CHAPTER 5 TECHNICAL TRANSFER IN GEOLOGICAL SURVEY

5.1 Introduction

The important point in technical transfer on geological mapping for the geologists of DGEO is to enable them to acquire technological strength and knowledge required for ongoing geological mapping at scale 1:200,000 and mineral resources assessments and to carry out the same work by themselves.

Basic technological strength comes from geological classification. The field survey provides them with opportunities for their experiences to geologically classify every occurrence in the actual site selected for the mapping. On the other hand, mapping and mineral resources interpretation needs for knowledge about geology and ore genesis in the area.

We found that DGEO's geologists who have experience in overseas studying and/or training have acquired technology and knowledge enough for mapping and mineral resources interpretation during the preliminary field survey for the mapping area selected. On the other hand, the others have not even for mapping by their own, although they have high motivation for acquiring general knowledge on exploration and mining and technology for field survey.

Based on the above, we held workshop on basic knowledge necessary for mapping and mineral resources interpretation prior to the second survey. We intended to enable them to strengthen their knowledge on geology and mineral deposit so that we would smoothly carry out actual work in the site.

5.2 Workshop for Geological Mapping

The workshop agenda included route map making, bedding observation and rock identification as basic knowledge for mapping and detail geological observation on rocks and mineralization, geochemical prospecting, reading of satellite image and aerial photograph, etc. as supplemental knowledge. The workshop was held on 4 and 5 October 2006 at the DGEO main office. Participants from DGEO were 16 persons in charge of geology, geochemistry and GIS.

Workshop agenda were as follows:

① Introduction
② Outline of geological map
③ Outline of geological mapping
④ Geology in the field -general geology-
⑤ Practice for field work
⑥ Geology in the field -sedimentary rocks-
⑦ Geology in the field -igneous rocks-
⑧ Geology in the field -metamorphic rocks-
⑨ Geology in the field -structural geology-
⑩ Geochemical exploration
⑪ Interpretation of field data
⑫ Alteration and mineralization
⑬ Fundamentals of photo-interpretation
⑭ What is remote sensing ?
⑮ Application of remote sensing techniques
⑯ Practice of photo-interpretation

Photo 5.2.1 Technological presentation at workshop

Photo 5.2.2 Technical training at workshop (Aerial photograph reading)

5.3 Preliminary Training in Attapeu

The actual site training of total five days was conducted for six geologists of DGEO who were our survey team members prior to and during the field survey, i.e., on 11 through 13 October 2006, on 11 November 2006 and on 15 January 2007. We had Dr. Yasushi Watanabe, Group Leader of Mineral Resources Research Group, National Institute of Advanced Industrial Science and Technology, join our training on 15 January 2007 and strengthen their knowledge on geology and mineralogy. Through the actual site training, they acquired practical technology and knowledge on what they learned in the workshop. Actually, they carried out survey work based on their acquirement.

Programs for the actual site training were shown in Table 5.3.1.

As described above, our survey campaign for mapping at scale 1:200,000 includes actual surveying and training for the DGEO geologists to ensure strengthening their technology and knowledge.

Participants in our surveying are as follows:

- Mr.Sixomxeun Duangsurigna, Senior Geologist, DGEO in Vientiane
- Mr.Siphandone Vilayhack, Senior Geologist, DGEO in Vientiane
- Mr.Phonetalome Vilaysan, Geologist, DGEO in Vientiane
- Mr.Sisaad Phomkenthao, Geologist, DGEO Pakxe Office
- Mr.Thavone Khounchanthida, Geologist, DGEO Pakxe Office
- Mr.Amkha Voravong, Geologist, DEM of Attapeu Province

Table 5.3.1 Programs for the actual site training

Geographical understanding	
—	To take a position on a topographic map
—	To take a location by using GPS
—	To plot a location to route map
Geological basic understanding at an outcrop	
—	To name a rock
—	To name a rock forming mineral
—	To measure dip and strike of a stratum
—	To decide rock facies
—	To decide a fault
—	To decide hierarchical relation of stratums
—	To decide old and new relation of igneous rocks
—	To describe geological phenomenons on the route map and a field note
Basic understanding for ore deposits	
—	To define fracture characteristics
—	To identify alterations
—	To name altered minerals
—	To identify mineralizations
—	To name mineralizaed minerals
—	To describe ore deposit phenomenons on the route map and a field note
Basic understanding for geochemical sampling (stream sediments)	
—	To select point to conduct sampling at stream
—	To carry out sampling by using a sieve
Basic understanding for geological mapping	
—	To draw up geological cross section based on described route map and field note
—	To draw up geological columnar section based on described route map and field note
—	To draw up geological boundary trace on the topographical map

Photo 5.3.1 Observation instruction at the outcrop

Photo 5.3.2 Formation measurement instruction

Photo 5.3.3 Observation instruction at mineral indicative outcrop

Photo 5.3.4 Geochemical instruction for riverbed sand sampling

5.4 Training for Geological Mapping in Attapeu

We have two teams made up of a Japanese geologist and three DGEO geologists for each from an efficiency point of view in terms of fieldwork and on-the-job training. The topographical map used for surveying is the 1:50,000 map issued by National Geographic Department since our mapping scale is 1:200,000. The second and the third field survey were carried out, respectively, on 11 October 2006 through 13 December 2006 and on 13 January 2007 through26 February, including the actual site training.

Photo 5.4.1 Compiling data after field survey

Photo 5.4.2 Identification of rock samples

We held workshop on results of the second survey and presentation of the current technological information on mineral deposits as a seminar prior to the third survey, aiming at further strengthening of their capacity for geological and deposit investigation, on 9 January 2007 at the DGEO main office. Participants from DGEO were 9 persons in charge of geology, geochemistry and GIS. We had Dr. Yasushi Watanabe, Group Leader of Mineral Resources Research Group, National Institute of Advanced Industrial Science and Technology present items c and d below.

Workshop agenda were as follows:

a. Result of the second survey

b. Occurrences of metamorphic and granitic rocks in the eastern Attapeu - the second survey

c. Present situation of rare earth resources and deposits

d. Hydrothermal alteration patterns over the El Salvador porphyry Cu deposit, Chile

During the geological survey of the third survey, progress of strengthening the capacity of DGEO geologists for geological investigation was confirmed for identifying what aspects of technique and knowledge have not acquired. Before the end of the third survey of geology and mineralization surveys, draft geological map was produced. Since the final map was to be produced in 1/200,000 scale, draft geological maps were produced in 1:100,000 scale. An occasion to produce geological map only by DGEO geologist was set to know the progress of training and level of understanding. A summary of levels of the skills and knowledge as of the end of the third survey are rated for DGEO geologist on an individual basis.

The fourth survey was conducted in DGEO, Vientiane, during the period of June 7 to 29, 2007. During this period, the results of the second and third surveys were considered together with the results of various laboratory work and stream sediments geochemical survey and draft geological map (1:200,000 scale) was produced based on the original geological map at a scale of 1:100,000. In addition to this, selection of the areas for detail geological mapping area (1:10,000) for the fifth survey was done through this work. The technical transfer of following three aspects are conducted to the geologist of DGEO.

a. Compilation of original geological map (1:100.000 scale) to the final geological map (1:200,000 scale)

b. Understanding the various results of laboratory work and application of them to mineral exploration

c. Identifying anomaly of stream sediments geochemical survey

The fifth field survey consisting of geological survey in the detail area was conducted from October 15 to December 17, 2007. The purpose of geological survey of this period was to create 1/10,000 scale geological maps in the detail area. The main object of this field survey for technical transfer to the DGEO geologist is to further accumulate on-site experiences of geological survey and mineral exploration and obtaining skills to applying these to actual situations by themselves.

On to conduct geological survey in the detail area, C/P has to recognize fully about the following. Therefore, we held the meeting about following and unified consciousness among participants of geological survey.

a. Why must we investigate the area to be intended for in detail ?

b. What kind of deposit can be existed in the area ?

C/P was drawn geological route map and draft geological map as a post field activity by themselves. Through this work, C/P could be taken experience about geological survey and prospecting more than before (Photo 5.4.3).

During fifth field survey from December 2 to 14 in 2007, we had Dr. Yasushi Watanabe, Group Leader of Mineral Resources Research Group, National Institute of Advanced Industrial Science and Technology and Mr. Satoshi Kobayashi, Natural Resources and Energy Conservation Team, JICA, joined our field work. Through this joint activity, Dr. Watanabe instructed following to C/P in the filed (Photo 5.4.4).

a. An observation method of mineral occurrences in the outcrop

b. A recognition method of the spatiality of alteration in peripheral area of mineral occurrence locality

c. An interpretation method of the process of deposit formation

The sixth field survey continuously to follow fifth field survey was conducted from January 12 to February 26, 2008. The purpose of geological survey of this period was to create 1/10,000 scale geological maps in the detail area. In addition, detailed geological survey to confirm a persistence of comparatively promising mineral occurrence which discovered by fifth field survey was conducted by following method (Photo 5.4.5 and Photo 5.4.6).

a. Trench survey of the peripheral area of mineral occurrence locality (trench size is 10m in length)

b. Tracking survey of the mineral occurrence (area width is 2km x 1km)

We engaged in technical transfer about the method to make a next phase survey plan after above surveys on the assumption that C/P discovered a promising mineral occurrence in the act of geological mapping, scale 1/200,000 or 1/10,000.

Photo 5.4.3 Drawing of geological map by C/P

Photo 5.4.4 Participants of survey with Dr.Watanabe

Photo 5.4.5 Trenching survey near by mineral occurrence

Photo 5.4.6 Discovery by tracking survey

5.5 Progress of Technical Transfer and Present Skill Level

Through the geological surveys until the 6th field survey, basic understanding and practice on geological mapping and mineral survey of DGEO's geologists have been increased steadily by OJT. Counterparts' level of geological survey has been improved and they have come to recognize importance of field data acquisition on geology and mineralization at outcrops. Their motivation has increased during the geological survey in this project. We can evaluate that they have grown up so that they can draw geological maps by themselves under the supervisor or in a small area. A summary of levels of the skills and knowledge as of the end of the sixth field survey are rated for DGEO geologists on an individual basis (Table 5.5.1).

Table 5.5.1 Skill level ratings as of the end of the 6th field survey

Subject for geological field training 2nd to 6th Field Survey (October 2006 to February 2008)	Intelligibility level after field survey					
	DGEO (Vientiane)			DGEO (Pakxe)		DEM (Attapeu)
	Mr. Sixomxeun Duangsurigna	Mr. Siphandone Vilayhack	Mr. Phonetalome Vilaysan	Mr. Sisaad Phomkenthao	Mr. Thavone Khounchanthida	Mr. Amkha Voravong
Geographical understanding	*2nd → 6th*	*2nd →6th*	*2nd →6th*	*2nd →6th*	*2nd →6th*	*2nd → 6th*
− To take a position on a topographic map	H→H	H→H	H→H	H→H	H→H	H→H
− To take a location by using GPS	H→H	H→H	H→H	H→H	H→H	H→H
− To plot a location to route map	H→H	H→H	H→H	H→H	H→H	H→H
Geological basic understanding at an outcrop	*2nd → 6th*	*2nd →6th*	*2nd →6th*	*2nd →6th*	*2nd →6th*	*2nd → 6th*
− To name a rock	H→H	H→H	M→MH	M→MH	M→MH	M→MH
− To name a rock forming mineral	H→H	H→H	M→MH	M→MH	M→MH	M→MH
− To measure dip and strike of a stratum	H→H	H→H	M→H	M→H	M→H	M→H
− To decide rock facies	H→H	H→H	M→MH	M→H	M→MH	M→H
− To decide a fault	H→H	H→H	L→M	L→H	L→M	L→H
− To decide hierarchical relation of stratums	H→H	H→H	M→MH	M→H	M→MH	M→H
_ To decide old and new relation of igneous rocks	H→H	H→H	L→M	L→MH	L→M	L→MH
_ To describe geological phenomenons on the route map and a field note	H→H	H→H	L→M	L→H	L→M	L→H
Basic understanding for ore deposits	*2nd → 6th*	*2nd →6th*	*2nd →6th*	*2nd →6th*	*2nd →6th*	*2nd → 6th*
− To define fracture characteristics	H→H	H→H	L→M	L→MH	L→M	L→MH
− To identify alterations	H→H	H→H	L→M	L→MH	L→M	L→MH
− To name altered minerals	H→H	H→H	L→M	L→MH	L→M	L→MH
− To identify mineralizations	H→H	H→H	M→MH	M→H	M→MH	M→H
− To name mineralizaed minerals	H→H	H→H	L→M	L→MH	L→M	L→MH
_ To describe ore deposit phenomenons on the route map and a field note	H→H	H→H	L→M	M→MH	L→M	M→MH
Basic understanding for geochemical sampling (stream sediments)	*2nd → 6th*	*2nd →6th*	*2nd →6th*	*2nd →6th*	*2nd →6th*	*2nd → 6th*
− To select point to conduct sampling at stream	H→H	H→H	H→H	H→H	H→H	H→H
− To carry out sampling by using a sieve	H→H	H→H	H→H	H→H	H→H	H→H
Basic understanding for geological mapping	*2nd → 6th*	*2nd →6th*	*2nd →6th*	*2nd →6th*	*2nd →6th*	*2nd → 6th*
_ To draw up geological cross section based on described route map and field note	H→H	H→H	M→MH	M→H	M→MH	M→H
_ To draw up geological columnar section based on described route map and field note	H→H	H→H	L→M	M→H	L→M	M→H
_ To draw up geological boundary trace on the topographical map	H→H	H→H	L→M	M→H	L→M	M→H

H: high level, MH: moderate to high level, M: moderate lebel, L: low level

Most of DGEO's geologists, who have already got higher level capacity, are older than 40 years. They have experience of studying abroad with scholarship in foreign countries such as old Soviet Union, Eastern Europe, Vietnam etc. Academic career of younger geologists are limited to graduates from technical school. Most of the young geologists, who count for more than half of the total number of staff, are less experienced in geological survey, mineral exploration and interpretation work. Budget of DGEO for geological survey and the mineral exploration is limited. Apart from manpower, necessary materials and vehicles for field survey are not equipped in DGEO. Consequently, field activities of DGEO are concentrated and connected to occasion of joint surveys together with foreign countries or limited to supportive activities associated with such project.

Hereafter, geologists of DGEO will come to examine and evaluate survey reports submitted by concession holders and mining companies. While they need relevant knowledge of geology and metallogeny and ability of geological survey work to fullfil these tasks, it is important assignment to secure geologist and to encourage geologist.

As mentioned, the present technology can be summarized as follows;

1) The basic technique of geological survey work and mineral exploration is gradually improving.

2) They do not reach a level yet that they can carry out individually survey in a large area such as the area of 1/200,000 scale geological mapping.

3) They do not reach a level yet that they can individually do geological and metallogenyic interpretation.

4) Lack of necessary equipment for geological survey and mineral exploration and necessary materials for making thin sections and polished specimen is hindering smooth implementation of survey work.

5.6 Technical Assignment

The consciousness for geological survey and fundamental ability of the geologists in DGEO has been improved through technical transfer of geological survey until end of 6th field survey. However, it is important to increase the advanced knowledge related to drilling survey and geophysical survey, in order to conduct field survey and interpretation of survey results by DGEO individually.

It is expected that elder geologist with much experience will retire and number of younger geologist with less experience will increase in near future. Under such circumstances, it becomes important to acquire advanced knowledge of geology/metallogeny and high technology of survey/exploration for DGEO to conduct individually field survey/prospecting and make report of the survey. It is also very important to draw up an education system for settling these matters and to encourage talent in it.

Based on the items mentioned above, the assignment to the future is as follows;

1) Although the geologists of DGEO have reached a level that they can individually make geological mapping through OJT of geological mapping and mineral exploration, it is recommendable that geologists of DGEO individually carry out geological survey work in a standard area consisting of simple geology relatively easy to interpretation, for further CD of geological works.
2) If any mineral potential area is found, further mineral exploration work will follow. There are various geological works at advanced stages of exploration. As the geologists of DGEO do not have experience of geological works of latere stage of exploration, hereafter, it is necessary to expand understanding and experience of survey method adopted in each phase of mineral exploration process.

3) To improve geological survey method and mineral exploration technology, it is necessary to level up technical strength and to collect information of geology and metallogeny, through studying abroad, cooperating with foreign researchers and so on.

4) To ensure succession of technology, it is necessary to settle problem of understaffed and to train geologists and technical leader.

CHAPTER 6 GEOCHEMICAL ANALYSIS

6.1 Introduction

Geological sample analysis takes place at a division of DGEO called the Analytical Division (hereinafter referred to as the Lab). The Lab's daily activities include preparation of samples, thin section, polishing, chemical analysis, and mineral analysis. The main objective of the project is the capacity development of the Lab staff counterparts (C/P) through OJT (On the Job Training) analyzing samples that are collected in the field for the purpose of geochemical mapping.

6.2 Present Situation and Issues of the Lab

6.2.1 Human Resources

The Lab had eleven(11) staff members at the beginning of this project activity, and has recruited two more new members, and one member moved to a provincial office so that the total number of staff members is now twelve(12) (as of July 2008); the staff list is attached in Annex 11. In the first period of the field survey, two of the Lab staff members took residence in the Sepon mine, and according to information obtained from one of the C/P, there are already one or two staff sent to Sepon mine from DGEO. The dispatched staff stays at the site for a few months in general, and they are separated from ordinary work at the Lab.

In the Lab, an Atomic Absorption Spectrophotometer (hereinafter mentioned as AAS) is mainly operated by two deputy directors to determine the metal element, and seven analysts (including two new members) are engaged in the preparation of samples, pre-treatment and wet analysis. A total of three geologists and mineralogists are on staff to cut samples, crush and make thin sections and conduct mineral analysis. Only a few of the staff are engaged solely in laboratory work since most are busy conducting fieldwork, participating in negotiations with mining companies and so on, so that few samples are analyzed compared with the number of staff.

6.2.2 Condition of Analytical Instruments and Consumables

The main analytical instruments are listed in Annex 12.

The foremost problem is the difficulty to maintain and update instruments because of insufficient budget provisions.

The AAS is an indispensable analytical instrument for the analysis of any metal sample. During the first field survey, however, only one of the three AAS was barely operational. The Lab recognizes the importance of maintenance, but it is limited by its budget. There is no service engineer for AAS in Laos, so an engineer is usually called from a manufacturing agency in Thailand. When an instrument goes out of order, it tends to be left for long periods of time due to lack of budget. Many of the analytical instruments face the same problem and are vulnerable to break down at any time.

There are few suppliers in Laos, so generally they don't have stocks of laboratory consumables and equipment and must import these things from foreign countries when they have an order. The terms of delivery largely depends on what kind of equipment or consumable is ordered. Delivery of spare instruments takes more than a month, while common chemicals can be supplied in a week.

The scope of the Project does not include supply of equipment, however, the Project team considered it is necessary to keep the equipment working in order to conduct the minimum required analysis, and decided to request an agent to check the existing AAS. Meanwhile, the DGEO also considered the AAS problem is serious, and in October 2006 a new AAS (AA-6300) was installed in the Lab. On the other hand, the project team called a service engineer in June 2008 to perform maintenance on a furnace AAS which had been left inoperational since 2001. Now it is in working condition. Table 6.2.1 presents the condition of AAS at present.

Table 6.2.1 Present conditions of AAS

Name	Manufacturer	Condition
GBC 902	GBC	Flame-type AAS. Not working. Because model is too old, repair parts are no longer available.
GBC 902	GBC	Same model as above. In poor condition with insufficient sensitivity so that it is no longer used since installation of AA-6300.
GBC 932AA	GBC	Graphite furnace-type AAS, designed for high sensitivity analysis. Originally it was introduced for water analysis by UNDP project. The study teams examined the possibility of repair and finally fix it. Now it is in working condition.
AA-6300	Shimadzu	Flame type AAS. Installed in 2006. Only one instrument currently working for geochemical analysis

Photo 6.2.1 AAS-GBC902 (flame type)

Photo 6.2.2 AAS-GBC932AA (graphite furnace)

Photo 6.2.3 AAS-Shimadzu6300 (flame type)

Photo 6.2.4 AAS-Shimadzu6300 (flame type)

6.2.3 Actual Chemical Analysis

The Lab's analysis targets are rock, ore, sand, soil, sediment and water, although water samples have not been analyzed up to the present date.

The Lab has the capacity to handle all general parameters for rock analysis. Previously, the water purifier was not in working order, so the parameters which need pure water for analysis, such as MgO and CaO, could not be carried out. In February 2007, the operation of a water purifier (water distiller)

began, so this type of analysis can now be done. It should also be noted that Lab has no experience to analyze rare earths.

The major element of ore can be analyzed, but the detection limit is relatively high. Tin and titanium had not been analyzed, because of shortages of chemical and equipment troubles. Antimony cannot be analyzed because a special attachment is needed i.e. a hydride generator for AAS. Tungsten has never been analyzed.

As DGEO has not carried out any of its own projects or research, the main activity of the Lab is to analyze samples from outside sources such as mining companies or investors with payment. However, the money earned is passed on to the government because the Lab is not operating on a self-supported accounting system. Some of the samples require only preparation without analysis, and in these cases, the client then sends the prepared sample to a testing laboratory in other country.

Ore samples are usually analyzed by aqua regia digestion. The standard operating procedure (SOP) developed by a UNDP expert was partially modified by analysts to be utilized for daily analysis. They are sure to include SRM (Standard Reference Material) in each one lot of analysis samples, and always check the reliability. If the measured SRM is different from the recommended value, an analyst will re-analyze the sample lot. However, the specific criterion for rejecting outliers has not been determined.

NOTE: What is SRM?
SRM is the certified reference material that supports a producer's measurement of the concentration of an element or mineral. There are many associations which produce and provide SRM, e.g., NIST (National Institute of Standards and Technology, USA), USGS (United States Geological Survey), AIST (Institute of Advanced Industrial Science and Technology, Japan), etc. In the field of geochemistry, many types of geological samples are supplied.

6.3 Geochemical Analysis Plan

Table 6.3.1 shows the original plan before starting the field survey.

Table 6.3.1 The original geochemical analysis plan

Item and Element	No	Survey Stage and Number of Samples			
		Geological Mapping		Mineralogical Survey	
		Phase II	Phase III	Phase V	Phase VI
(1) Thin section	100	25	25	25	25
(2) Polish section	100	20	20	30	30
(3) X-ray diffraction	100	20	20	30	30
(4) Rock analysis SiO_2,TiO_2,Al_2O_3,Fe_2O_3, FeO,MgO,MnO_2,CaO,NaO_2 K_2O,P_2O_5,LOI: 12 elements Rb,Sr,Ba,Zr,V,Nb,Y,La,Ce, Pr,Nd,Sm,Eu,Gd,Tb,Dy,Ho, Er,Tm,Yb,Lu: 21 elements	30	10	10	5	5
(5) Ore analysis Au,Sb,Ag,Cu,Fe,Mn,Ni,Pb,Zn, Ti,Sn,W: 12 elements	200	40	40	60	60
(6) Stream sediments Au,Sb,Ag,Cu,Fe,Mn,Ni,Pb,Zn, Ti,Sn,W: 12 elements	4000	2000	2000		
(7) Magnetic susceptibility	100	30	30	20	20
(8) Fluid inclusion	30			15	15
(9) Geo-chronological analysis K-Ar or U-Pb	6			3	3

The plan was modified to correspond with the present conditions of the Lab. The points of revision are explained below.

X-ray diffraction was done in Japan due to a lack of apparatus at the project site.

Geo-chronological analysis and fluid inclusion could not be analyzed at the site, so it was outsourced.

Magnetic susceptibility was to be measured at the site.

In general, geochemical surveys start from screening to scoping. At the first stage, a large number of samples, such as stream sediment, should be analyzed for screening to discover any anomalies. The analysis is best done within a short period of time to detect lower concentrations. The most suitable analytical procedure is thought to be coincidental multi-element analysis such as ICP (Induced Current Plasma spectroscopy). Unfortunately, the AAS used by the Lab can only analyze the elements one by one, and the detection limit is relative high. Moreover, human capacity is limited, so the screening purpose analysis is difficult to complete in a certain period while staff continue other daily procedures. Therefore, the study team decided that the Lab would only analyze ore samples. The study team decreased the number of parameters because of the difficulties to gain accurate analysis results. The following twelve elements were originally targeted: Gold (Au), Silver (Ag), Copper (Cu), Iron (Fe), Manganese (Mn), Nickel (Ni), Lead (Pb), Zinc (Zn), Titanium (Ti), Tin (Sn), Tungsten (W) and Antimony (Sb). However, recently Tungsten (W) and Antimony (Sb) were excluded for the following reasons:

- Antimony cannot be measured accurately without a special attachment.
- Tungsten analysis needs a particular lamp for AAS.

Other sample analysis was contracted out to ALS-Chemex, an Australian laboratory well established in the field of geochemical analysis. This company has a branch office in Vientiane so the smooth and prompt delivery and analysis of samples is expected.

The number of ore samples analyzed in the Lab is listed in Table 6.3.2.

Table 6.3.2 Number of ore samples

	Number
(1) 2nd field survey	19
(2) 3rd field survey	29
(3) 5th field survey	57
(4) 6th field survey	55
(5) 6th field survey (addition)	25
Total	185

6.4 Actual Technical Transfer

6.4.1 Evaluation of Analytical Technique

The Lab has gained a certain technical level over its many years experience, but in terms of individual staff capacity, it seems to vary greatly and the quality of work is scattered. Because laboratory quality management is not sufficient, troubles were observed, such as problems identifying samples, misunderstanding dilution factor, and serious contamination caused by human error. Therefore, the strengthening of laboratory control is necessary, including quality control. The staff takes measures depending on the occasion, not to improve the overall system.

6.4.2 Items of Technical Transfer

Following the above discussion, the technical transfer was done through OJT in the Lab. Actual activity is discussed below.

<Recovery test using SRM>

To know the actual accuracy and limit, the staff analyzed SRM repeatedly, and checked the resultant value against the recommended value. The result is summarized in Table 6.4.

Table 6.4.1 Recovery test

Element	Result	Name of SRM				
		GXR1	GXR3	GXR4	GXR6	JCu
Cu (ppm)	analyzed	1078	8.3	5626	61.4	3.69%
	recommended	1110±115	15±5	6520±550	66±6	3.71%
	evaluation	acceptable	slightly low	low	acceptable	acceptable
Zn (ppm)	analyzed	784	207	72.4	127	
	recommended	760±100	207±33	73±7	118±17	
	evaluation	acceptable	acceptable	acceptable	acceptable	
Pb (ppm)	analyzed	750	37.2	58.9	113	
	recommended	730±60	15±7	52±6	101±15	
	evaluation	acceptable	high	acceptable	acceptable	
Fe (%)	analyzed	25.8	19.4	2.96	5.51	
	recommended	25±1.2	19±0.4	3.09±0.06	5.58±0.41	
	evaluation	acceptable	acceptable	slightly low	acceptable	
Mn (ppm)	analyzed	790	22020	130	940	
	recommended	880±70	22300±2400	149±26	1040±50	
	evaluation	slightly low	acceptable	acceptable	slightly	
Ni (ppm)	analyzed	20.8	35.1	23.6	8	
	recommended	41±8	60±15	42±6	27±3	
	evaluation	low	low	low	low	
Ag (ppm)	analyzed			3.1		
	recommended			4±1		
	evaluation			acceptable		
*Au (ppm)	analyzed	2.35～2.67				
	recommended	2.76				
	evaluation	acceptable				

* Pe-1 is used as SRM for Au analysis.

The results seem mostly acceptable except for Nickel analysis. It was later recognized that the digestion procedure for Nickel was not suitable, and therefore, a new digestion procedure has been introduced.

<AAS analysis by high temperature burner>

Some elements, such as Tin, Molybdenum, Titanium etc., require the use of a particular high temperature burner for AAS analysis. The Lab staff had no experience with high temperature analysis using the Shimadzu AAS, therefore practical training was given.

<Analysis of Ti, Sn and FeO>

There was also practical training given for the analysis of Ti, Sn and FeO.

Photo 6.4.1 Analysis of FeO

Photo 6.4.2 Gold analysis by AAS-6300

Photo 6.4.3 Alkaline fusion of ore sample

<Alkaline fusion for sample preparation>

Alkaline fusion is a basic technique for geological sample preparation, however, the analysts at the Lab were not familiar with the technique. Training was provided to the staff and Ti, Sn and Ni were analyzed using this technique.

<Improvement of AAS analysis accuracy>

Training was given in advanced techniques to obtain more precise measurement for samples which have interference or high coexisting material. The new techniques are matrix-matching, solvent washing and the dilution method. These methods were tested and compared with the previous technique, and then actual effectiveness was confirmed.

<Determination of MDL and LOQ>

The Lab had never examined MDL (Method Detection Limit) and LOQ (Limit Of Quantitation). In the past, a UNDP expert gave the staff some suggestions concerning the reporting of results but it was not understood. During technical assistance this time, it was repeatedly explained that the limit of

detection for chemical analysis should be determined through experiment in each laboratory. The results are summarized in Table 6.4.2.

Table 6.4.2 MDL and LOQ

	Ag	Cu	Pb	Zn	Au	Ni	Ti	TiO2
Test date	2006.11	2006.11	2006.11	2006.11	2007.2	2007.1	2007.1	2007.1
unit	ppm	ppm	ppm	ppm	ppm	ppm	ppm	%
Mean value	3.06	1.99	15.10	38.80	0.28	18.5	354.8	
Standard deviation	0.25	0.69	4.53	1.52	0.05	2.7	46.5	
Detection limit	0.8	2	15	5	0.2	10	150	0.02
Quantitation limit	2.5	7	45	15	0.5	30	500	0.08

<Direction of quality management>

Through the repeated analysis of recovery testing to determine the detection limit, some problems in the analysis became obvious. For example:

- Contamination in the laboratory
- Mistakes in the preparation of calibration standards
- Miscalculation of the dilution factor
- Selection of unsuitable calibration curves
- Operation of equipment without calibration

Based on the situation, the technical guidance for staff was given with the purpose to improve the laboratory. The laboratory chief started giving detailed direction to analysts to reduce the frequency of mistakes. At the same time, emphasis was put on the importance of calibrating measurement tools, such as the micropipette. The analysis was repeated multiple times with known concentration samples in order to check improvement.

<Analysis manual>

An analysis manual was made containing sample treatments and reporting procedures. The manual was reviewed and revised through the activities to make improvements for the purpose of both the convenience for analysts and to establish good practice. The attached manual is the latest version in the sixth activity period. (Annex 13)

<Training of O&M for Furnace AAS>

When the project team outsourced maintenance of the furnace AAS, the team also arranged for training on O&M (operation and maintenance) to laboratory staff members to prepare to start operations. Because the Thai language is very similar to the Lao language, laboratory members could easily understand the Thai engineer. Therefore, almost all laboratory members attended the training and gained a certain understanding. The training was led by a pair of engineers from an Agency of GBC Company; a service engineer who is an expert of machinery, and an application chemist who is familiar with analysis by GBC AAS. For this reason, the trainees were able to learn not only AAS O&M, but also important points on detailed analytical procedures. So the training was very fruitful for all staff members.


Photo 6.4.4 Training for furnace AAS operation by Thai engineer

<Small seminar for laboratory members>

A technical seminar for laboratory members was held twice. The seminar was presented in English and it was interpreted accordingly into the Lao language by the C/P for all members. The contents of the seminar are as follows:

1st seminar (January 2008)

- Basic theory of AAS
- Calibration, maintenance and use of laboratory measuring tools

2nd seminar (June 2008)

- Accuracy and how to select a laboratory measuring tool
- Type of geological samples and suitable preparation
- Uncertainty and quality management for chemical analysis

<Documentation for management>

The staff was trained about the importance of documentation, for example, the necessity of keeping a ledger, and carrying out operations by following a checklist. The following items were made and operational training was given.

- List of standard solutions
- Gas consumption record
- Checklist for AAS operation

The degree of developed capacity for each laboratory member is listed as follows.

Table 6.4.3 Evaluation of capacity development
(from the beginning of project to the end of 8th survey)

	Phengsy Syrithongdy	Soubin Siphandone	Phouthong Ngoneka-seumsouk	Sikhai Sayavong	Davone Simixay	Kita Louang Aphay
Practical skill						
Basic laboratory work	S→S	S→S	A→A	A→A	A→A	A→A
Aqua regia digestion	S→S	S→S	A→A	A→A	A→A	A→A
Alkaline fusion	S→S	S→S	C→C	B→A	B→A	C→C
Calibration of measuring tools	B→A	B→A	C→C	B→A	B→B	B→B
Operation of flame AAS	A→S	A→S	C→C	B→A	B→A	B→B
Operation of furnace AAS	B→B	C→B	C→B	C→B	C→B	C→B
Trouble shooting for AAS	A→A	A→A	C→C	B→B	C→C	C→C
Theoretical understanding						
Basics for geochemical analysis	H→H	H→H	-	M→M	-	-
Basic theory of AAS	H→H	H→H	-	M→M	-	-
Concept of detection limit	L→M	L→M	-	L→M	-	-
Interference and its control	L→M	L→M	-	L→M	-	-
Contamination management	M→H	M→H	-	L→M	-	-
Uncertainty of measurement	L→M	L→M	-	L→M	-	-
QA/QC	M→M	M→M	-	M→M	-	-
Recovery and repeatability	M→M	M→M	-	M→M	-	-

Legend : Practical skill S: Staff member can do alone and can give instruction
A: Staff member can do alone
B: Staff member can do with supervision
C: Staff member has no experience
Level of understanding H (High level)
M (Moderate level)
L (Low level)
*Only English speaker is evaluated 'Level of understanding'

They are gradually promoting their understanding about the importance of quality management and the actions needed for quality improvement. It is regrettable, however, that time is not allowed for these activities.

6.5 Training in Japan

The training programme in Japan for Mr. Boualay Saatsy who is a director of the Lab was carried out in December 2006. Training programme and schedule is shown in Table 6.5.1.

Table 6.5.1 C/P training schedule in Japan

Date		Place	Contents
12/3	Sun	move	Leaving from Laos
12/4	Mon	move	Arriving at Japan
12/5	Tue	JICA	Courtesy call and orientation
12/6～12/13 (6 days)		MRC Environment technology center	Training for geochemical survey Case study of geochemical exploration Training for geochemical analysis ○ pretreatment ○ selection of analysis procedure ○ quality control ○ Q&A Training for mining discharge monitoring Case study
12/14～12/15 (2 days)		AIST (Geological Survey of Japan)	Explanation of functions and activities Tour and training of laboratory section
12/16	Sat		
12/17	Sun		
12/18～12/20 (3 days)		MRC Myoho mine water treatment plant (Nachi-Katsuura) Shimadzu headquarters (Kyoto)	Study tour for treatment and monitoring of mining discharge. Study tour in Shimadzu central laboratory and training of O&M for AAS.
12/21	Thu	MRC, KKC	Final report
12/22	Fri	JICA	Debrief session and evaluation of training
12/23	Sat	move	Leaving from Japan
12/24	Sun	move	Arriving at Laos

Photo 6.5.1 Training of geochemical analysis at mrc environmental technology center

Photo 6.5.2 Myoho mine discharge water treatment plant

6.6 Future Task

6.6.1 Laboratory Equipment and Consumables

The Lab is always faced with tight finances and insufficient materials so that the new AAS installation was considered a special honor. However, there is still equipment in need of repair or update. The following equipments are urgently needed:

- Fume hood
- Sand bath
- Standard weight for analytical balance
- pH meter, Electric conductivity meter

A graphite furnace AAS has high sensitivity and it provides capability to measure very low concentrations, making it possible for the Lab to lower the detection limit and start the measurement of stream sediment. The project team considered the possibility that repair of the existing furnace AAS might contribute to increased Lab capacity once operations began. In the second period of the field survey, the study team identified the cause of the problem, and then, in the 8th period, the team fixed the furnace AAS so it was ready for analysis.

The most time consuming step in analysis of geological samples is digestion process, which, in the case of gold, requires more than 2 days. In the beginning, the poor capacity of digestion limited the number of samples that could be analyzed. For this reason, it was necessary to procure equipment for digestion to strengthen the analysis capacity. In 2007, a new sand bath was prepared by the project, which greatly increased the capacity of sample digestion. This fact proves that effective investments are necessary to strengthen capacity. The furnace AAS requires a relatively small sample size, such as a few ten μL for one measurement. In comparison, gold analysis by flame AAS requires 50mL. If geological sample analysis by furnace AAS was started, the Lab could reduce time needed for sample digestion, and in turn, the Lab can increase analysis capacity and also save costs.

6.6.2 Staff Capacity Development

There is no fixed training plan or evaluation system for the staff, making it difficult to know the capacity of each individual staff member. A training system should be established, which includes a gradual capacity development system with a stepwise achievement check. Still now, training for newly recruited staff members is not organized. The training is given by senior staff members as OJT through daily work. The C/P recognizes the necessity of well organized training, which can give the basic idea of the proper attitude for analysis. At present, the translation of the manuals from English to Laotian has come under consideration. If this is achieved, the manual would be an effective tool for the laboratory work.

6.6.3 Laboratory Management

It can be concluded from the above discussion that the overall management of the laboratory is lacking in stringency. For instance, the staff members display no habit of calibrating measuring tools like the mechanical pipette. Presently, they have come to understand that certain laboratory tools need to be calibrated before use. However, they tend to skip the process when a lot of work has piled up, which results in doubtful results. This very fundamental attitude is required for good practice and will require a dramatic change in the behavior of laboratory members. Therefore, the establishment of complete management will likely require some time. Another problem is the faulty documentation measures apparent in the disorganized experimental back data and reported results, making it very difficult to find out past results. It will most likely take a long time to establish a proper document control system. In consideration of ideal laboratory conditions, there are many improvements to be made. However, the laboratory has a long established style of its own so one can expect that rapid change would be difficult. Firstly, the establishment of a common understanding of present laboratory conditions among the study team and DGEO is of pressing importance.

6.6.4 Laboratory Improvement Plan

Laboratory staff would like to start water analysis mainly targeted at mine effluent. It should first be understood that the water analysis laboratory must be separated from the rock analysis laboratory. Because, water analysis requires a very low concentration level of detection, whereas rock analysis is usually set at a far higher level of concentration, it would cause serious contamination. The water analysis laboratory is recommended to obtain new laboratory equipment such as glassware, and in addition, laboratory indoor conditions should be improved. The quality of pure water is applicable for rock analysis but not suitable for water analysis.

On the other hand, the current situation has been recognized by C/Ps through the project activities, that is, DGM cannot measure low concentration samples. To enable the analysis of lower concentration samples, it is necessary to start the operation of furnace AAS as well as instill greater accuracy management.

On the basis of the above considerations, it is recommended that DGEO should clarify the objective of laboratory operation and its function for the future. After that, the laboratory development plan will be established.

At a steering committee meeting in June 2008, it was proposed that the following issues be discussed specifically:

- What is the prospective function for the laboratory as a governmental laboratory? Is it a research laboratory for administrative direction, or a reference laboratory for quality control of mining activities, or alternatively, a study laboratory for investigation?
- What is the target material of the laboratory?
  Ore, rock, soil, sediment, discharge water from mines, environmental water, etc.
- Based on the above discussions, what is the required measurement range and analysis quality?

In response, DGEO expressed that they hoped the Lab would function as a reference laboratory and would start monitoring mine effluent. To crosscheck the quality of ore, the Lab should have the same level of ability as a private laboratory. To start water quality analysis, DGEO should start by setting the basic conditions of the laboratory room. The required level of achievement seems to be a great hurdle to clear, but DGEO hopes to make progress step-by-step. DGEO requested cost estimations for several cases with different achievement levels, so rough estimations of the cost for certain developing levels was submitted.

The management of DGEO gradually came to understand that laboratory operation requires the appropriation of a certain amount of spending, and to achieve higher quality analysis requires more investment and more manpower. Because a laboratory is a particular kind of body, it is necessary to acquire the advice of an expert to make a laboratory development plan.

Wherein, the project has proposed plans for short-term and middle- to long-term laboratory development as follows.

<Analysis of current conditions>

The problems the Lab is currently experiencing are listed as follows.

The Lab can analyze ore and rock samples, but the quality of analysis is not stable due to insufficient quality control. The detection limit is relatively high so that at times it does not meet customer requests for very low concentration of an element. Because there are only a few mid-level staff members, there is concern over the weakening of technical level after high-level staff retires. Also, financial resources are insufficient to run the laboratory. The limited budget for maintenance of analytical instruments could possibly halt continuous

operation. The working conditions are not acceptable. The Lab only analyzes samples from outside customers.

The action plan to solve above problems is as follows.

<Short-term development plan>

Target: Basic condition improvement

Activitiy 1: Improvement of working conditions

Action: Facility improvement

The working conditions in the laboratory are not necessarily favorable. The exhaust gas and wastewater from daily work in the laboratory are discharged directly without any treatment. The analysis of geological samples requires a decomposition process with strong acid or alkali, and in particular, the analysis of gold requires Aqua regia which produces a lot of gas containing acid mist. However, the capacity of the exhaust fan is inadequate, and should be improved.

Generally, treatment of exhaust gas is processed with neutralization and absorption. However, the installation of a treatment system is relatively expensive, so allocation of funds for this in the near future is unlikely. At the very least, exhaust power should be strengthened earlier. Treatment of laboratory wastewater also requires a special facility, but merely neutralizing it is a simple process to start. This requires a vessel and general chemicals, so immediate implementation is expected.

The graphite furnace AAS is ready to start operation. The operation room conditions need dust-proofing because the AAS is vulnerable to dust.

Activity 2: Strengthening quality management

Action: Budget allocation and human capacity development

The Lab currently suffers from insufficient funds for basic running costs such as chemicals and reference materials, which results in limitations on quality management. To improve the quality of analysis, in addition to regular samples, this requires the analysis of QA/QC samples. To do so, the analyst would, for example, perform a blank test, repeated test, reference material measurement, and so on. The laboratory operation costs should be estimated accordingly to include these items, and be allocated on a steady basis. On the other hand, quality management activities increase working time and human resource needs. Moreover, it is expected that highly-skilled analysts will retire in the near future. To cover these factors, intensive training of the mid-level staff members is an urgent issue.

Activity 3: Appropriate maintenance of analytical instruments

Action: Budget allocation and continuous training

An analytical instrument, especially AAS is most frequently used and it has a lot of consumable components. Because AAS is a precision instrument, it needs maintenance by a trained engineer of an agent at some level. The funds for maintenance of instruments should be accounted. The Lab can call the engineer on demand, but it is recommended to make a service contract for overall maintenance.

Activity 4: Increase analysis parameters

Action: Procurement of necessary equipment and training for procedures

The Lab is capable of analyzing rare earth elements and the others which it was unable to analyze previously because of the insufficient detection limit of the flame AAS. Analysis of

new elements requires special lamps and a standard solution for each element. The Lab staff members have little or no analysis experience using a furnace AAS, so training should be provided. It will be necessary to introduce new parameters through the practical determination of detection and quantitation limits.

<Medium- to long-term development plan>

Target 1: To be comparable to international standards
Target 2: Implementation of DGEO own project

Activity 1: Advancement of capacity of chemical analysis

Action: Strengthening human capacity development and quality management

In order to steadily develop individual human capacity, the organized, scheduled training will be introduced along with the evaluation of achievement. A staff recruitment plan will be put in place.

At the same time, to improve the quality of analysis, quality management should be enhanced. Moreover, increasing analysis parameters of geological samples, the Lab will start water quality analysis. An obligation should be put in place to prepare Standard Operating Procedure (SOP), a kind of manual, and determination of the detection and quantitation limit for newly introduced parameters. All manuals will be translated into the Lao language.

Activity 2: Buildup of laboratory facility

Action: Implementation of budget and separating a room for water analysis

For further improvement of laboratory working conditions with consideration for environment preservation, the exhaust gas treatment facility and laboratory wastewater treatment system will be installed. It is recommended that the room for water quality analysis be separated from the geochemical sample analysis room to prevent contamination due to the large difference in the concentration level for each. Separate use of glassware is also recommended, so the laboratory will be upgraded accordingly.

The general monitoring parameter of water quality is quite different from that of geological samples. To meet the requirement of water quality monitoring, the Lab must start analysis of new specific parameters. That is, installation of new instruments and analyst training will be necessary.

The most essential parameters for water quality monitoring to perform pollution control in relation to mining activities are listed with the corresponding equipment needed as follows:

- **pH**: pH meter
- **Electric Conductivity**: EC meter
- **Heavy metals**: AAS
- **Cyanide**: Ion meter or spectrometer
- **Mercury**: Mercury analyzer or cold vapor generation unit for AAS

Except heavy metals, these are all new parameters.

Activity 3: Start DGEO own project

Action: Exploration of mineral resource, monitoring of discharge from mining, ore quality testing, etc

The Lab has not yet implemented its own project, and the main activity has been the analysis of samples from private companies and donor projects. In the future, DGEO will strengthen its capacity as a governmental organization, and will then be able to conduct monitoring of mining activities to provide administrative direction, and will be a reference laboratory which

can validate geochemical sample analysis in Lao. To this end, a monitoring plan should be prepared, and based on that plan, the allocation of appropriate personnel and funding will be needed. New recruits are necessary for personnel positioning given the stringent outlook upon the impending retirement of existing staff. New staff members are required for field surveys or sampling for the new monitoring scheme, and in consideration of the increased number of samples. It is better to start planning recruitment early because a certain period is needed for a recruit to become a full-fledged worker through the assistance of technical instruction by experienced staff.

Table 6.6.1 Requisite activities for development

Category	Items	Activities	
		Short-term	**Middle to long-term**
Working condition	Gas exhaust facility	Discharge capacity is improved.	Fume hood with scrubber is installed.
	Wastewater treatment	Equipment of neutralization is set.	Waste water treatment system is improved.
	Safety control	Safety tools are procured. Staff is trained about laboratory safety.	→Continue
Quality management	Budget implementation	Cost for QA/QC sample analysis is accounted.	→Continue
	Training and education	Intensive training of middle level staff members is conducted.	Institutional staff training is established.
	Standardization of procedure	SOP is prepared.	Translation of SOP to Lao language is progressed.
	Determination of detection limit	Detection limit of new parameter is determined.	Detection limit is reviewed.
	Determination of quality control standard and implementations	Tolerable limit of QA/QC sample measurement is determined and implemented.	Monitoring of Quality management activities is started.
Analysis instrument	Budget for O&M	Budget for consumables is allocated.	→Continue
		Possibility of making service contract is considered.	Instruments maintenance and updating plan is prepared and implemented.
Analysis capacity	Increase of analysis parameters	Lab can analyze platinum and palladium.	Lab can analyzes rare earth elements and others.
	Lowering detection limit	Geological sample is analyzed by furnace AAS.	Analysis procedure is reviewed and improved.
	Analysis of water quality	Water quality analysis by furnace AAS is tested.	Equipment for water quality analysis is procured.
		Designing water quality analysis room.	Consumables and standards are appropriated.
			Training of basic parameter analysis is provided to analyst.
Administrative capability	Check of Ore quality	Accuracy is improved with quality management.	→Continue
	Monitoring of mine effluent	Monitoring plan is prepared.	Staff is trained about sampling procedure.
	Administrative directive	Evaluation procedure of monitoring result is determined.	Monitoring plan is authorized and implemented.
			Monitoring report is prepared.
Human resource development	Appropriate staff assignment	Staff assignment plan is prepared.	New staff is recruited in line with the plan.
	Training and education	Training plan is prepared with assessment.	Institutional staff training is established.

CHAPTER 7 CONSTRUCTION OF GIS-BASED GEOLOGICAL AND MINERAL RESOURCES INFORMATION SYSTEM

7.1 Introduction

The regular work of Geological Information Division (GID) at DGEO is to produce GIS database (1:1,000,000 geological map, 1:200,000 geological map, Concession area map and so on.) and manage the library and the rock/mineral resource museum. In this Project, it is aimed that capacity of the C/P is further developed through technical transfer trainings focusing on understanding GIS basic theory and actual operation by using the existing data of various sources.

7.2 Present Situation and Issues at DGEO

Questionnaire and interview surveys were conducted during the first field survey regarding the following topics, in order to clarify the present situation of DGEO. The results are summarized in each section.

7.2.1 Equipment

The present condition of the hardware which the Geological Information Division (GID) possesses was confirmed focusing on the following equipment:

1) Computers

The GID currently possesses four PCs. While the memory of two of the computers is not sufficient, the CPU, hard disk and the OS satisfy the minimum requirements for running GIS software. Meanwhile, the remaining two machines have sufficient memory for creating reports and spreadsheets but they are not sufficient for running the software required for images with large volumes of data and database operation. At present, the purpose of these PCs is to use GIS software (MapInfo) to create data, output maps and create reports and ledger sheets.

Boosting the memory of the machines is an issue for utilization of the equipment that the GID currently possesses. Meanwhile, it is essential to introduce new high-end PCs for the application of advanced GIS software.

Table 7.2.1 List of computer

1	Product Model Name	
	CPU	INTEL PENTIUM Ⅲ 551MHz
	Memory	256MB
	Hard Disk	40GB (3 PARTITIONS C, D, E)
	CD/DVD Drive	CD-ROM 50X(MAX)
	Operating System	WINDOWS XP VERSION 2002
	Interface (USB, SCSI etc)	
2	Product Model Name	
	CPU	PENTIUM R4. INTEL R
	Memory	256MB
	Hard Disk	40GB (2 PARTITIONS C,D)
	CD/DVD Drive	CD-ROM 52X(MAX)
	Operating System	WINDOWS XP VERSION 2002
	Interface (USB, SCSI etc)	
3	Product Model Name	
	CPU	PENTIUM PRO®
	Memory	64MB
	Hard Disk	2GB (3 PARTITIONS)
	CD/DVD Drive	NONE
	Operating System	WINDOWS 95
	Interface (USB, SCSI etc)	
4	Product Model Name	
	CPU	PENTIUM®
	Memory	64MB
	Hard Disk	1GB (1 PARTITIONS)
	CD/DVD Drive	CD-ROM 12X
	Operating System	WINDOWS 95
	Interface (USB, SCSI etc)	

2) Plotter/Printer

A plotter which was purchased ten years ago is still being used to output A0 size sale maps. There are frequent malfunctions with parts but as they are old, it is difficult to obtain spare parts. The revenue from the sale of mining concession maps, and geological and mineral resource maps (1:1,000,000) output using this plotter, is an essential source of income for the maintenance of GIS equipment and for purchasing office supplies. In this project, securement of a new plotter is a future issue as the need for a plotter for the output of updated 1:1,000,000 geological and mineral resource maps and newly compiled 1:200,000 and 1:10,000 geological and mineral resources maps, will increase from the latter half of the second year. In this result, new plotter (HP DESIGN JET 800) was leased for the project during the 4th field survey.

Table 7.2.2 List of plotter / printer

1	Product Model Name	HP DESIGN JET 750C
	Resolution (dpi)	COLOR 300 dpi, BW 600 dpi
	Memory	NONE
	Paper size (A0, A1 etc)	MAX A0, UP TO WIDTH 84cm
	Paper type	REGULAR, COATED, MATT
	Print color / black & white	COLOR
2	Product Model Name	HP PSC 1315 ALL IN ONE
	Resolution (dpi)	
	Memory	NONE
	Paper size (A0, A1, etc)	A4
	Paper type	REGULAR
	Print color / black & white	COLOR

In terms of printers, they are currently using one A4 size multi-function (photocopier/ printer/ scanner) printer.

3) Scanner

Table 7.2.3 List of scanner

1	Product Model Name	UMAX Mirage IISE
	Scanning resolution (dpi)	700 dpi x 1400 dpi (Hardware resolution)
	Paper size (A0, A1, etc)	A3 (up to 11.4" x 17")
	Scan color / black & white	color

They have one scanner which can handle up to A3 size paper and can be used for scanning GIS data entry base maps and topographic maps. However, while the maps to be scanned are generally A1-A0 size, the largest size which the scanner can handle is A3. At present, the process is that one map is divided into two files then mosaicked by image processing in the computer. In this process, there is a potential for large errors to occur in the input base map due to the precision in the scanning and mosaicking stages, and there is also concern that there may be errors in the following GIS data entry. DGEO is also fully aware of this issue, however it is thought to be extremely difficult financially to secure a new A0 scanner. An alternative to this would be to establish a close alliance with the government agencies which possess A0 scanners (National Geographic Department, Mekong River Committee, etc.) and commission scanning work at a minimal charge.

4) Digitizer

A digitizer was used to create GIS data however it is not currently used due to malfunction.

7.2.2 Software

Questionnaires focusing mainly on the fields mentioned below were used to confirm the current condition of the software which the GIS department possesses. The availability of software in this project was assessed, while the application of more efficient equipment and software was also examined by grasping the current introduction of software, maintenance aspects and the environment of usage.

1) CAD Software

AutoCAD is the type of CAD software used, and it is applied for creation of mid to large-scale geological maps. It is not the latest version of the software and version upgrades are not conducted.

Table 7.2.4 List of CAD software

	Category	CAD	Major purpose of use / Extension modules / Remarks
1	Product name	AutoCAD	Create Geological map 1:25,000, 1:10,000, 1:5,000, 1:2,000, 1:1,000
	Software version	2004	
	Purchase year		
	On maintenance contract	No	

2) GIS Software

It is understood from the questionnaires that various types of GIS software are being used for various purposes. The main software used in practice is MapInfo and it is used for compiling the various mining, geological and mineralogical maps which GID sells. GID prints out maps and sells them in response to user requests, while constructing various GIS databases, creating the print layout and updating appropriate information. MapInfo is good for data entry and conversion, and is a typical model of GIS software. At DGEO, there are also staff members who are adept at running MapInfo and a series of procedures such as, data creation, update and printing are culminated. In a discussion about the type of GIS software which should be adopted, there was a request for MapInfo not to be increased and for the introduction of GIS software instead which is adept at constructing databases and analysis. Also, the request came from the need of better data compatibility for utilizing GIS data provided by the Laos National Geographic Department (NGD) and other governmental organizations which adopt ESRI`s ArcGIS as a GIS system. The JICA study team agreed with this and DGEO consented a proposal from the study team to adopt ESRI`s ArcGIS (ArcView).

Table 7.2.5 List of GIS software

1	Category	**GIS**	Major purpose of use / Extension modules / Remarks
	Product name	MapInfo	drawing map, digitize map, contour, stream
	Software version	6	
	Purchase year	1997	
	On maintenance contract	No	
2	Category	**GIS**	Major purpose of use / Extension modules / Remarks
	Product name	ArcView	3D
	Software version	3.2	
	Purchase year		
	On maintenance contract	No	
3	Category	**GIS**	Major purpose of use / Extension modules / Remarks
	Product name	ER Mapper	Analyze satellite images, create DTM
	Software version	6	
	Purchase year		
	On maintenance contract	No	
4	Category	**GIS**	Major purpose of use / Extension modules / Remarks
	Product name	Surfer	Create graphic, 3D
	Software version	3.2	
	Purchase year		
	On maintenance contract	No	
5	Category	**GIS**	Major purpose of use / Extension modules / Remarks
	Product name	TNTmips	Mosaic map, input control point, convert lat/lon to UTM
	Software version		
	Purchase year		
	On maintenance contract	No	

3) DTP Software

Joining several scanned images (mosaic), removing unnecessary sections, regulating file colour and contrast of images created from scanned maps, is carried out as preparation for GIS data entry base maps. The efficiency and precision of data entry by GIS can be dramatically increased by carrying out this work steadily. GID uses Adobe Photoshop, which is a fitting choice, for this work.

Table 7.2.6 List of DTP software

1	Category	**DTP**	Major purpose of use / Extension modules / Remarks
	Product name	Photoshop	mosaic map, cut map, rotate map
	Software version	7.0	
	Purchase year		
	On maintenance contract	No	

4) Database Management System

At GID there are no technicians who specialize in database management and there are only a few employees who can operate Microsoft Access. DGEO participates as a representative for Lao PDR in the Southeast Asian Network for a Geoscience Information System (SANGIS: http://203.148.160.165:8080/sdx/sangis/index.html) initiative sponsored by CIFEG（International Center for Training and Exchanges in the Geosciences）. Compilation of a bibliographic information database is required as part of the activities and Microsoft Access is primarily used for this objective.

Table 7.2.7 List of database management system

1	Category	**DBMS**	Major purpose of use / Extension modules / Remarks
	Product name	Access	Organize bibliographic data, journal, magazine, report, map
	Software version	2000	
	Purchase year		
	On maintenance contract	No	

7.2.3 Network Construction/Web Server

A survey was conducted on the status of DGEO and DOM computer network web server as an environment for GIS technical transfer and website release.

1) Network Construction

The following were focused on and confirmed in regard to network configuration inside GID and the whole of DGEO and DOM.

- Server Computer (hardware and software)
- Client Computer (hardware and software)
- Networks Tools (hardware and software)
- Others (storage mechanism, power supply, etc.)

However, at present there is no network environment such as LAN and several PCs which are in rooms with phone lines spread out, can only access dial up internet connection from the computers. Training of technicians for networks and LAN construction is considered urgent for the pursuit of information sharing and efficient utilization of resources.

2) Web Server

Meanwhile, DGEO and DOM do not possess their own web server and are using a web server that belongs to the administrative Science, Technology and Environment Agency (STEA). The DGEO and DOM website was created by support from the World Bank and it is currently updated one a year. Update is carried out by the Geological Information Division preparing the updated contents then handing them over to STEA who then uploads them. The main contents which are updated include statistics, geological maps and mineral resource maps.

The main complaints by the users of the website are mainly the slow connection speed, lost links and old information. Out of these complaints, things which are attributed to the web server environment, such as connection speed, depend on STEA. STEA introduced a new server machine in May 2006 and the environment is expected to improve. On the other hand, complaints attributed to the contents of the website depend on DGEO and DOM and urgent improvement of conditions is expected.

The opinion from DGEO and DOM on the website update in this Project was that an entirely new one should not be created as the update and addition to the existing site is preferred. The JICA study team agreed with this and will conduct technical transfer for website release and website operation and maintenance (O&M) when development of new data is advancing in the third year of the field study.

7.2.4 Personnel Capacity

The following details have been confirmed in regard to the personnel (9 people) who are employed by the Geological Information Division. In addition, an interview was carried out to reflect the GIS technical transfer, for things such as the expectations of training through discussions and the GIS related technology that they would like to acquire. It is assumed that the trainees for the GIS technical Transfer training will be selected among them. It is understood that only one employee has experience with GIS operations among the interviewee, and as most employees do not have any experience, it is essential for training to begin from the basics of GIS.

1) Specialized Field

	Geology	Mining	Cartography	English
Specialty	5	1	1	1

(person)

2) Trainee Experience

	Yes	No
Any experience of participating in GIS trainings?	2	6

(person)

3) Can Operate/ Experienced Software (GIS, RS, programming language, database management, website construction etc.)

Familiar / experienced GIS or any other software?	AutoCad	1
	TNTmips	1
	ArcView	1
	MapInfo	1

(person)

4) Desired Outputs of Training/Acquisition of GIS Related Technology

- To try new software such as ArcView, ArcInfo, MapInfo, Photoshop, and MapServer
- To construct map database
- To analyze satellite image data
- To construct geological database system
- To learn GIS from the basics

7.2.5 Daily Routine

A hearing survey was conducted in regard to the Geological Information Division (GID)'s routine work and the roles of GID in DGEO, focusing on the items mentioned below. According to the results of the survey, it is understood that there is a lot of cooperation at the GID with other departments for data generation of the results of field survey and mining concession information. As a result, technical transfer and utilization of this project's products hereafter will take into account smooth assimilation with DGEO`s existing systematic role-sharing for more effective development.

1) Main Work at the GID

- To assist interpreting remote sensing area by using aerial photography and satellite image
- Geo processing, mineral exploration reports and disseminating geo-mines information
- To collect all data from the field work
- Monitoring, inspect mining concession areas

2) Contents of Cooperation between GID and Other Departments of DGEO

- To formulate and implement GIS standards
- Using GIS Lao projection
- To provide training, consultancy and share experience

3) Contents of Cooperation between GID and External Agencies (private companies, universities, research institutes, etc.)

- To conduce using GIS
- Assessment and total quality management
- Attend workshop and seminars

7.3 Surveying of Geology /Mineral Resource Information at DGEO and the Related Institutions

The previously created information checklist was used to ascertain the geological and mineral resource information which DGEO possesses and the related information which is the base of the GIS

database. Not only the volume of the items was checked, but importance was also placed on the quality of data characteristics such as whether it was paper based information or electronic file, and in the case of maps, whether it was paper map information and if there is vector data such as point, line and polygon. In addition to DGEO, the related information that other Laotian affiliated organizations possess was also identified. The following seven fields were the subjects of the check.

1) Geology
2) Mineral Resources
3) Geophysical and Remote Sensing
4) Natural Environment
5) Local Infrastructure
6) Mining and Exploration Concession
7) Other related information

The related information which DGEO and other affiliated organizations possess is listed in Annex 15.

To the fourth survey, the focus was on the collection and control of existing information. The operating process of the GIS database and website construction based on the existing information will be described in a manual created in the third year of the survey work.

7.4 Integrating of the Existing Data and Constructing of GIS Database

When constructing the GIS database, the existing DGEO database, which was confirmed in the first year of the survey, was taken as a base, data duplication was avoided and a standard frame was adopted to increase interoperation. Proposals are given in the World Bank's 「Sector Plan for Sustainable Development of the Mining Sector in the Lao PDR」, for evaluating and collecting existing geological and mineral resource information and for the future framework of GIS databases. An abundance of mining related information, including infrastructure information, has already been collected in this project and we have been provided with data collected by the WB in order to avoid duplicate collection. Furthermore, the Geo-science Database specifications in the World Bank project were proposed and DGEO accepted them as the specifications for their database. The results offered to DGEO were accepted and on the basis of these, the JICA study team made detailed additions and revisions in accordance with DGEO. The World Bank's output reached DGEO in late December and the JICA study team member responsible for GIS database construction/homepage release followed it up accordingly. The database specifications were formulated by the JICA study team. The points that were given attention to are finding and filling the missing items of the WB data specification, reflecting changes in the data O&M system due to DGM (Department of Geology and Mines)'s organizational changes, and formulating specifications for the data (metadata) summarizing the items related to the nature of the data, such as data source, the creating organization, creation period, depository, and the responsible party. Based on this, consultation and formulation with DGEO was performed at the fourth stage of the field survey.

Construction of a new GIS database was carried out upon completion of the various geological and mineral resource maps output from this project. For those data, the database specifications will be in accordance with the database specifications from the consultation and formulation with DGEO.

7.5 DGEO and DOM Website

During the first and second field surveys, the MIH was reorganized as the Ministry of Energy and Mines and it was decided at the end of October 2006 that the affiliated DGM would also be divided into the Department of Geology (DGEO) overseeing geological and mining industry potential and analysis, and the Department of Mines (DOM) overseeing monitoring of mining concession, mines, and the mining environment. In fact, both departments were divided in May 2007. Following discussion with DGEO's chief staff regarding the current website, it was decided that the following plans would be advanced.

- As an interim measure, the former DGM website will be updated, and individual website will be established for DGEO and DOM, while the updated contents of the same will be utilized. As the current technician responsible for updating of web contents would be concentrated in the DGEO, there would be no technicians for website in DOM and website update and management will be overseen by DGEO.
- The IT environment within both organizations will be developed, the staff related to GIS, IT and the website will be enhanced and when the opportunity for each website to operate has increased, the website will be split to give each of them jurisdiction over the contents.
- At that time, the convenience for website users will be taken into consideration and links to the other sites will be created with easier interface.

The website will be divided from the DGM website, where information on Lao PDR geology, mineral resources and mining industry legal system and mining lots was collected in the one location, into one part only dealing with geological and mineral resource information and the other dealing with the mineral legislation, concession information and mine monitoring. In particular, from the perspective of foreign mining related investors, it is inconvenient as they will be compelled to access DGEO site for geological information and access GOM site separately for concession information. Consequently it could give an impression that the mining related organizations in Lao PDR being underdeveloped and could lead to underestimation of the mining industry potential. In the future, it is essential for both agencies to fully consider harmonized operation of a website with individual contents for each website.

While examining the above-mentioned website operation plans, the contents of the DGM website were examined to make the results obtained from the Lao PDR geographical and mineralogical survey easy to understand and to rapidly promote the interest of domestic and foreign investors. There are contents for the sixth field study to be carried out in the third year of the plan however, as many of the contents of the DGM website use GIS data, the contents were confirmed and discussed at an earlier date. When examining the contents, in consideration of the strong desire of DGM to use the already operating DGM website for the new one as a base, the format and contents were decided as shown below after discussing the issues and problems with the contents with the C/P.

- The website format will follow the current format.
- Attempt to publish an up to date version of the mining concession map as the current one is from December 2003, the mining concession map is valid to be published by December 2006. During the 8th survey, the JICA team confirmed that the mining concession map had been updated then latest July 2008 edition.
- Southeast Asian Network for a Geoscience Information System (SANGIS) operated by the International Center for Training and Exchanges in the Geosciences (CIFEG) is published in the DGEO collection of publications but there is no link on the DGEO website. A link to SANGIS will be posted on the website unless there is some kind of difficulty with the access limitation.
- In regard to the production of gold, copper, tin, sapphire, coal, potassium feldspar, plaster, barite and lead-zinc within Lao PDR, maps will be published with easy to understand statistics of production and sales turnover from the past five to ten year, together with updating mine distribution charts, including the location of operating mines. There are descriptions on the current website relevant to the six mine products from gold to potassium feldspar thus there will be new descriptions of three products from gypsum to lead-zinc.
- Upon investigation of mine management and operation by domestic and overseas mining related investors, valuable information about infrastructure and natural environment, new power facilities and power networks, meteorological information such as precipitation amount and quantity of evaporation, and information about biodiversified preserves and watersheds will be published.

- Many of the web pages on the website cannot be opened thus links will be created so that all pages can be viewed.
- Pages will be created reporting the latest news and report contents from not only DGM and affiliated governmental agencies but also from private enterprises who are actively expanding into mining activities in Lao PDR.
- A page will be created introducing the Rock and Mineral Museum of DGEO.
- The "Mineral Reserves of Lao PDR 2005" which was collated by DGEO in 2005 summarizing the reserves of mineral resources, will be published on the mineral potential page.
- At present there is no link to other organizations however, a link will be created for both private and public, mining and GIS related organizations.
- In the project the existing 1:1,000,000 geological maps will be revised, a 1:200,000 geological map and a mineral resource map will be compiled for the southern Attapeu area, a 1:10,000 geological map and mineral resource map will be compiled for the same area, geochemical exploration and chemical analysis will be carried out.

The contents of the current website and the updated website are described in the comprehensive Website Map attached in the Annex 13.

7.6 Technology Transfer to C/P

7.6.1 GIS Software and Equipment Used for Training

GIS software and equipment used for training are as follows:

- GIS software: ArcGIS (Version 9.2) ---------- 2 licenses
- GIS hardware: Personal Computer ---------- 2 sets
  Plotter ---------- 1 sets

7.6.2 GIS Technology Transfer Training

Training was carried out twice during the Project corresponding to construction of GIS database. The first training in November 2006 was carried out focusing on the concept of GIS, basic operation, and handling existing data. In the second training in February 2008, the purpose was to ensure that C/P might effectively operate a GIS database which had been on the way of establishment.

1) The First GIS Training (November 2006)

In November 2006, GIS technology transfer training for compiling maps was carried out for the first time for a period of three weeks in accordance with the level of participants focusing on the concept of GIS, basic operation, and handling existing data. The first half of the training was carried out by a combination of lectures explaining the concept and theory and practical training of the operation of the software and the latter half focused on practical training. There were five official trainees (three from the GID and two from Mining-Concession Management) and four auditors at the most attended the lectures and the trainees were extremely enthusiastic.

This training session was conducted centered on the operation of the new ArcView9.1 GIS software however, there was only one license procured by this project so there was a serious shortage for the nine participants. Therefore, a request was made to a local software distributor for two month limited evaluation editions of ArcView and an additional three licenses were received thus training was carried out using a total of four sets (approx. two people per PC). In addition, after the training course a further three evaluation sets were prepared and provided to DGM. There is a concern that work productivity and efficiency may be affected, when it is assumed that it would be used for creation of the products in this project and for DGEO`s routine business in future but GID has only one ArcView license.

Three of the trainees were fairly familiar with other GIS software (MapInfo) and were quick to understand the new software. In addition, learning of the training contents was speeded up as there was excellent teamwork as those trainees helped other trainees who had no experience using GIS and filled in the gaps when understanding of English was a problem. The Figure below shows the attendance (○ = attended) during the training period and the marks of the last test that was conducted (excluding the auditors).

Table 7.6.1 Attendance and evaluation of GIS training

1st GIS Training Course
From November 1 - 17, 2006

Class1 9:00-10:30 / Class2 10:45-12:00 / Class3 13:30-15:30 [MCM: Mining Concession Management]

	NAME	Dept	Division	11/1 Wed			11/1 Thu			11/3 Fri			11/6 Mon			11/7 Tue			11/8 Wed			11/9 Thu			11/10 Fri			11/13 Mon			11/14 Tue		
				1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3
1	Inpong HOMSOMBATH	G	Geo-Info	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○
2	Chantala KEO HAVONG	G	Geo-Info			○						○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○
3	Kuang Nuvong THEPVONGSA	G	Geo-Info	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○
4	Madmano VIPHAKEO	G	Geo-Info	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○
5	Toun INTHAVONG	G	Geo-Info																														
6	Khampha PHOMMAKAYSONE	G	Geology	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○
7	Oudom PHAMMACHANH	G	Geo-Info	○	○	○	○	○	○			○	○	○	○		○																
8	Sayphet VILAYPASEUTH	M	MCM	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○					
9	Boun Gnong Sidavong	M	MCM										○	○	○	○	○	○				○	○	○	○	○	○	○	○	○	○	○	○

	NAME	Dept	Division	11/15 Wed			11/16 Thu			11/17 Fri			11/20 Mon (Review)			11/21 Tue (Exam)			Exam Result
				1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	
1	Inpong HOMSOMBATH	G	Geo-Info	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	89
2	Chantala KEO HAVONG	G	Geo-Info	○	○	○	○	○	○	○	○	○	○	○	○			○	91
3	Kuang Nuvong THEPVONGSA	G	Geo-Info	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	92
4	Madmano VIPHAKEO	G	Geo-Info	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	90
5	Toun INTHAVONG	G	Geo-Info																
6	Khampha PHOMMAKAYSONE	G	Geology	○	○	○													
7	Oudom PHAMMACHANH	G	Geo-Info	○															
8	Sayphet VILAYPASEUTH	M	MCM																
9	Boun Gnong Sidavong	M	MCM	○	○	○				○	○	○	○	○	○	○	○	○	95

In the questionnaire survey at the end of the training, many people replied that the contents were satisfactory. There was a difference among the participants in the level of GIS knowledge and experience, and some of the participants who were learning GIS operation for the first time said that the training period was short.

Photo 7.6.1 GIS training (1/2)

Photo 7.6.2 GIS training (2/2)

The future tasks are to decided how to continue development when the JICA study team member responsible for GIS database construction/homepage release are not present and how to sustain the results of the training. Furthermore in order to ensure acquisition of technology, it is essential to utilize

the technology acquired in the training for the DGEO's routine business, the way in which to do so when the team member is not present is also an issue.

The following tasks were proposed to DGEO and DOM, with their agreement, in order to establish the technology and utilize it in work. Technical support will also be carried out accordingly by Email.

- Check each of the WB's collected and integrated GIS dataset using ArcView (Check items: coordinate system, attribute field name, data type, contents, codes) and create a summary report
- Try reproducing 1:1,000,000 Geological Map and Concession Map with marketable quality in ArcView
- Try creating map layouts for geological mining investment suggested by Mr. Shirai by combining WB's collected GIS dataset
- Prepare the updates for DGEO/DOM website contents (especially text)

2) The Second GIS Training (February 2008)

The second GIS technology transfer training was carried out for the period of 4th to 22nd of February 2008. The purpose of the second training was to ensure that C/P might effectively operate a GIS database which had been on the way of establishment and the schedule of the training was set to meet the purpose. The schedule consisted of three parts shown below.

- Review of basic operation of ArcGIS (once learned at the first training)
- Input of 1:200,000 geological map and data editing which would be required from then on
- Explanation of newly introduced functions

Depend on three parts shown above, detailed training schedule was prepared and approved by Laotian staff in charge. Nine (9) staffs attended at the beginning of the training and some staffs forced to be absent because of business trip in the middle of the training. Finally four (4) staffs fully completed the training. They are;

1. Mr. Inpong HOMSONBATH
2. Mr. Chanthala KEOHAVONG
3. Mr. Kuangnuvong THEPVONGSA
4. Ms. Vannapha PHOMMACHANH

The training was took place following the schedule which had been prepared in advance. In the course of training, at first, operation was demonstrated on the PC and operation was done by each trainee. Sometime trainees made notes of explanation on process and operation. Practice of operation was repeated many times so that trainee might master each training item.
Throughout the raining, new function was introduced after mastering such items as basic operation of ArcGIS, how to generate new data, how to edit generated data. Finally, practice of image generation on display by multi-layer was took place by each trainee applying knowledge just obtained by the training. Figure 7.6.1 shows an example of output Bolikhamsay Province. This figure was generated by contour data of Bolikhamsay Province, road, river extracted from a data set of whole Laos using data extraction function. The extracted data was converted to a new data set of Bolikhamsay Province and images were generated using function of display and output.

Table 7.6.2 Schedule of the 2nd ArcGIS training

			Arc GIS Training Schedule	
	YY:MM:DD		10:00~12:00	14:00~16:00
1	2008/2/4	Mon	Training data install to computer	Outline of ArcMap/ArcCatalog/ArcToolbox
2	2008/2/5	Tue	Explanation of Tool bottoms	Handling ArcMap
3	2008/2/6	Wed	Handling ArcMap	
4	2008/2/7	Thu	Update for Georeference using ArcToolbox	Convert to ArcMap data from MapInfo data
5	2008/2/8	Fri	Convert to ArcMap data from MapInfo data	Handling Arc Catalog
6	2008/2/9	Sat	Holiday	
7	2008/2/10	Sun	Holiday	
8	2008/2/11	Mon	Map data and attribute data edit	Map data and attribute data edit
9	2008/2/12	Tue	Explanation of Properties	Explanation of Properties
10	2008/2/13	Wed	Make new shapefile	Make new shapefile
11	2008/2/14	Thu	Layout and printout	Layout and printout
12	2008/2/15	Fri	Layout and printout	Data Edit using by Arc Tool(union,clip,etc)
13	2008/2/16	Sat	Holiday	
14	2008/2/17	Sun	Holiday	
15	2008/2/18	Mon	Data Edit using by Arc Tool(union,clip,etc)	Data Edit using by Arc Tool(union,clip,etc)
16	2008/2/19	Tue	Question time	Question time
17	2008/2/20	Wed	Conference with new geology database	Conference with new geology database
18	2008/2/21	Thu	Conference with new geology database	Examination/questioner
19	2008/2/22	Fri	Conference with new geology database	Training Data copy to DVD

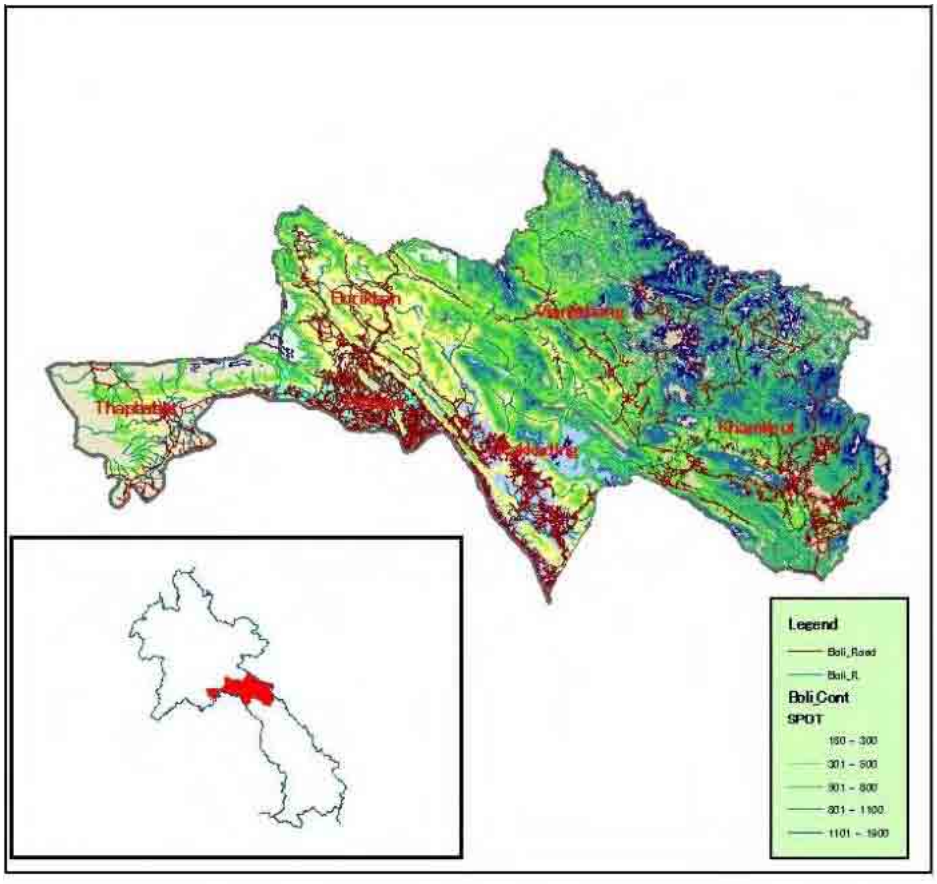

Figure 7.6.1 Example of GIS data output, Bolikamsay Province

7.7 Progress of Construction of Database

GIS database constructed by the Project is shown in the table below.

Major Item	Holder Name	File name	DATA Type
Administration	South East Area	Southeast.shp	Polygon
Boundary	Lao Country	Lao_Country.shp	Polygon
	Lao Country	Country.shp	Polyline
	Province Boundary	Province.shp	Polygon
	District Boundary	Admini.shp	Polygon
	Province Capital		Point
Geology	Geology	Geology	Polygon
		VT_geology2000000	Polygon
		Samnea_Geology200000	Polygon
		Midle_Lao_Geology200000	Polygon
		Kangkhai_Geology200000	Polygon
		South_geology_200000	Polygon
		Samneua_geology2000000	Polygon
	Mineral Point	Lao_mineral1_point	Point
		Lao_mineral1_font_point	Point
		W_sheet1_font_point	Point
		W_sheet1_text	Point
		W_sheet_text	Point
		W_sheet_region	Polygon
	Faults	FAULT	Polyline
		South_Fult_200000	
		Samneua_Fult2000000	
Natural information		Steam	Point
		HotSpring	Point
Catchments Area		Catch	Polygon
		Hlampanhngai	Polygon
		Hoayhoh	Polygon
		nam mo	Polygon
		xeset2-3	Polygon
		Xekongsee	Polygon
		xekong5	Polygon
		xekong4	Polygon
		xekaman3	Polygon
		xekaman1	Polygon
		Nnpiep	Polygon
		nngum2	Polygon
		nngum5	Polygon
		nngum3	Polygon
		namteun3	Polygon

Major Item	Holder Name	File name	DATA Type
Catchments Area	Catchment Area	namsane3	Polygon
		Nammouan	Polygon
		Namlik	Polygon
		Namcha	Polygon
Concession	Prospection	Prospection Area.shp	Polygon
	Exploit	Expl_region.shp	Polygon
	Explorasion	ConcessionEx_rectangle.shp	Polygon
	Prospection	PROSPECS.shp	Polygon
	Exploit	EXPLORAS.shp	Polygon
	Explorasion	EXPLOITS.shp	Polygon
Protection Area	Army area	Army Area.shp	Polygon
		BNCA.shp	Polygon
Reservation Area	Reservation Area	reservoir of laos project.shp	Polygon
		namsan2.shp	Polygon
		nam mouan.shp	Polygon
Contour	Contour	contour.shp	Polyline
Image Data	Satellite image data	dtm-lao	
		Shadoe	
		aster_attapeu.img	Img
		med_palsar_attapeu.img	Img
	Topographic map	F-48.tif	Tiff
		F-47.tif	Tiff
		E-48.tif	Tiff
		E-47.tif	Tiff
		D-48.tif	Tiff
Land use	Whole country	attapeu.shp	Polygon
		bokeo.shp	Polygon
		bolikham.shp	Polygon
		champasak.shp	Polygon
		khammouan.shp	Polygon
		luangnamtha.shp	Polygon
		luangphabang.shp	Polygon
		oudomxai.shp	Polygon
		phongsali.shp	Polygon
		saravan.shp	Polygon
		saravavakhet.shp	Polygon
		vientiane.shp	Polygon
		vtcapital.shp	Polygon
		xaisomboun.shp	Polygon

Major Item	Holder Name	File name	DATA Type
Land use	Whole country	xamnua.shp	Polygon
		xayabury.shp	Polygon
		xekong.shp	Polygon
		xiengkhuang.shp	Polygon
	Central	Udit.shp	Polygon
		Pislok.shp	Polygon
		Pijit.shp	Polygon
		Kampangpet.shp	Polygon
		Sukotai.shp	Polygon
Map index	Mapindex	M200000.shp	Polygon
		M250000.shp	Polygon
		M500000.shp	Polygon
		M100000.shp	Polygon
Irrigation	Irrigation	Irrigation project	Point
		Irr_project	Point
		Irr_area	Polygon
		Irr_canal	Polyline
Electric Power	powerstation	existing diesel generation plants.shp	Point
		substation.shp	Point
	transmissionline	115kv transmission line.shp	Polyline
		22kv transmission line.shp	Polyline
		230kv.shp	Polyline
		500kv.shp	Polyline
Road	Road	Lao10000_roads.shp	Polyline
		Main_road.shp	Polyline
River	River	Main river.shp	Polyline
		Lao-river.shp	Polyline
		Lake.shp	Polyline
Weather	Weather	Avrain2.bmp	bit map
		Avrain7.bmp	bit map
		MAXTEMP2.bmp	bit map
		MAXTEMP7.bmp	bit map
		MINTEMP2.bmp	bit map
		MINTEMP7.bmp	bit map
Forest cover	Forest cover	forest_cover.shp	polygon

7.8 Training in Japan

The training programme for GIS, remote sensing and data management of geology and mineral resources were carried out in Japan in January and August, 2008. Mr. Khampha Phommakaysone, Deputy Director General of DGEO, followed the programme of GIS and remote sensing, and Ms. Chansavath Boupha, Deputy Director General of DGEO, followed the programme of data management. Training programme and schedule is shown in Table 7.8.1. and 7.8.2.

Table 7.8.1 C/P Training schedule in Japan (for GIS and remote sensing)

Date		Place	Contents
1/5	Sun	move	Leaving from Laos
1/6	Mon	move	Arriving at Japan
1/7	Tue	JICA	Courtesy call and orientation
1/8～1/10 (3 days)	Wed-Thu	mrc, AIST (Geological Survey of Japan), ERSDAC	Training for GIS and remote sensing technologies. ○ software ○ data processing ○ case study
1/11～1/12 (2 days)	Fri-Sat	Hishikari gold mine, Ogiri geothermal power station	Study tour for exploration and exploitation of vein-type gold deposit and geothermal energy.
1/13～1/14 (2 days)	Sun-Mon		
1/15～1/17 (3 days)	Tue-Thu	KKC, mrc	Training for GIS and remote sensing technologies. ○ data processing ○ case study
1/18	Fri	JICA	Debrief session and evaluation of training
1/19	Sat	move	Leaving from Japan, Arriving at Laos

Table 7.8.2 C/P Training schedule in Japan (for data management)

Date		Place	Contents
7/12	Sun	move	Leaving from Laos
7/13	Mon	move	Arriving at Japan
7/14	Tue	JICA	Courtesy call and orientation
7/15～7/17 (3 days)	Wed-Thu	mrc, JOGMEC KKC	Traning for data management of geology and mineral resources
7/18～7/19 (2 days)	Fri-Sat	Matsuo Neutralization plant, Osarizawa mine, Sumikawa geothermal power station	Study tour for treatment of mining discharge, exploration and exploitation of vein-type cupper deposit and geothermal energy.
7/20～7/21	Sun-Mon		
7/22～7/24 (3 days)	Tue-Thu	AIST (Geological Survey of Japan), MMTEC	Traning for data management of geology and mineral resources, preparation of geological map
7/25	Fri	JICA	Debrief session and evaluation of training
7/26	Sat	move	Leaving from Japan, Arriving at Laos

7.9 Future Task

7.9.1 Application of GIS Database

Main work of the staff in charge of database at GID is data processing and output requested by DGEO, DOM and other related organizations. At present, 2 to 3 staffs are engaging these work and they are fully occupied to response those requests. The processing work is done mainly using MapInfo. As already existing data have been made by MapInfo and the engineers are much familiar with MapInfo than ArcGIS in processing and editing work, it is expected that there will be much dependence on MapInfo in future resulting in less occasion of operating ArcGIS. Although MapInfo is well-developed software, MapInfo is equipped efficient function which MapInfo cannot afford. From now on, database should be operated by ArcGIS and by doing so various effective applications could be developed. At the first GIS technology transfer training, a detailed manual of ArcGIS operation is prepared. Consultation with this manual is sure to be great help when any question on data processing and operation on ArcGIS.

7.9.2 Training GIS Specialists

Training was carried out twice during the Project corresponding to construction of GIS database. As a result, one of the staffs was coming out as a new GIS engineer. Including the new engineer the total number of engineers who are in charge of database is limited to only three (3). As processing work of data related to geology and mines should be done within GID and diversification of daily work is expected, volume of work at GID is sure to expand. Besides, manpower is also required to update website. To cope with increasing work volume, the numbers of engineers should be increased

7.9.3 Facility to Support GIS

Mining operation and exploration project have a duty to submit reports of working results at regular intervals. These reports contain unique and valuable information for further explorations and geological works. To control accumulating reports in order and utilize effectively information contained in report at most extent, a database system is indispensable. Generation of electric data from submitted reports and upload to a database require additional manpower and enhanced GIS facility such as software, computer, data storage and input/output unit (scanner/printer).

CHAPTER 8 CO-OPERATION PROJECT BY OTHER DONORS

8.1 Introduction

Lao PDR has received a considerable amount of assistance in geology and mining field from the donor community. This has largely been related to:

- Assistance for strengthening the DGM (currently DGEO and DOM).
- Capacity development of DGM (currently DGEO and DOM) staff
- Assistance for geological mapping and mineral exploration
- Environmental management.

8.2 Geological and Mining Projects of Donors

Table 8.2.1 provides a list of major donor-funded projects undertaken in the geology and mining field since 1975, including the JICA project.

Table 8.2.1 List of projects funded by donors since 1975

Period	Donor	Project Title
Completed in 1980	Vietnam Govemment	1/200,000 Geological Mapping Project in Samnua-Khangkhay
Completed In 1981	Vietnam Govemment	Salt Prospecting at Savannakhet Sub Basin, Savannakhet Province
Completed in 1982	Vietnam Govemment	Iron Prospecting at Phou Nhuon, Xiangkhoang Province
1977-1982	Vietnam Govemment	Gypsum Exploration at Dong Hen, Savannakhet Province
Completed in 1985	Vietnam Govemment	Coal Prospecting at Chakeui-Kaleum, Saravan Province
Completed in 1986	Vietnam Govemment	Coarse Sand Prospecting at Ylay, Vientiane Capital
1982-1986	Vietnam Govemment	Potash Prospecting at Tha Ngon Area, Vientiane Capital
Completed in 1987	Vietnam Govemment	1/200,000 Geological Mapping Project in Vientiane-Ban Keun
Completed in 1991	Vietnam Govemment	1/1,000,000 Geological Mapping Project over Indochina
1989-1992	UNDP	LAO/88/023, Strengthening the Department of Geology and Mines.
1993-1997	UNDP	LAO/93/005, Mineral Sector Development.
1994-1999	Vietnam Govemment	1/2 00,000 Geological Mapping Project in MiddlePart of Lao
1997-2000	UNDP	LAO/97/019, Environmental Management of Mineral Resources.
2002-2005	Vietnam Govemment	Nong Lom Potash Procpecting in Khammouane Province
2002-2007	Vietnam Govemment	1/2 00,000 Geological Mapping Project in Northern Part of Lao
2004- on-going	Thailand Govemment	Collaborate Project between DGM and DMR
2005- on-going	Vietnam Govemment	1/2 00,000 Geological Mapping Project in Southern Part of Lao
2006	WB	Sector Plan for Sustainable Development of the Mining Sector in the Lao PDR
2006-2008	JICA	The Geological Mapping and Mineral Information Service Project for Promotion of Mining Industry in the Lao PDR

8.2.1 World Bank

World Bank has been providing assistance to the Department of Geology and Mines (currently DGEO and DOM) since 2004. The activities include;

- Strengthening of Management Capabilities in DGM (currently DGEO and DOM).
- Sector Plan for Sustainable Development of the Mining Sector in the Lao PDR
- Monitoring and Evaluation of Benefits Streams to Natural Resources Operations

The study of "Sector Plan for Sustainable Development of the Mining Sector in the Lao PDR" was completed in the end of year 2006. The purpose of the study is to understand the current status of Lao mining industry and identify the issues to formulate the sector plan for sustainable mining development. The main tasks of the study are as follows:

① Geological data and assessment
② Evaluation of the economic potential of Lao mineral resources
③ Institutional strengthening measures
④ Assessment of international competitiveness factors for investment
⑤ Formulating the mining policy

8.2.2 UNDP

UNDP provided assistance to DGM (currently DGEO and DOM) of 3 consecutive projects for the period of 10 years as follows;

- First Project: To strengthen the DGM (currently DGEO and DOM) in the renovation, the establishment of a modern chemical Lab, the provision of the geological equipment and staff training in these areas.
- Second Project: To have given a strong emphasis and upgrading the capacities of DGM (currently DGEO and DOM) staff in fields of geological mapping, chemical analysis, ore microscopy, photo-interpretation, mineral title management, mining law, mineral taxation.
- Third Project: To be to promote the development of the sustainable private investment in the Lao mineral sector and undertake the training activities in environmental regulations and management, laboratory analysis of environmental samples and field geology and mineralogy.

8.2.3 UNIDO

UNIDO has been funding the Project on "Removal of barriers to the introduction of artisanal gold mining and extraction technologies". The objective of the Project is to assist a pilot suite located in a transboundary river basins in assessing the extent of pollution from current activities, introduce cleaner gold mining and extraction technology which minimize or eliminate mercury releases and develop capacity and regulatory mechanisms that will enable the sector to minimize negative environmental impacts. The Project also aim to improve the quality of life of miners.

8.2.4 DGMV

The Development of Geology and Mines of Vietnam has been supporting many projects since 1980. Projects mostly focus on geological mapping and mineral investigation at scale of 1:200,000, mineral prospecting and exploration such as coal, potash, iron and gypsum exploration. They also include capacity building for DGM (currently DGEO and DOM) staff.

8.2.5 DMR

The Department of Mineral Resources of Thailand has been cooperating with DGM (currently DGEO and DOM) for many years. Cooperative activities in recent years include;

- Geological survey and mineral resources investigation.

- Technical advice on geoscience laboratory.
- Technical advice on geological museum.

8.3 The Need for Co-operation Project

While enhancement of mining sector and preparation of basic data of geology and mineral resources had been supported by various international assistance donors, present situation is still far from satisfaction due to the limitation of both financial and human resources at DGEO and DOM. Especially, Capacity Development is one of the key issues and the government of Lao PDR has been requesting continued support to these issues. The Project implemented through JICA has started with good timing and effective manner laying emphasis on Capacity Development as well as preparation of basic information, and the Project is a center of expectations of Lao government.

CHAPTER 9 SEMINAR AND WORKSHOP

9.1 Presentation at International Seminar (PDAC)

During the 7th Survey, a presentation was made to introduce mineral potential and Project activity at the occasion of PDAC held in Toronto, Canada, from 2 to 5 of March, 2008. Materials such as pamphlet and poster used for the presentation were prepared jointly with C/Ps during the 6th Survey.

Attendant of the PDAC is followings;

- Thongphant INTHAVONG: Director General of Department of Mines
- Khampha PHOMMAKAYSONE: Deputy General of Department of Geology
- Yoshiaki SHIBATA: Mitsubishi Material Techno Corporation
- Satoshi KOBAYASHI: JICA Tokyo

Moreover, Chansavath BOUPHA, Deputy General Director of Geology Department and Khamtanh VONGPHANSIPASEUTH, Deputy General of Department of Mines also attended by invitation of the World Bank.

The PDAC seminar is held every year on regular base in the first week of March in Toronto. PDAC consist of two main activities, namely, Trade Show and Investor Show. Trade show is an exhibition attended by organizations of mineral exploration, exploration consultant companies, survey instrument companies and analysis service companies and etc,. Investor show is attended by mining companies and exploration companies. The Project attended Investor Show and set a booth to introduce mining climate and mineral resources potential of Lao PDR to promote investment from overseas to Lao PDR.

The total number of attendant of the PDAC was announced to be more than 20,000 much more than the last year. A lot of attendant visited the presentation at the booth of Lao PDR and made a series of question on mineral potential, mining law, status of database of geology and how to access to information.The back grounds of the visitors to Lao PDR booth are Chinese (almost half), then, Australians and Canadians of exploration companies.

Attending international seminar like PDAC was very fruitful as mineral potential of Lao PDR was appealed widely, C/P studied situations of mining and exploration of various countries, and had a chance to exchange information with mining people. Other organizations attended the PDAC were demonstrating voluminous basic date far well organized than Lao PDR impressing that Lao PDR should make hurry in preparation of basic data.

Photo 9.1.1 shows Lao PDR booth and Figure9.1.1 shows a part of the poster presented.

Photo 9.1.1 Lao PDR booth at PDAC

Figure 9.1.1 The poster presented at PDAC

9.2 Workshop

A workshop was held jointly with C/P in Vientiane on August 6, 2008 during the 8th Survey. At the workshop presentations were made on the achievement of preparation of information which is one of the main purposes of the Project, C/D activity during the process of preparation of information and recommendations of institutional enhancement of DGEO and DOM exchanging opinions among the attendant.

Agenda of the workshop is shown in Table 9.2.1.

Table 9.2.1 Programme of workshop

Workshop on Geological Mapping and Mineral Information Service Project

Date: 06 August 2008

Place: the Lao Plaza Hotel, Vientiane, Lao PDR

Chairman: Mr. Thongphath

	Topics	Presenter	Time		
1	Openning address from the Department of Mines	Mr. Thongphath INTHAVONG	8:30	~	8:50
2	Openning address from the JICA Vientiane Office	Mr. Hiroshi TAKASHIMA	8:50	~	9:00
3	Outline of JICA/DGEO/DOM Project	Mr. Yoshiaki SHIBATA	9:00	~	9:20
4	Thechnical transfer and progress in geological survey	Mr. Motomu GOTO	9:20	~	9:40
5	Thechnical transfer and progress in chemical analysis	Ms. Yasuko KAMEGAI	9:40	~	10:00
	(Coffee break)		10:00	~	10:15
6	Thechnical transfer and progress in GIS	Mr. Chantala KEOHAVONG	10:15	~	10:35
7	Geology of Attapeu Area	Mr. Siphandone VILAYHACK	10:35	~	10:55
8	Mineral resources of Attapeu Area	Mr. Yoshimitsu NEGISHI	10:55	~	11:15
	Discussion		11:15	~	11:35
	(Lunch)		11:35	~	12:35
9	Geology and mineral resources in southern Lao PDR	Mr. Nguyen Van NGUYEN (Dept. of Geology and Mines of Vietnam)	12:35	~	12:55
10	Geology and mineralization of Sepon District	Mr. Boun Oum BOUTTATHEP (Lang Xang Mineral Co.)	12:55	~	13:15
11	Phu Kham Cu-Au Deposit: A porphyry-skarn system	Mr. Natthapong PROMAJAKARIN (Phu Bia Mining)	13:15	~	13:35
12	Rare earth mineral resources in Bolaven Plateau	Dr. Yasushi WATANABE (Geological Survey of Japan)	13:35	~	14:05
	Discussion		14:05	~	14:30
	(Coffee break)		14:30	~	14:50
13	Mining policy of Lao PDR: current and future	Mr. Eravanh BOUNGNAPHALOM	14:50	~	15:10
14	Development plan of geological sector -2006 to 2020-	Ms. Chansavath BOUPHA	15:10	~	15:20
15	Geological mapping projects in Lao PDR	Mr. Khampha PHOMMAKAYSONE	15:20	~	15:30
16	Summary of recommended actions	Mr. Yoshiaki SHIBATA	15:30	~	15:40
	Discussion		15:40	~	16:05
17	Closing remarks	Mr. Thongphath INTHAVONG	16:05	~	16:15

CHAPTER 10 CONCLUSION AND RECOMMENDATION

10.1 Conclusion

The results of the survey are summarized as shown below;

(1) **Field geological survey:** Field geological survey was carried out in cooperation with Laotian counterpart in Attapeu area of southern Laos. So far there was no organized regional survey. Geological setting such as geological formation, characters of rocks, age, structure, mineralisation and etc., have been clarified by the survey. A mineralization of gold and copper was detected by geochemical survey of stream sediment sampling took place at the same time.

(2) **Detailed survey:** A detailed joint survey was carried out over promising area detected by geochemical survey said above. Several promising gold and copper indications were newly discovered by the detailed field survey. Some of these indications suggest porphyry copper type mineralization revealing distinct mineral resources potential in the area.

(3) **Mineral Information service:** Two sheets of geological and mineral resources map of 1:200,000 scale were generated and one sheet of geological and mineral resources map of 1:1,000,000 scale was revised as a part of preparation of information of geology and mineral resource data to promote investment from foreign companies to Laotian mining sector. To provide information to potential investors GIS database was enhanced and website was reconstructed with newly obtained data through the Project.

(4) **Mineral Information service:** By the request of counterparts, the Project adopted ArcGIS for construction of database to allow flexibility to utilize data prepared by other organizations and analysis capability although the Geological Information Division had been developing a database depend on MapInfo. Existing MapInfo data has been converted into ArcGIS data.

(5) **Mineral Information service:** During the term of the Project, the Department of Geology and Mines was reorganized to be consisting of two departments, namely Department of Geology and Department of Mines. According to this change the website was revised and contents were reviewed and substituted by newly obtained data to provide information targeting to potential investors.

(6) **Technical Transfer of geological survey skill:** In the course of mapping of 1:200,000 scale, the survey team and counterparts cooperated in the area of Attapeu during geological and geochemical field survey. A series of technical guidance and technical transfer are also took place during the field work aiming to enhance capacity of the counterpart staff. As a result, level of awareness as well as capability concerning geological survey had been improved among geologists of DGEO.

(7) **Technical Transfer of GIS:** So that counterparts may master operation of ArcGIS, training was provided twice during the Project. Although understanding of basic part was attained thanks to this training, further study by self-training is needed for advanced processing and analytical function

(8) **Technical Transfer of chemical analysis:** During the Project, analysis of ore samples by Atomic Absorption Spectrometer was conducted and thin section for rock observation and polish specimen for ore samples are produced at the Laboratory of DGEO.

(9) **Issues of chemical analysis:** Input of equipment, materials and technical staffs (increase number of staffs and training or new recruitment) is necessary to improve quality, accuracy and efficiency of chemical analysis. To secure necessary budget, a policy of management of lab and middle to long term plan should be established.

(10) **Overall achievement and future issues:** Enhancement of information and capacity development are expected two main purpose of the Project. Here the survey team and Laotian counterpart proudly share the opinion that each purpose has been realized more than expectations held at the beginning of the Project. Basic policy that every item should be done following joint work basis has been maintained through out the Project. This basic policy cultivated mutual understanding between the survey team and Laotian counterparts and led to the great success of the Project. However, enhancement of information transmission and capacity development can be accomplished only by further day-to-day effort of counterparts as well as long run support to them.

10.2 Recommendation

The Department of Geology and the Department of Mines are requested to fulfil function as a center of mining of Lao PDR further improving conditions necessary for promotion of mining investment and mining sector can be a driving force of national economic development of Lao PDR. Expecting to contribute super goal of the Project, recommendation are given below;

(1) After reorganization of the Department of Geology and Mines, two Departments were established with enhanced function to provide service for Mines and Geology separately. From now on each Department should make effort to improve internally. ⇒ **Institutional Enhancement**

(2) Neither present manpower nor present facilities of the departments are enough to provide essential service which is expected to be given by governmental organization of mining/geology. Improvement of those insufficiencies is the most urgent matter. ⇒ **Organizational/Functional Enhancement**

(3) Two offices, namely, Vientiane main office and Pakse local office are established. But these two offices cannot afford to control mining and exploration activities over whole territory of Lao PDR. Additional two local offices should be newly established to cover northern and central areas. These new local offices should be a branch of both departments of Geology and Mines. It is also important to build up a closer connection with Department of Energy and Mines of local goverments.

⇒ **Organizational/Functional Enhancement**

(4) To guarantee a policy that mining concession should be issued to proper applicant such as experienced mining companies and exploration companies, it is necessary to provide them proper, sufficient and high quality information of geology and mineral resources. It is also important to prepare and publish useful information attained by the survey carried out by the Department itself. To realize this function, enhance a section of geological survey/mineral exploration and set up field survey team as well as securing budget necessary for survey project.

⇒ **Survey as DGEO's own project**

(5) Implementation of internal survey/exploration project is essential for propagation/succession of technology, training of specialists and interaction with foreign organizations.

⇒ **Training of engineers through survey activities of DGEO's own project**

(6) As work reports (defined in mining law as an obligation of concession holder) is very useful information for future exploration, get reports secured and keep these information in database. Enhance manpower and facility of Geology Information Division so that all of the results of geological survey and exploration may be accumulated in GIS database.

⇒ **Enhance Mineral information service**

(7) Analytical Division, present and in near future, should work as a reference lab for rock/mineral analysis and also providing analysis service of mine waste water for environmental monitoring. To carry out these functions, additional improvement of working condition, new investment for facility, enhance quality control by capacity development of staffs and maintenance of analytical equipment are needed. ⇒ **Enhance facility of Chemical Analysis Center**

(8) Although technical levels have been upgraded over various fields comparing to the beginning savage of the Project, capacity development should be continued by inviting specialists from outside for training and sending staffs to overseas training and studying. ⇒ **Training of staffs**

(9) To accelerate capacity development, innovation of facility and preparation of information of geology/mineral resources, pursue occasions of joint project with foreign organizations same as this Project. ⇒ **By involvement of joint projects with foreign organizations**

Recommendations above are summarized in Table 10.2.1.

Table 10.2.1 Recommendation for Reinforcement of DGEO and DOM

Major items		Countermeasure, Plan			Expected result
		2009～2010	2010～2015	2016～2020	
Expansion of manpower (professional staffs)	DGEO	7 person (Geologist :4, GIS:1, Analysis: 2)	10 person (Geologist: 7, GIS: 2, Analysis: 1)	10 person (Geologist: 7, GIS: 1, Analysis: 2)	Institutional Enhancement
	DOM	4 person (Mining: 2, Geologist: 1, Environment: 1)	6 person (Mining: 3, Geologist: 2, Environment: 1)	6 person (Mining: 3, Geologist: 1, Environment: 2)	
Enforcement of facilities	Tools and instruments for field survey	Tools and instruments for field geological works, exploration of mineral resources and ground measurement		Tools and instruments for field geological works, exploration of mineral resources and ground measurement	Reinforcement of facility and function
	Software and hardware of IT	Additional GIS software license (3 licensees), introduction of LAN in Department and additional introduction of PC and peripheral items.		Additional GIS software license (2 licensees), and additional introduction of PC with peripheral items.	
	Chemical analysis instruments	Improvement of the laboratory, secure of maintenance of instruments, complete maintenance of instruments, exhaustiveness of spare parts and consumables, keep peripheral instruments for mine drag water analysis.		Establish an exclusive lab and introduce exclusive materials for water quality analysis	
Training of staffs	Junior figures	By involvement of joint projects with foreign organizations and training given by invited specialists from foreign countries			Organizational/Functional Enhancement
	Core figures	Addition to the above, by training or studying abroad, especially for core figures of the Departments.			
Branch office	Monitoring of mining activity Monitoring of environment	Establish a branch office in then northern area (for example at Luang Phabang)		Establish a branch office in the Central area (for example at Savannakhet)	Enhanced organizational function of inspection of mines and information of mining activity
Mineral information service/training of engineers	1/200,00 Geological Map 1/50,000 Geological Map	Complete 1/200,00 Geological Map sheets of whole territory (By joint projects with foreign countries)		Carry out 1/50,000 Geological Map sheets project (By joint projects with foreign countries)	Mineral information service for investment promotion in mining
Mineral information service/training of engineers	Preliminary exploration work over promising area	Exploration work over (By joint projects with foreign countries) areas by the initiative of DGEO (By joint projects with foreign countries)		Establish national scheme of basic survey over promising areas by DGEO's own project	Mineral information service for investment promotion in mining