scale maps. For general surveying for quarries, the department needs GPS and portable PCs installed with GIS.

Table 6.1.1 GIS-related Equipment at the GDMR

Dep.	Office	Number of staff	PC	OS	CPU	GIS software	
						ArcView 3.3	ArcMap 9.0
DoG	Mapping	6(5)	Clone 1	Windows-XP, 2002	Pentium4, 1.5GHz	Yes	－
			Dell 1		N/A	Yes	Yes
	Research	6(2)	Clone 1		Pentium 3, 930MHz	Yes	Yes
	Environment	5(1)	HP 1		Pentium Dual, 1.8GHz	Yes	－
	Analysis	6(0)	Clone 1		Pentium 4, 2.2GHz	Yes	－
DMRD	Mapping	27 including 2 beginners	9	Windows-XP	Pentium 4, 1.5GHz	－	Yes
DMR	Concession management	6(1)	4	Windows-XP	Pentium 4, 3GHz	Yes	－
DCMR	Crushed stone	5(1)	5	Windows-XP	Pentium 4	Yes	－
	Sand construction	5(0)				－	－
	Clay construction	5(0)	3			－	－

	Administration	5(0)				Yes	–

* Numbers in parentheses indicate number of staff who can operate GIS

(4) Evaluation of GIS Datasets

Assessment of GIS datasets in the GDMR is as follows:

Table 6.1.2 Evaluation of GIS Datasets and Databases

Items	Evaluation
Databases	• Though there is a text-based database of concession information for tax collection in the DGMR, there is no data exchange with spatial information and no relationship with the GIS database.
Data content ・Sharing	• There is no sharing of data such as geology, mineral resources, and concessions between DoG, DMR and DMRD.
・Format	• No unified data format.
・Concessions	• Concession datasets, namely GIS shape files, are managed in different directories named for each license holder. – There are many disorganized files, which might cause human error in data management and data entry. – Non-standardized data entry. For instance, there may be several names for one company. – There is a lack of required attribute fields in GIS data to indentify each concession. – Concession map creation under special conditions, for instance, making a map just for MOU concessions requires additional labor, time, and many steps. – Attribute structure is not standardized, and no data links to list of title holders. – Because there is no standardized data management procedure, only the person currently in charge can understand and manage the contents.
・Geology	• Data is missing in some fields of the geological GIS shape files. • GIS datasets are divided by province, and the attribute structures for geological GIS data are inconsistent. – This causes some redundancy in geological GIS datasets. – Standardized management of geological information is not possible, and compilation of shape files cannot be completed.
Technical level	• There is a lack of understanding of data management, and GIS has been used just for map creation. • Understanding of GIS and databases is at the beginner level, except for a few intermediate users. • There is a commonly seen need for GIS and databases in daily operations.

Given the clear need for concession and geology GIS datasets to resolve issues, as pointed out in Table 6.1.2, for database construction in this study, the following procedures were carried out to compile and edit unified datasets to create a GIS shape file with the appropriate attribute structure. For concession information, only the GDMR-provided mineral attributes were revised. Measures taken for concession datasets:

- Unified the attribute field structure for each shape file and enter corresponding concession ID numbers for attributes fields of the shape files
- Integrated all the shape files into one shape file
- Linked the concession IDs in the shape file to the concession ID fields in the related concession table, to enable access to detailed concession information from the GIS shape file.

Measures taken for geological information:

- Unified the attribute fields for each feature in geological units in the shape file
- Integrated all geological units and sent the dataset to the DoG

(5) Evaluation of IT Use

IT and database management issues facing the GDMR are as follows:

- There are only four GDMR PCs connected to the Internet, and no LAN setting in the GDMR office.
- Thus, there are no e-mail communications, or data transfers, and software has not been upgraded.
- Almost no GIS datasets are shared.
- Almost all software is unofficial (pirated) copies, and not eligible for upgrades to current versions.
- There is a lack of computer anti-virus measures.
- Although some newer staff members have a basic knowledge of database construction, there is a lack of staff IT training for sustainability.

However, there is a common understanding of the importance of GIS and database utilization.

(6) Information in Company Annual Reports

Corporate annual reports are stored in the DMR, and some are also stored in the DoG. The reports include exploration results, which are crucial to properly estimate the mineral potential in Cambodia. However, this information has barely been utilized thus far. At the same time, there are indications that some of the contents of these reports might not be very reliable. Therefore, in order to utilize such reports appropriately, a geo-scientific evaluation of the contents by well trained staff members is required, such as geologists from the DoG. The use of currently unutilized information is a crucial step for nations such as Cambodia that lack resource information.

6.2 Construction of the GIS database

The GIS database mentioned in this section is that for GDMR internal use which includes spatial data, text, tables and some linkage to websites. The structure and contents of this database differ from those of the website database. Data collected for the database construction are listed in Table 6.2.1. The database integrates parts of two other databases, a GIS database for spatial information and a text database. The following projection system has been used for the integrated GIS datasets for the country, and the same system is used in this study.

- Projection: UTM, Zone 48
- Ellipsoid: Everest 1830
- Datum: Indian 1960

6.2.1 Structure of the Database

The database has an entry window for two types of users, administrative users and general users, in order to protect the contents (Fig.6.2.1). General users are able to search, make lists, and print out all of the contents. The administrators have a password, which authorizes them not only to manipulate the database like general users, but also to edit and to add new data. The text-base database is constructed on Microsoft Access. In the entry window, the database also provides links to ArcMap9.2 and ArcView3.3 for spatial data.

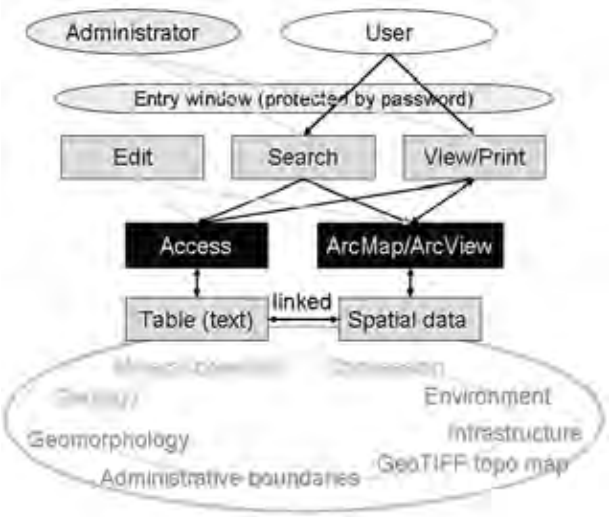


Fig.6.2.1 General Structure of Databases for the GDMR Internal Usage

While the mineral resource information is created based on the results of ESCAP and this study and is accessible to many possible users in the GDMR, the concession datasets contain confidential information and might be restricted to a few officers' use at the present time. Therefore, two types of databases, i.e., a mineral resource database and a concession database, have been constructed independently in this survey. If future revision of the mining law encourages the disclosure of concession information, then it will not be too difficult to integrate the two databases.

Table 6.2.1 Collected Datasets

Item	Data Source	Contents
GIS Database	JICA	Administrative boundaries, elevation contours, river networks, watershed areas, index maps, land-use, densely populated areas, road networks, rail lines, geology, historical heritage sites etc., JICA (2003)*
GIS revised database		Revised GIS datasets mentioned above; JICA report (2005)**
Topographic maps		JICA Report(1999)***
ALOS satellite imagery		SUM of EDC, AVNIR-2, PRISM, PanShapen data; some reading errors in 13 provided DVDs
SPOT5 satellite imagery		15 scenes (some reading errors) with GIS data, 2003-2006,
Geology, faults	MIME－GDMR DoG	Based on 1:200,000 geological maps Some revisions especially for the northeastern part of Cambodia are required, Data are still being revised in the this study
Mineral deposits and occurrences		Based on ESCAP (1993), MIME (1999) and KIGAM (2001)
Concessions	MIME－GDMR DMR	Concession data as of 26th November, 2008; integrated into one shape file, after revising attribute structure and contents.
Existing and planned dams	MIME, Hydroelectricity	Two existing dams and five under construction or planned.

Existing and planned power grids	Department	GIS created based on a report by the Japan Electric Power Information Center Inc.
DEM（30m Interval）	MPWT	Covering all of Cambodia (30 m interval DEM based on ASTER data)
Topographic maps		1:100,000 topographic maps covering the whole country, GeoTIFF files
Road Planning		Paper-based maps provided, then scanned
Environment, forest reservation areas	MoE	National parks, forests and landscape conservation areas, as of November, 2008
Monthly precipitation	MWRM, Meteorological Department	Average monthly precipitation for the past 10 years at 21 meteorological stations
Landmines and UXO	CMAC	Paper-based maps, digital scanned maps, and GIS datasets including level-one survey by CMAC, landmine and OUO contaminated areas
SEZ	CDC	Locations of economic zones, capital etc., downloaded from the website www.cambodiainvestment.gov.kh
Oil and gas concession areas	JOGMEC(offshore) JICA（onshore）	Consultants information titled " Cambodia: Prospect as an oil producing country, issues with resource development due to unsettled maritime boundaries" (in Japanese), April, 2007 and JICA report titled "Cambodian Energy Situation", June, 2008
Landsat satellite imagery	Geocomm	Covering the whole country, Downloaded from the website www.gisdatadepot.com

* : The Study on the Establishment of GIS Base Data for The Kingdom of Cambodia, March, 2003
** : The Reconnaissance Study Project for the Establishment of an Emergency Rehabilitation and Construction of the Kingdom of Cambodia, September, 2005
*** : The Reconnaissance Study Project for the Establishment of an Emergency Rehabilitation and Reconstruction of the Kingdom of Cambodia, March, 1999

(1) Mineral Resources Database

The mineral resources database is comprised of a main table for mineral resources and some related tables such as company list, index map code list, area name list and so on (Fig. 6.2.2). The following is a list of the main characteristics of the database:

- Individual management for administrator and general users by password
- The main menu is divided into various processing operations
- Various functions such as individual mineral deposits or occurrences, searching and sorting, switch to GIS applications
- Special privileges for administrators; addition, deletion and revision of main and related tables
- Original resources, ESCAP (1993) and JICA (2009)
- Editing spatial datasets for mineral deposits and occurrences are point features in GIS

Actual displayed tables and operational flow are shown in Fig.6.2.3.

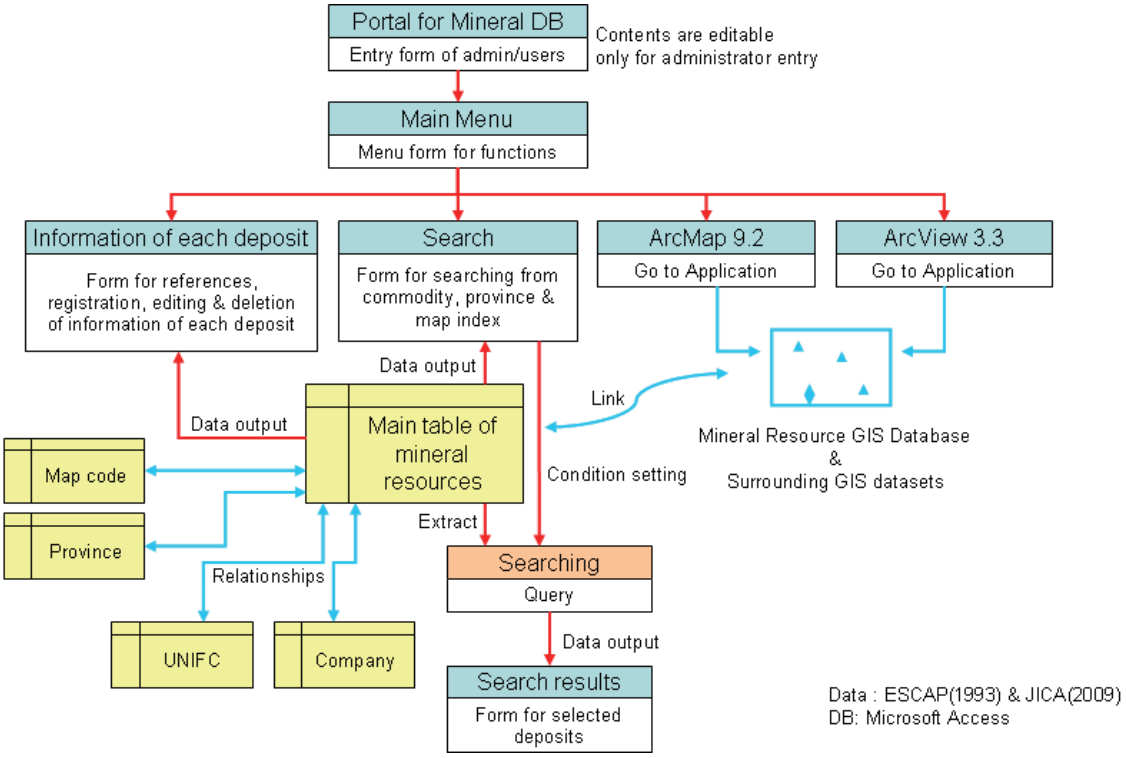


Fig.6.2.2 Structure of the Mineral Resources Database

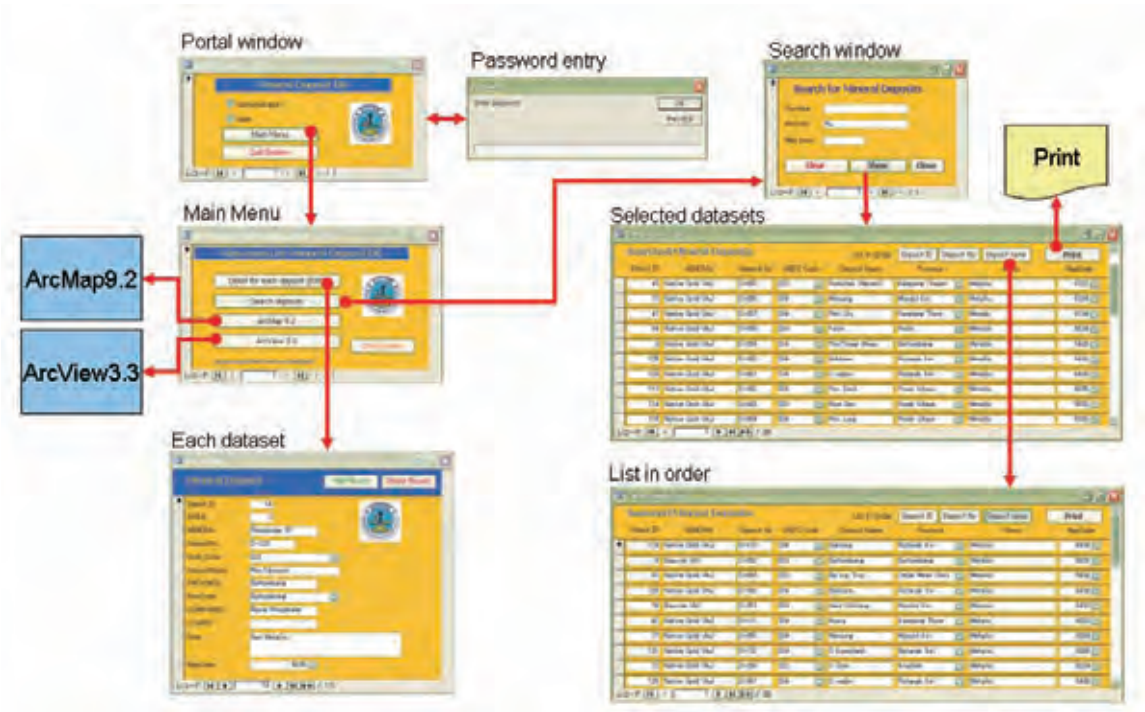


Fig.6.2.3 Operational Flow of the Mineral Resources Database

(2) Concession Database

The concession database is comprised of a main table for main concessions and some related tables such as company list, map code list, area name list, license category list, activity level and so on (Fig.6.2.4). The following are the main characteristics of the database:

- Individual password-activated management for administrators and general users
- The main menu is divided into various processing operations
- Various functions such as individual mineral deposits or occurrences, searching and sorting, switch to GIS applications
- The individual concession table has a field for web URL, providing a direct link to the web sites of companies which are disclosing exploration and mining activities (requires Internet access)
- Special privileges for administrators: addition, deletion and revision of main and related tables
- Original resources: concession data provided by the DMR, current as of November, 2008
- Editing spatial datasets for mineral concessions as polygon and line features in GIS

Actual displayed tables and operational flow are shown in Fig. 6.2.5.

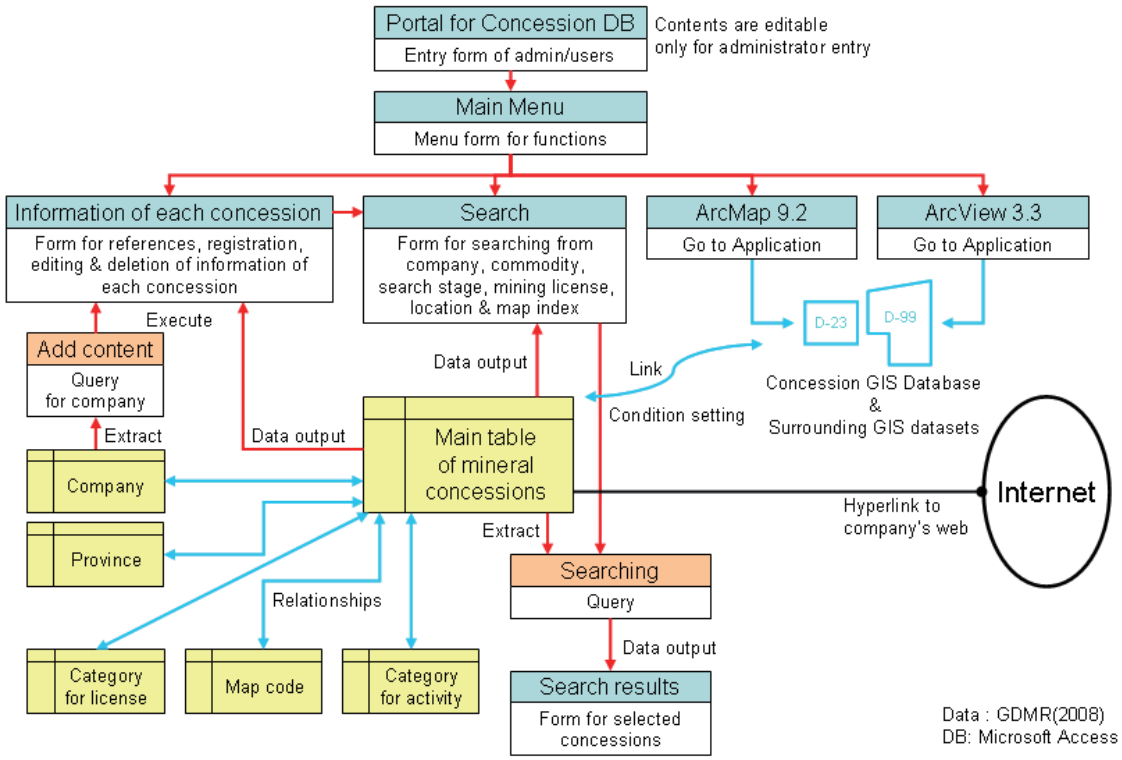


Fig.6.2.4 Structure of the Concession Database

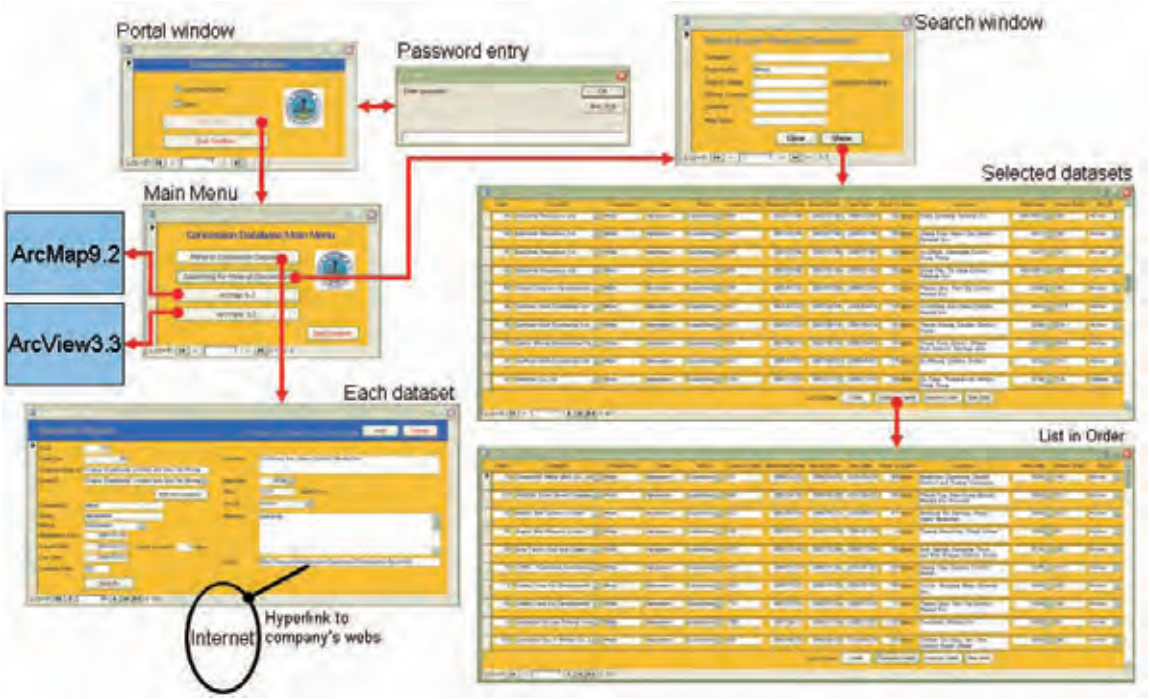


Fig.6.2.5 Operational Flow of the Concession Database

6.2.2 Some Outputs from the GIS Database

Based on collected and edited GIS datasets and numerical tables, the following maps have been created to show examples of useful applications for the GDMR and investors.

(1) The GIS datasets of landmines and UXOs provided by the CMAC were integrated with distributions of mineral resources (ESCAP, 1993) and concessions (GDMR, 2008) as shown in Fig.6.2.6. White polygons show concessions that are at stages before licensing such as preliminary proposal and proposal, MOU, and processing stages. When setting up concession areas, collaborative relationships with organizations such as CMAC may be useful for acquiring information to help create landmine and UXO risk maps that can provide decision-making information to potential investors. Thus these datasets are one of the GDMR's most important information services.

(2) As each polygon or line feature indicating concession areas has one or more links with related tables, database users can access license holders, areas, license numbers, categories of licenses, due dates, expiration dates, index map numbers and so on by just clicking the respective features shown on the GIS display (Fig.6.2.7). The GIS database provides a retrieval function that will help the GDMR staff members to improve work efficiency.

(3) Infrastructure in Cambodia is still largely underdeveloped. For instance, local roads may become impassable in the rainy season, which may disrupt the transport of supplies, while in the dry season, there is very little precipitation. There are also regional differences, and monthly precipitation information may be very important for exploration and mining. In this GIS database, average monthly precipitation data for the past 10 years provided by the MWRM is linked to 21 meteorological stations (Fig.6.2.8).

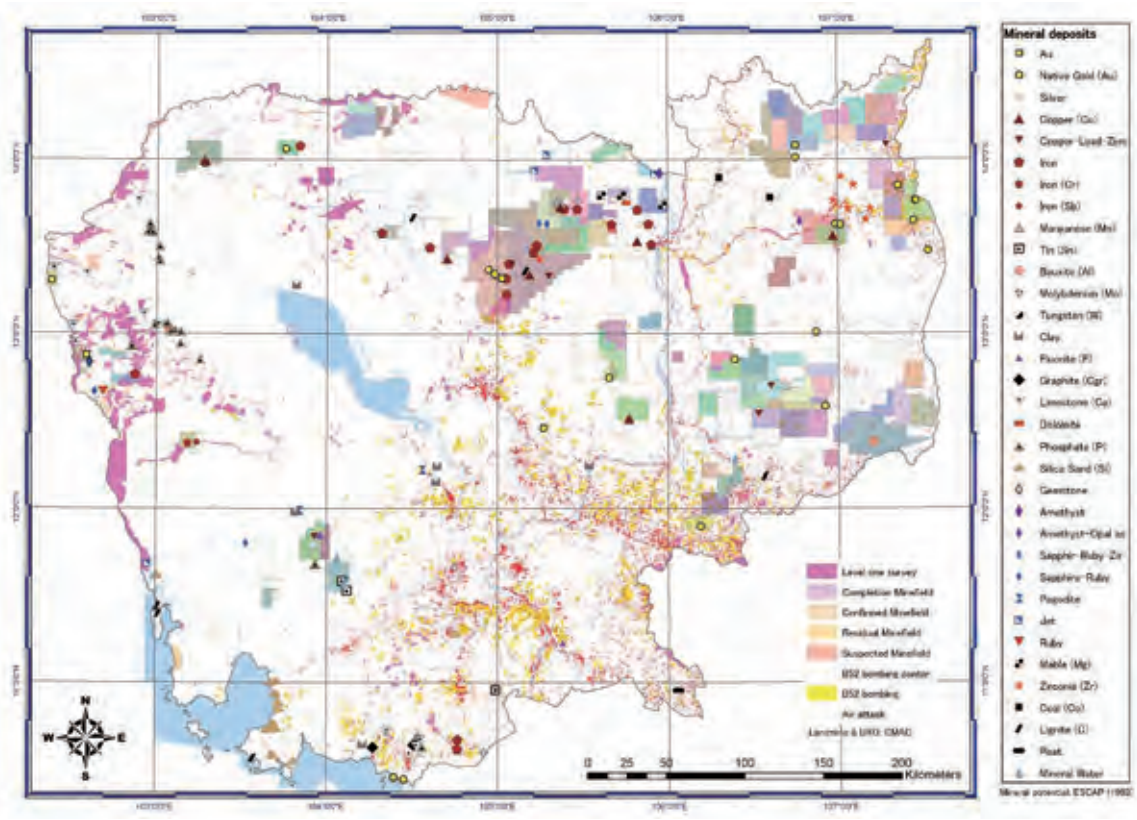


Fig.6.2.6 Distributions of Mineral Resource Concessions (as of November 2008), Mineral Potential Areas, and Landmine and UXO Areas

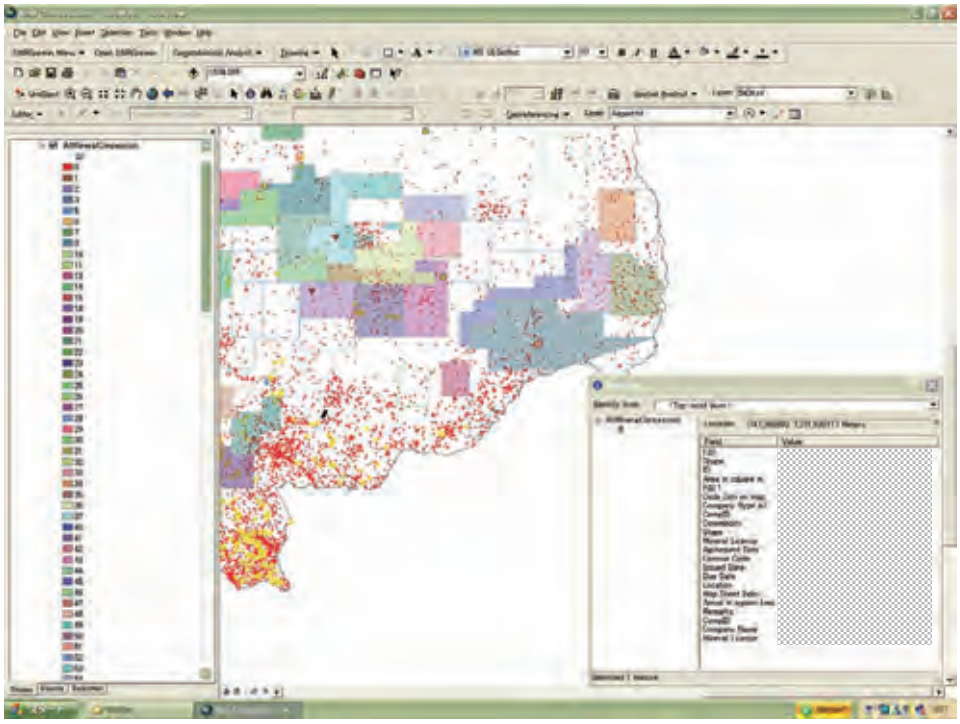


Fig.6.2.7 Concession Spatial Data with Related Attribute Information

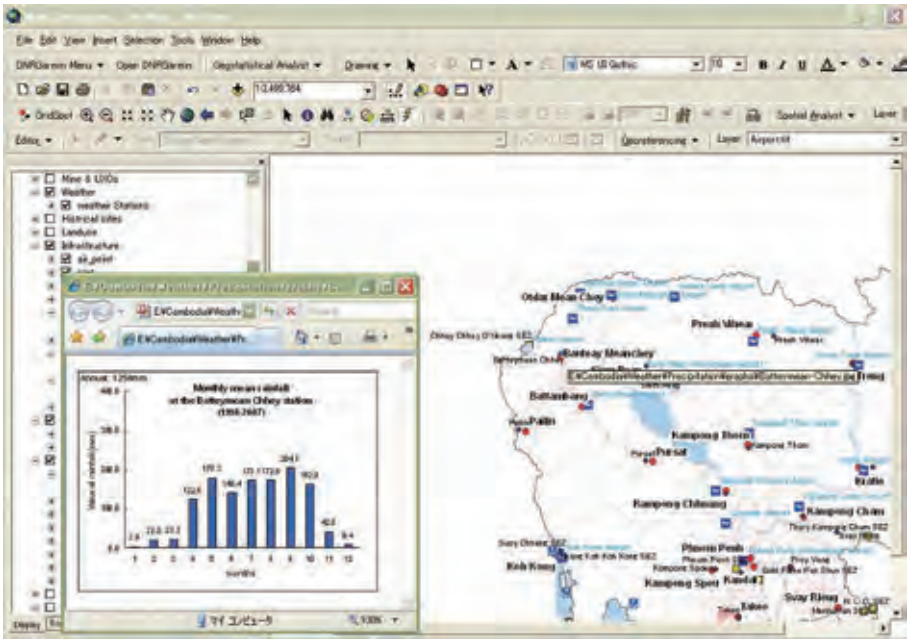


Fig.6.2.8 Linkage between Meteorological Stations and Monthly Average Precipitation Graph

6.3 Website Construction

The use of websites in Cambodia is at the emerging stage (Digital Review of Asia Pacific 2009-2010), because of insufficient Internet connections at the present time. However, the importance of the Internet is well recognized by governmental organizations, and almost all major ministries and related organizations have their own website (Appendix VI-1). While the MIME also discloses its institutional structure, some statistics, related laws and regulations, business directories and so on in English and Khmer, the web site still does not contain some of the most important items such as its vision, policy and strategy. The GDMR is now permitted to create its own new website by the MIME, and the creation was included in the S/W of this study.

Fig.6.3.1 Preliminary ASEAN-Base Designed GDMR Web Design

Two young staff members of the GDMR, who are in charge of developing the database for the MIME side, were selected as collaborative C/P members for web creation. For actual web development, a local consulting contract was signed with the MANICH Enterprise for web

designing, programming, web-server and web-GIS server setting, server maintenance and so on.

6.3.1 General Concepts of the Website

Regarding web contents for the mining governmental organizations, there have already been several discussions by related organizations at ASEAN meetings. The GDMR had a basic framework for the website based on the ASEAN standard (Fig.6.3.1). In this study, we modified the framework as a starting point and constructed a new general structure by adding contents and designing some new functions, considering the special features of Cambodia (Appendix VI-2).

The final main specifications of the GDMR website are summarized in Table 6.3.1.

Table 6.3.1 Main Specifications of the GDMR Web Development

Items	Specifications
Web design & construction	ASEAN standards, in English and Khmer
Development of mineral resources DB with searching tool	Based on ESCAP database, adding results obtained in this survey, which will be separately developed from internal DB
Dynamic map service	Dynamic web site development for spatial data distribution using web-GIS technique
Development of registration tool	Registration functions for exchanging information with clients
Design & development of administrative tool	Self-management tool for GDMR staff members
Development of retrieval tool	Tool for searching in the whole web site for clients
Training	Several day training for GDMR staff members so they will be able to maintain the web site on their own
Hosting of web server	Hosting of Web Server from 1 February 2009 to March 2011
Maintenance of web server	Keep security fixes updated and upgrade the system
Inspection for approval	Final inspection was made at the end of February, 2010
Opening of website	Internally: in mid November, 2009 Publicly: in the end of Sep., 2010

6.3.2 General Structure of the Website

The GDMR website is comprised of the main site and the web-GIS site as shown in Fig.6.3.2. The administration tool was also developed to support self-maintenance by selected administrators of the GDMR. The official domain address is http://www.gdmr.gov.kh/.

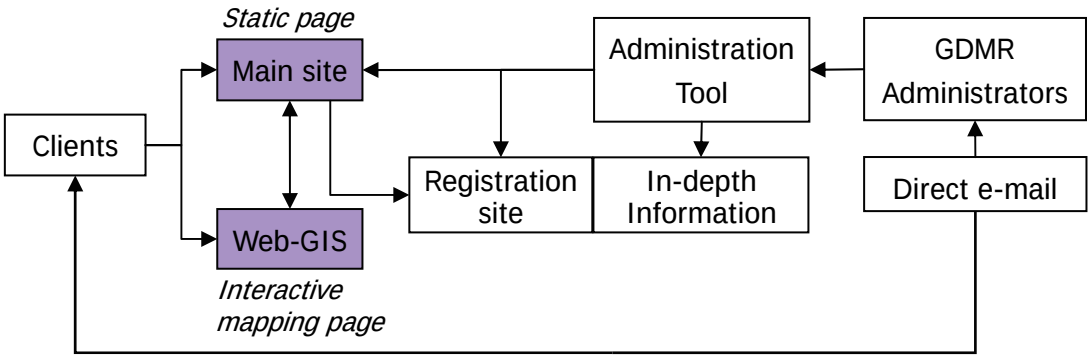


Fig.6.3.2 General Structure of the GDMR Website

The GDMR website is run by three servers in California, which are for the main site, web-GIS, and map servers, respectively (Fig.6.3.3). The main site server retrieves documents, figures, tables and images stored in the database on demand from clients (web users), and provides them to clients. An administrative tool called "Admin cms, content management system" provides a document editor for website administrators of the GDMR to update the contents. The web-GIS server supports map creation and transfers clients' requests to the map server. The high-performance map server searches and integrates map datasets from a database which stores various kinds of spatial information and feeds the image files back to the web-GIS server. The clients can see the integrated and visualized mapping information through a web-GIS window. The visualized map consists of eight sheets of tiles for high-speed map processing, and each tile is made of transparent thematic maps retrieved by the clients on-demand. In order to create export files with the PDF format, a new tool called PDF Engine was developed.

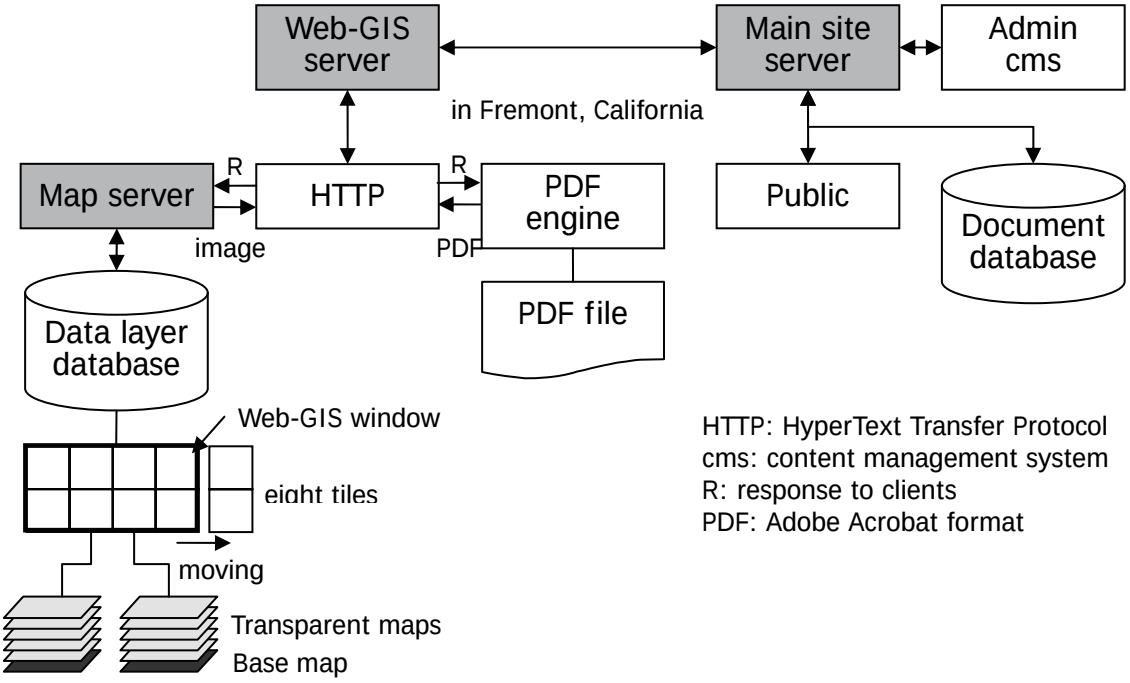


Fig.6.3.3 Dataflow in the GDMR Website

6.3.3 Main site and web-GIS

(1) Main Site

The GDMR main site is a static site which provides documents, tables and figures on mining policy, related laws and regulations, fiscal regime, concession applications, new projects, statistics, news and announcements as information from a mining sector governmental site (Fig. 6.3.4). On the top page, news and announcement columns were added to make the site dynamic. Regarding the mining policy, it is not officially settled at this moment, and only a basic statement for it is shown in the main site. After establishing of a new mining policy

within the next one year following this master plan described in this report, it should be uploaded to the website.

Fig.6.3.4 The GDMR Top Pages in English (left) and Khmer Versions (right)

At the same time, a plan for creating a new user registration page to provide a means for exchanging in-depth information such as concession information in investor's target areas was proposed to the GDMR, which approved of it after internal discussion. The contents are described in a next section.

(2) Registration Pages

Through discussions with counterparts, we have found that we have a common desire

to create a new service page for registered members which provides not only ordinary mineral- and mining-related information, but also more detailed information to promote future investments for potential investors who are interested in the Cambodian mining sector. However, no practical ideas for the registration page have been proposed so far. At the same time, the concession information has not been shared in all departments of the GDMR. Here, to promote information disclosure and sharing, three kinds of ideas were proposed to the GDMR, which are summarized in Table 6.3.2. Proposals I and II are services for future investors. Proposal III is a system for internal usage by the GDMR, which provides access privileges to staff members to share some spatial information such as concession datasets with relevant information.

Today, many natural resource-rich countries disclose concession information, which is one indicator of the mining activities of those countries and provides information for determining practical exploration conditions in the surrounding area. However, such information disclosure approaches have not been implemented in Cambodia due to legal restrictions. Proposals I and II are ingeniously planned as information disclosure approaches, and provide user-oriented cyber space for registrants to provide more in-depth information for more practical stages such as exploration license application procedure without visiting the GDMR office. Proposal III provides a useful internal opportunity for registered staff members to share the latest concession coverage in the GDMR and helps provide users with a better understanding of current activities. The proposals were presented in the seminar.

Table 6.3.2 Proposals for Registration Pages

No	Main User	Registration	Contents	Fee
Ⅰ	Registered Clients (future investors)	Clients: submit registration form to the GDMR GDMR: examine the application form and send passwords to the authorized clients	• Access allowed to in-depth information including concession maps • Provides practical information about interest areas	Charged, for instance, US$10/month
Ⅱ	Registered Clients	Same as Proposal Ⅰ, but simpler examination	Provides practical information about interest areas, but no access to concession maps	Free
Ⅲ	Registered GDMR staff members	Provides passwords to the four departments of the GDMR, which provide access to spatial information including concession data	Absolute access privileges to the webGIS datasets including concession maps	Free

The GDM adopted Proposal II after an internal meeting. The procedure for this registration is shown in Fig. 6.3.5. After registration, clients are eligible to download the final report of this study, “Investment Guide Book” and related figures, and their inquiries will be given the highest priority by GDMR staff members. Entry items for registration and the registration service room are shown in Fig. 6.3.6.

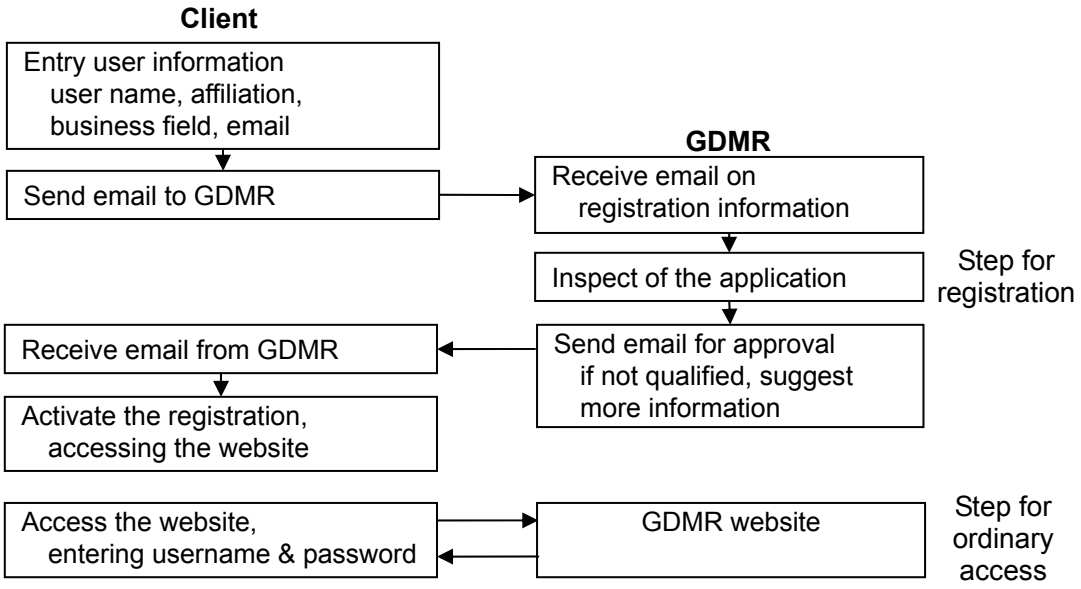


Fig. 6.3.5 Procedure of the Registration Page

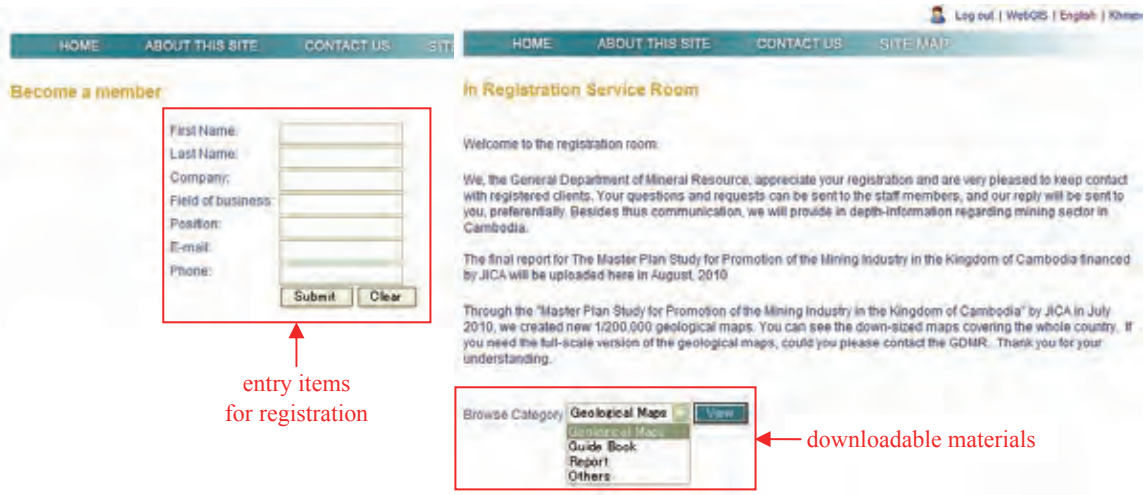


Fig. 6.3.6 Entry Items for Registration and the Registration Service Room

(3) Web-GIS Site

The web-GIS is a dynamic site which provides an interactive mapping service of spatial information such as geological and mineral resource distributions with surrounding mining-related data, including administrative, geographical, and infrastructural (road networks, ports, hydroelectric plants, etc.) information on demand (Fig.6.3.7). Clients can display the integrated maps on the map window, selecting required thematic information from the left menu panel. Clicking the left button on the map display enables relevant, more detailed attribute information to appear on the pop-up table. By clicking the legend button, the user opens the legend pop-up window, which appears on the screen. Also, clicking the legend display button on the left menu brings up the control pop-up windows and shows the corresponding legend and enables clients to select the label visibility options on the map. However, the current site has

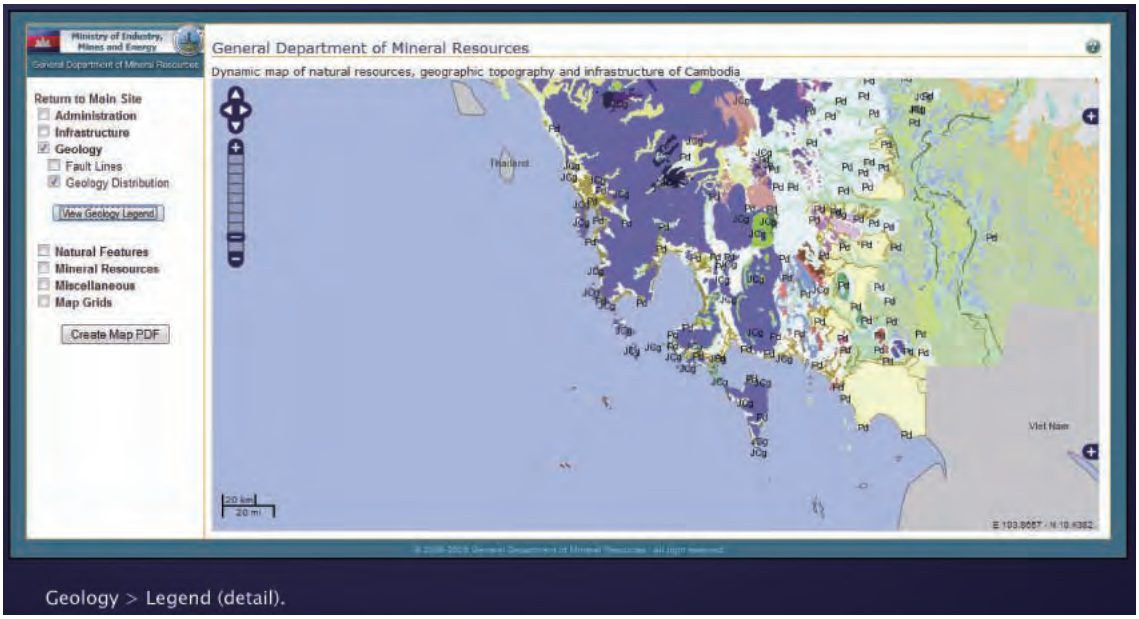


Fig.6.3.7 Web-GIS Site（Geological Map）

no mining concession information, at the GDMR's request. A new tool called PDF Engine was developed in order to export an export file in PDF format based on the map created by the client (Fig.6.3.8). The PDF file contains the created map with a scale bar and legends. The file also has links to the website of the original data source organization.

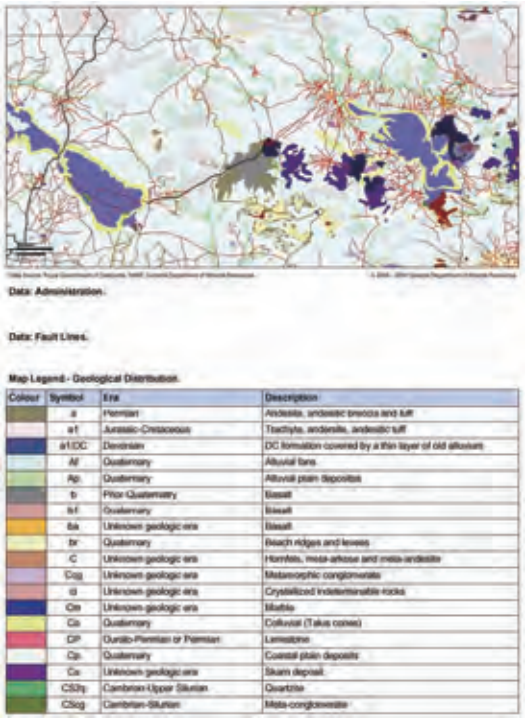


Fig.6.3.8 An Example of PDF File Output from the Web-GIS Site

In all past JICA M/P mining projects, commercial systems have been utilized to develop a web-GIS site, because of the complexities of web-GIS programming. In this project, the original programming was made using existing open source codes, enabling the creation of a cost-effective, flexible and 100% original site.

The web-GIS component of the website uses JavaScript, which users might be required to install. The interface is designed to run on Windows, Linux and Macintosh operating systems. All of the spatial information on the map is plotted on the WGS84 coordinate system.

In the coming months, we plan to develop a distance measuring tool on the web-GIS window and an integration tool with satellite imagery such as Google Earth.

6.3.4 Administration Tool for Web Maintenance

An administrative tool was developed to help GDMR's administrators maintain the system on their own (Fig.6.3.9). The tool is protected by username and password, which are provided to selected administrators. After entering their username and password in the log-on screen, the administrators are taken to the administrative front page. In the administrative front page, clicking the retrieved document to be up-dated boots up the page manager, and it provides a document editing function such as that found in commercial business software (Fig.6.3.10). This enables administrators to revise not only documents but also tables and pictures in English and Khmer.

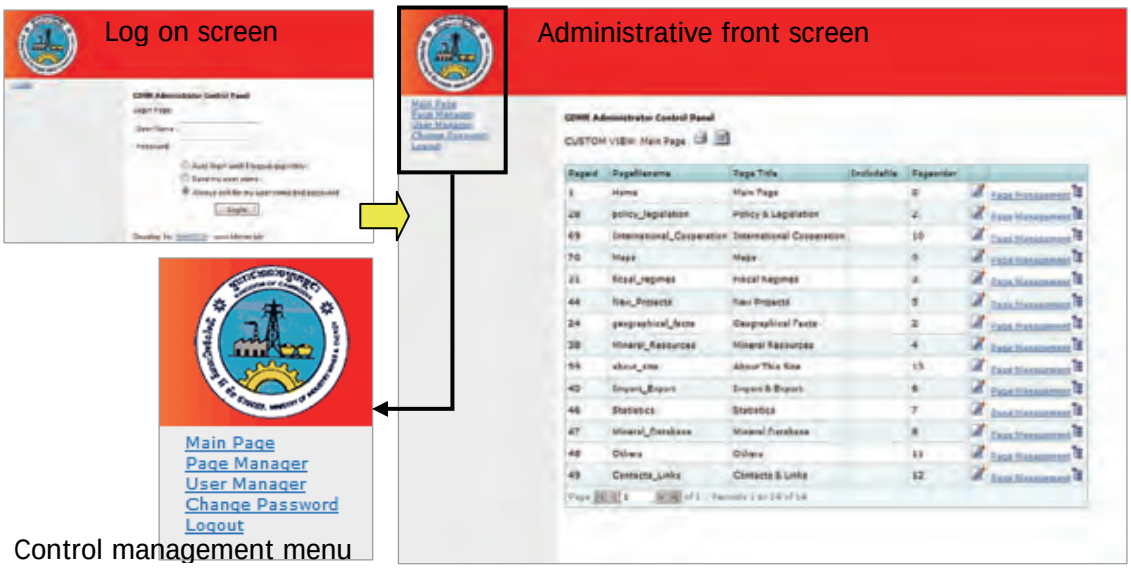
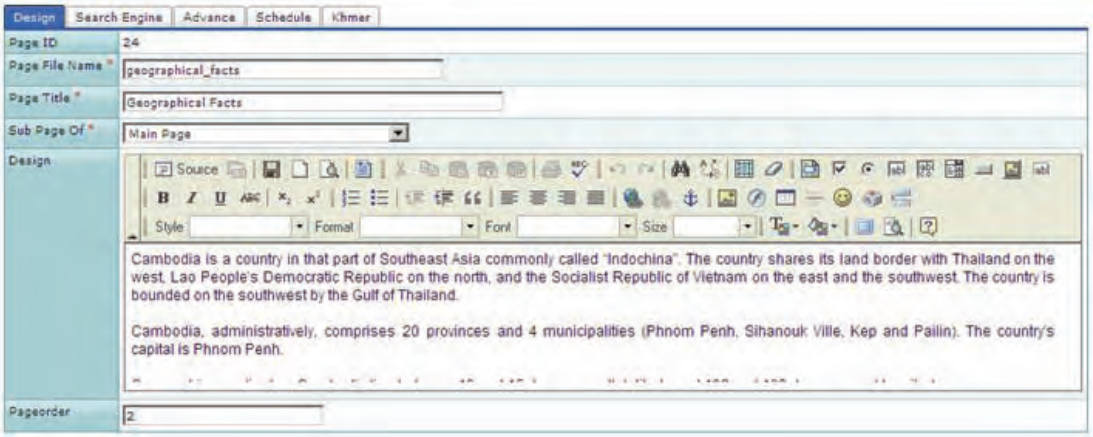


Fig.6.3.9 Administration Tool

Page manager for English



Page manager for Khmer

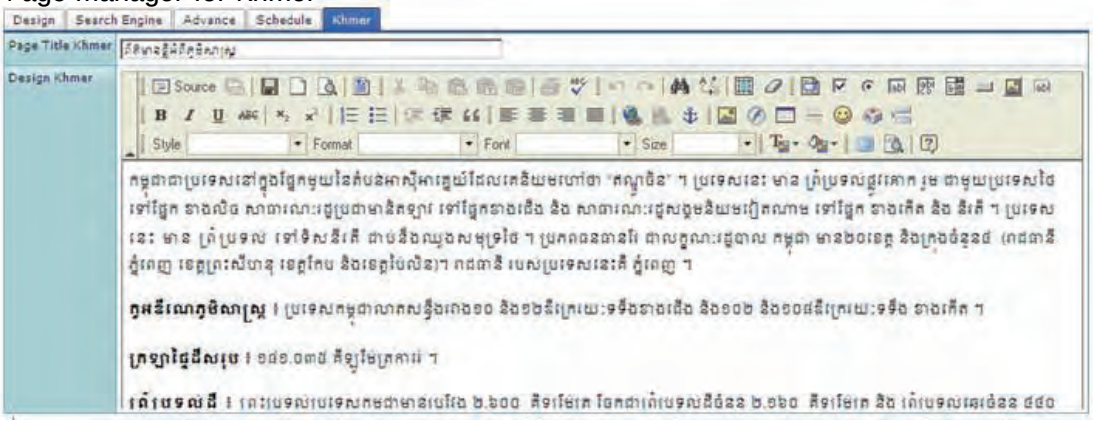


Fig.6.3.10 Page Manager for Writing Edit

6.4 Technology Transfer

Website Maintenance Training Course

Website maintenance training was implemented on 27th and 28th November, 2009 for six staff members selected from the four departments of the GDMR, using a newly developed website maintenance tool called CMS (Content Management System) with a user guidebook (Appendix VI-3, 4). The six participants were presented with certificates of completion after finishing the training course (Appendix VI-5).

Chapter 7 Proposed Action Plan for Investment Promotion

7.1 Goal for the Master Plan

The main goal of the Master Plan for Promoting the Mining Industry is to increase the mining sector's share of GDP in the coming 10 years.

According to a recent IMF statistical appendix, the mining sector accounted for 0.4% of Cambodia's GDP in 2007 (Table 7.1.1). The main aim of this study is to raise the share of GDP to 3% by 2015, and to 10% by 2020.

The development of Cambodia's mining industry will require the survey, exploration, development and production of that country's minerals. The mineral resource potential of Cambodia, as determined from Cambodian data, mineral resource information from neighboring countries, etc., has been estimated to include the following: 200-300 tons of gold; 4-5 million tons of copper; 200,000-300,000 tons of zinc; and 16 to 27 million tons of iron.

Furthermore, to reach the abovementioned target share of GDP proposed for the Cambodian mining sector, activities that will take 5-10 years to bridge the gap with the current state have been included as action plans in the present study.

The previous chapters have focused on the current state of and issues with the mining sector in Cambodia, and Cambodia's mineral resource potential. This chapter will introduce a proposed action plan for developing a sustainable mining sector in Cambodia that gives due consideration to the country's environment.

Table 7.1.1 Comparison of Economic Indices of the 3 Countries of Indochina

	Cambodia	Laos	Vietnam
Population (millions)	13.4 (2007)	6.3 (2008)	84.1 (2006)
GDP (billion US $)	8.7 (2007)	5.4 (2008)	60.9 (2006)
GDP per capita (US $)	649 (2007)	859 (2008)	723 (2006)
GDP growth rate (%, past 5 years)	9.9 (2002-2007)	7.1 (2003-2008)	7.8 (2002-2006)
Mining sector, share of GDP (%)	0.4 (2007)	25.8 (2008)	8.0 (2006)
Employment of Mining and quarrying sector (thousands)	22 (2007)	n.a.	n.a.

(Source: IMF Statistical Appendixes)

Cambodia

	2002	2003	2004	2005	2006	2007
GDP growth rate (%)	6.6	8.5	10.3	13.3	10.8	10.2
GDP of Mining sector (billion riels)	48	58	74	97	115	133
(share of GDP, %)	(0.3)	(0.3)	(0.3)	(0.4)	(0.4)	(0.4)
GDP growth rate of Mining sector (%)	25.6	18.1	24.2	26.3	15.9	6.4
Employment of Mining and quarrying sector	15	16	17	19	20	22
(thousands) (share of total, %)	(0.1)	(0.2)	(0.2)	(0.2)	(0.2)	(0.3)
GDP of Construction sector (billion riels)	985	1,106	1,288	1,631	1,995	2,338
(share of GDP, %)	(5.9)	(6.0)	(6.0)	(6.3)	(6.7)	(6.7)
GDP growth rate of Construction sector (%)	27.1	11.1	13.2	22.1	20.0	6.7
Employment of Construction sector (thousands)	120	153	195	234	260	299
(share of total, %)	(1.3)	(1.8)	(2.2)	(2.6)	(3.0)	(3.6)

(Source: IMF Cambodia Statistical Appendix)

(2) Summary of Action Plans

Table 7.1.2 summarizes the action plans proposed in this study, including budgets and time tables. Each action plan is described in detail in the following pages.

Table 7.1.2 Summary of Action Plans

	Action plan	Budget (1000 US$)	Basic Foundation Stage					Mining Fostering Stage				
			2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Institutional Reform	1. Improvement of basic information about mineral resources	1,810(T) 120(Y)										
	2. Establishment of Mining Council	10(Y)										
	3. Establishment of Mining Policy	-										
	4. Preparation of Mining Development Plan	160(T) 40(Y)										
	5. Amendment of the Mining Law and associated regulations related to mining	10(T) 20(Y)										
	6. Institutional reforms	100(T)										
	7. Fostering small and medium-scale mining	10-20(Y)										
	8. Preparation of mining infrastructure	5-10(Y)										
	9. Cooperation with stakeholders	10(Y)										
	10. Cooperation with neighboring countries	20(Y)										
Organizational Reform & Capacity Development	1. Construction of MIS, Promotion of publicity and Preparation of manuals	247(T) 10(Y)										
	2. Creation of Technology Center of Mineral Resources	1,600(T) 1,300(Y)										
Mine Safety and Environmental Management	1. Legal establishment for Mine Safety & Environment	73(T)										
	2. Establishment of National Safety Committee	10(T)										
	3. Intensive training for GDMR Staff for Safety/ Environment	80(T)										
	4. Establishment of Qualification System for Mining Operation	38(T)										
	5. Introduction of Environment Assessment	50(T)										
	6. Implementation of Base-line Survey	620(T)										
	7. Preparation of Guidebook for Mine Safety & Environment	50(T)										
	8. Unionization of Artisanal Gold Miners	800(T)										
	9. Decontamination of Areas Polluted by Artisanal Mining	1,000(T) /unit										

Expenditure T: Required at once (e.g. Investment cost), Expenditure Y: Required each year

High-priority action plans include 1) establishing a mining policy, 2) establishing a mining council, 3) amending laws and regulations related to mining, 4) establishing a legal framework for mining safety and mining environments, 5) improving basic information about mineral resources, 6) fostering small- and medium-scale mining, and 7) constructing an MIS.

7.2 Outline of the Action Plan for Mining Investment Promotion

7.2.1 Outline

The following items show investors' viewpoints about mining investment. Chapters 2 to 6 in this report examine the present state of and issues with the Cambodian Mining Sectors, based on these points of view.

Investor's View Point

- Mineral Potential
  - General/Mineral Geological Information/ (Exploration Activities)
  - Resource/Reserve Evaluation
  - Operational Situation of existing Mines/Mining History
- Political/National Economic Stability
  - Civil war/Conflicts with neighboring countries/International sanctions
  - Financial situation/ (National economics)
  - Political Ideology
  - Governance (by the national government)
- National Policy for Mining
- Infrastructure
- Land Use
- Local Communities
- Environmental Issues
- Mining Laws/Regulations
  - Non-discrimination against foreign investment
  - Equity and Equality
  - Securities for investment
  - Incentives/privileges for mining investment
  - Royalties/Fees
  - Procedures and systems for mining activities
  - Local communities
  - Environment
  - Resolution of conflicts
  - Occupational health and safety
  - Restrictions on mining by other laws
- Manpower
  - Capability of domestic engineers and skilled laborers related to mining operations
  - Availability of manpower and labor cost

Flexibility of employment of foreigners

Vocational education and training

- Procurement of equipment, spare parts, consumables, energy, etc.

Availability and cost (price)

Import duty

- Investment Laws/Regulations

One-Stop-Shop

Non-discrimination against foreign investment

Incentives/privileges for investment

Provisions for mining industries

- Taxation

International competitiveness

As a result of the discussion, the Study Team identified the items and associated actions to be carried out by the GDMR/MIME under the Action Plans for Mining Investment Promotion.

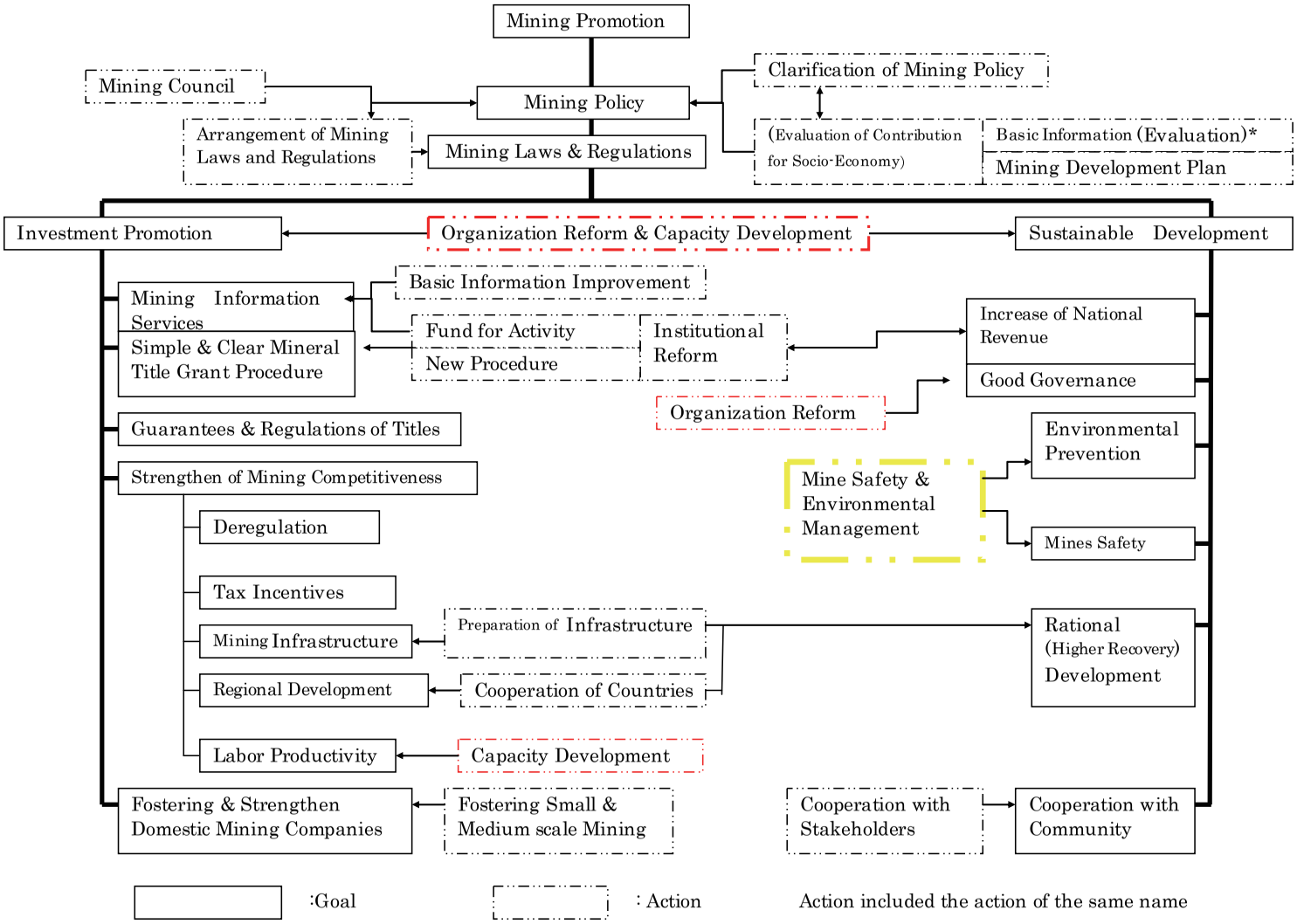


Fig.7.2.1 Outline of the Action Plan for Mining Investment Promotion

Fig. 7.2.1 is a schematic depiction of the goals and associated actions to be carried out under the Action Plan for Mining Investment Promotion.

Mining Promotion in Cambodia has the potential to become a key contributor to that country's socio-economic development.

To promote mining, the MIME must first clarify the significance of mining, and show the course of action in the 'Mining Policy'. With regard to the significance of mining promotion, the level of socio-economic contribution made by mining has to be examined (that is, mineral resources evaluation, calculations of resources and reserves within the context of 'Improvement of Basic Information about Mineral Resources', and 'Creation of a Mine Development Plan'). Then, based on the results of the evaluation, the course of action in the Mining Policy will be determined ('Establishment of Mining Policy'). In addition, a Mining Council should be established to reflect the opinions of the parties affected by mining activities and persons with knowledge of and experience with mining policy and mining laws and regulations ('Establishment of a Mining Council').

With the exception of construction materials, mining in Cambodia is largely undeveloped, so the promotion of mining investment is the key to promoting the mining sector.

Moreover, sustainable development, which involves the development of a robust mining industry and healthy socio-economic conditions that will continue to provide prosperity for future generations, is an essential part of mining promotion.

Therefore actions for sustainable development are considered to be the critical elements of the 'Action Plan for Mining Investment Promotion'.

To accelerate the promotion of mining investment, the GDMR will require its organizations and staff to undertake the 'Organizational Reform and Capacity Development' project.

To attract mining investors to Cambodia where only construction materials have been mined for many years, it is necessary to publicize the great potential for mineral resources in Cambodia. For that purpose, it is advisable to collect, analyze and map/compile new and detailed geological information, and information on current mining activities in the country, as well as to establish a system to enable investors to access the information easily ('Improvement of Basic Information of Mineral Resources' and funding for activities in 'Institutional Reform').

To promote mining investment, it is important to learn techniques from advanced mining countries, and then offer more attractive measures to investors.

Many countries that have succeeded in promoting mining investment have not only had rich mineral resources potential, but have also facilitated investors' access to mining rights by simplifying and clarifying the procedures for acquiring mining licenses ('Amendment of Laws and Regulations related to Mining' (hereafter 'Arrangement of Mining Laws and Regulations' and new procedures in 'Institutional Reform')). In addition, they provide 'Guarantees of Title' to facilitate mining activities. In Cambodia, it is important to clarify these items ('Arrangement of Mining Laws and Regulations') while implementing clear regulations that will prevent merely speculative investment in mining licenses where there is no intent to do

any actual mining.

Mine development is a risky business, because its viability depends on the characteristics of each ore deposit, such as ore grade and conditions of occurrence (area and volume, depth, dip, shape, geological conditions, and so on). Moreover, mines usually require a considerable amount of time and money to develop. For this reason, many mining countries have implemented various measures to provide financial support for mining activities. One of the most popular measures is preferential tax treatment. Also, the rates of royalties and fees have been reviewed in conjunction with global mining trends. It is desirable for Cambodia to provide taxation and incentives that have stronger competitiveness in comparison with other countries (‘Arrangement of Mining Laws and Regulations’).

Moreover, based on market economic principles, Cambodia should deregulate mining product transactions, in order to encourage the creation of mine products which provide a higher economic value to the country (‘Arrangement of Mining Laws and Regulations’).

The conditions for developing mining infrastructure, especially of transportation and energy, severely affect mining viability. Except for the biggest high-grade deposits in the world, it is financially unfeasible for a mining company to develop a mine which requires the construction of more than 100 km of transportation infrastructure. For this reason, the Government should develop the infrastructure (‘Preparation of Mining Infrastructure’).

Based on the geological information of this region, there is a possibility that mineral resources exist in the border areas with Laos, Vietnam, and Thailand. It is therefore important not only for economic reasons but also for sustainable development considerations, to prepare a framework for the reasonable development of mineral resources in collaboration with neighboring countries (‘Cooperation with neighboring countries’).

In addition, Cambodia should eliminate illegal mining while providing support to nurture legal artisan miners; and in the future, implement measures to foster and enhance domestic mining companies that will stabilize and encourage mining investment and economic activities in Cambodia (‘Fostering small- and medium-size mining’).

From the sustainable development point of view, mining wealth should be distributed to promote national prosperity, that is, it should be earmarked for poverty reduction, community development in mining areas, and re-investment in mining activities (‘Institutional Reform’).

Naturally, it is important to undertake mining activities under Good Governance (‘Arrangement of Mining Laws and Regulations’).

Mine safety and environmental management, under the newly prepared mining environmental and mining health & safety laws and regulations, are necessary to promote favorable mining activities (‘Mine Safety and Environmental Management`).

Moreover through cooperation with neighboring countries and development of infrastructure, the Government should focus on maximizing the economic benefits from mineral resources, which are finite and preserving resources for the future.

Conflicts between government, mining companies, communities, and environmental organizations have taken place in various countries around the world. To avoid these situations

while developing the mining sector, the Government must mediate the relationships between the stakeholders, such as miners, local residents, and so on, to create a cooperative atmosphere (‘Cooperation with Stakeholders’).

7.2.2 The Time Period for the Action Plan

The Time Period for the Action Plan is ten years, divided into two stages: the “Basic Foundation Stage” (2011-2015) and the “Mining Fostering Stage” (2016-2020).

To expand mining investment during the Basic Foundation Stage, the GDMR/MIME should carry out the activities to formulate the Mining Policy, complete the arrangement of mining laws and regulations, strengthen its institutional organization, and improve the information services.

In 2016, when mine development should be growing, and more detailed information on mineral resource occurrences will be available, the Government should specify the details of mine development plans carried out by the nation, then set the key goals, and create a mine development environment that facilitates full-scale development.

7.2.3 The Framework of the Action Plan for Investment Promotion

The Action Plan for Investment Promotion consists of following three parts:

(1) Institutional Reform (the actions outlined by the black border in Fig.7.2.1)
(2) Organizational Reform and Capacity Development (the actions outlined by the red border in Fig.7.2.1)
(3) Mine Safety and Environmental Management (the actions outlined by the yellow border in Fig.7.2.1)