REPORT
ON
THE MINERAL EXPLORATION
IN
THE DONG PAO AREA,
THE SOCIALIST REPUBLIC OF VIETNAM

(PHASE I)

MARCH 2001

JAPAN INTERNATIONAL COOPERATION AGENCY
METAL MINING AGENCY OF JAPAN

PREFACE

In response to the request of the Government of the Socialist Republic of Vietnam, the Japanese Government decided to conduct a Mineral Exploration Project in the Dong Pao Area Project and entrusted the project to the Japan International Cooperation Agency (JICA) and the Metal Mining Agency of Japan (MMAJ).

The JICA and MMAJ sent to the Socialist Republic of Vietnam a survey team headed by Mr. Kiyoharu NAKASHIMA from 21st November,2000 to 10th February, 2001.

The team exchanged views with the officials concerned of the Government of the Socialist Republic of Vietnam and conducted field survey in the Dong Pao area. After the team returned to Japan, further studies were made and this report has been prepared.

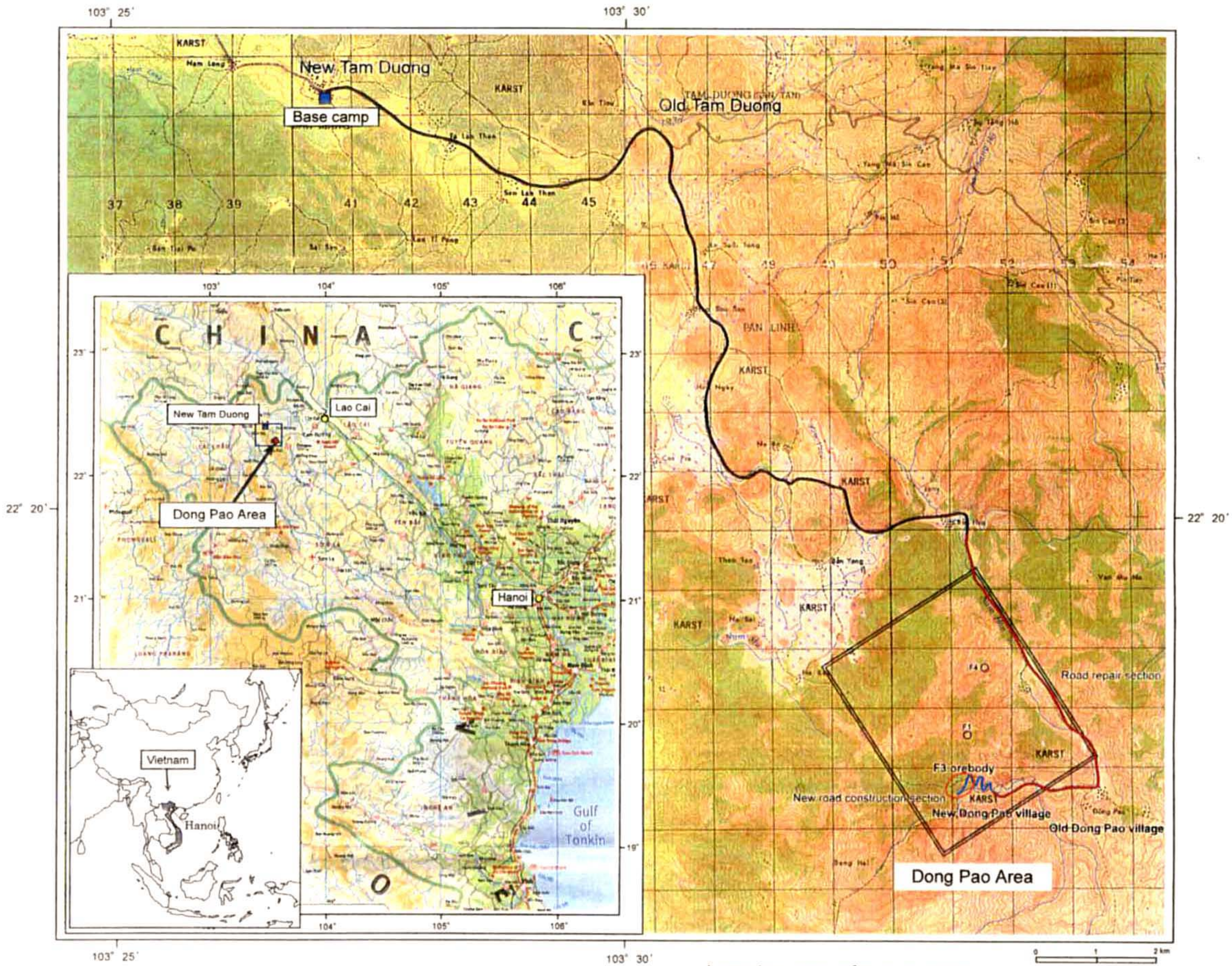
We hope that this report will serve for the development of the Project and contribute to the promotion of friendly relations between the two countries.

We wish to express our deep appreciation to the officials concerned of the Government of the Socialist Republic of Vietnam for their close cooperation extended to the team.

March 2001

Kunihiko SAITO
President
Japan International Cooperation Agency

Naohiro TASHIRO
President
Metal Mining Agency of Japan



Location map of survey area

Summary

The Mineral Exploration Project in Dong Pao Area, the Socialist Republic of Vietnam, has been designated as a part of the Regional Development Plan in the Country and has been completed for its 1st Year Campaign of the 2 Year Program. This report is prepared to describe the result of the 1st Year Campaign.

The field survey was carried out by the Survey Team dispatched by JICA and MMAJ, in cooperation with Vietnam National Mineral Corporation, in the period from November 21, 2000 to February 10, 2001.

The 1st Year program comprises geological survey, environmental baseline study, drilling investigation and metallurgical testing. Its objective is to verify possibility for commercial exploitation of the rare earth deposits in the Dong Pao Area.

The geology of the Project Area consists of limestone, shale, sandstone and siltstone of the Triassic system, and of alkaline volcanics and tuffs of Palaeogene. The intrusions include syenite and minor minette dikes. The major structural features in the Area are faults trending in the NW-SE direction and lineaments running in the N-S and E-W directions.

The soil samples collected in the course of the environmental baseline study have contained high total rare earth (T-RE_2O_3) exceeding 2 % at many localities in the vicinity of known rare earth ore bodies. The soil sampling has also led to locating new promising mineral indications at various localities. The multivariate correlation analysis of elements contained in the soil samples has indicated that the T-RE_2O_3 content is highly correlative to those of light rare earth elements and of such elements as Th, Sr, As, Pb, U, F and B.

According to the result of the water quality analysis, surface water is neutral to weakly alkaline in pH and 16.7 to 21.22℃ in temperature, except for a hot spring indicating water temperature of 28.9℃, and generally high in conductivity. Arsenic and fluorine contents, among analyzed minor elements, are high, reflecting mineralization in the general area.

A new meteorologic observation system has been installed at the weather station in New Tam Duong to continuously record temperature, humidity, precipitation and wind direction and velocity. According to the last 5-year weather record at the Tam Duong station, the climate in the area can be divided into two seasons; May to August with relatively high temperature (20 to 24℃) and precipitation (200 to 800mm/month) and September to April in the following year with relatively low temperature (13 to 18℃) and low precipitation (0.3 to 200mm/month).

The vegetation investigation has proved that virgin forests are progressively diminishing due to accelerated development of farmlands. It is also proved that major 53 and 9 rare plant species still exist in the general area.

The drilling investigation was carried out to explore the deeper part of the F-3 ore body by 16 drill holes totaling 1,480m in length. The geology that is observed in the holes comprises mineralized and altered syenite, limestone xenoliths and intruding minette dikes. Of the 16 drill holes, 7 holes encountered mineralized zones rich in rare earth contents exceeding 10 % T-RE_2O_3. The zone of mineralization exceeding 10 % T-RE_2O_3 extends in an area more than 100 m wide in the E-W direction and 300m long in the N-S direction. This mineralized zone is still open to the north and the west.

The mineralized zone presents an irregular form thinning out eastwards and deepens its position southwards. A typical ore intersection is that in the hole MJVD-10 indicating an average grade of 10.44 % T-RE_2O_3 for an interval of 52m. The ores of the F-3 ore body consist mainly of bastnaesite, being enriched in light rare earths according to the condrite-normalized pattern of the contained rare earth elements. Major ore minerals are bastnaesite, synchysite, barite, fluorite and minor monazite, associated with gangues such as quartz, calcite, K-felspars accompanying minor phlogopite, illite, kaolinite, halloysite, smectite, boehmite and so on. Bastnaesite is fine-grained, filling interstices between crystals of barite, fluorite, quartz or other minerals, or occasionally forms micro-veins cutting across these crystals.

The reserves of F3 ore body with the grade better than 10% T-RE_2O_3 are preliminarily estimated at approximately 890,000 tons with the average grade of 12 % T-RE_2O_3 containing 100,000 tons of T-RE_2O_3, based on the data obtained to date.

Some sixty rare earth ore bodies, regardless of their sizes, have been identified to date. Besides the F3 ore body, the F 1 and F 4 ore bodies have ever been worked for fluorite. The former is still being worked, while the latter has ceased its operation. The F7 ore body is approximately 1.5 km long in the E-W and 0.5 km wide in the N-S, and continues southwestward to the ore body F3. A surface sample that was collected from an outcrop in the western part has indicated high rare earth content of 11.09 % T-RE_2O_3. In addition, a sizeable soil-geochemical anomaly has been outlined in association with this ore body. These circumstantial evidences suggest a possibility of high grade and extensive mineralization at depth.

The ore bodies F 9, F 10 and F 16 are also extensive in their dimensions and form a number of significantly mineralized outcrops. Soil-geochemical anomalies that are associated with these ore bodies are significant in sizes and rare earth contents. It is, therefore, highly possible that significant ore bodies would be concealed in these areas.

The mineralization process in the Project Area can be interpreted as follows ;

(1) in late Mesozoic, the Triassic system was broken into a number of blocks by the NW-SE trending faults that resulted from the Alpine Orogenesis,

(2) in Palaeogene, alkaline magmas intruded along these faults at depth, forming syenite bodies,

(3) in the course of intrusion, high pressure and high temperature gases, containing rare earth elements, were built up at depth as the syenite was cooling down,

(4) these gases ascent along_cooling joints in the peripheries of syenite bodies or along fractured zones formed in limestone as the result of the intrusive activities,

(5) these gases were cooled down as migrating up- and out-wards and mixing with groundwater, and precipitated rare earth minerals, fluorite, barite and others at a certain temperature and pressure conditions, forming rare earth deposits, and

(6) these deposits were revealed on the surface as erosion proceeded.

Ore samples were collected from the F3 pit and submitted for the metallurgical testing. The chemical analysis of the ore samples indicated that the contents of T-RE_2O_3, $BaSO_4$ and CaF_2 were 9.25, 62.7 and 4.7 % respectively.

According to the result of the size analysis, the-8 μmm fraction of the crushed samples accounted for 32 % in size distribution with the TREO grade of 32.5 % and that of the ground samples, for 51 % in size distribution with the TREO grade of 22.1 %. Therefore, it is possible to produce crude rare earth concentrates with the grade better than 30 % T-RE_2O_3 by separating and concentrating the fine fractions.

The result of the metallurgical test that employed mostly flotation techniques under variable test conditions indicated that separation of bastnaesite was extremely difficult. A flotation test using heated water and magnetic separation test were also conducted, however, failed to obtain any better results. The reasons are ; (1) bastnaesite is highly decomposed due to weathering and extremely fine-grained, (2) fine-grained bastnaesite often forms middlings together with fluorite and/or barite, and (3) bastnaesite often occurs as micro-grain inclusions within fluorite and/or barite. Because of the first reason, the metallurgical test sample that was collected from the surface of F3 ore body may not be regarded as a representative of the ore body.

Based on the above results, the follow-up works are recommended as follows.

(1) Investigation for F3 Ore Body

Drilling Exploration:

It is essential for the economic assessment of F3 ore body to firmly delineate the ore body in its lateral and vertical extensions. A follow-up drilling exploration is necessary to delineate the northern and western extensions of the ore body, the limits of which have not been defined.

Metallurgical Testing (Mineral Processing):

The metallurgical testing for the surface sample of F3 ore body resulted in unsuccessful. The poor recovery and concentration of rare earths are attributed to fine-grained nature of bastnaesite in the test sample due mainly to intense weathering. It is necessary to carry out the flotation and magnetic separation tests, further in detail, for weak weathered representative samples collected from drill cores at depth in order to identify the optimum process for recovery and concentration of rare earth minerals.

Hydro- and/or Pyro-metallurgical Testing:

Although the flotation tests for the intensely weathered surface sample resulted in unsuccessful, the size analysis proved that the -8 μ mm fractions of the crushed and ground samples contained 32 % and 22.1 % of T-RE_2O_3 respectively. If crude concentrates with the grade of this order can be used as raw materials to produce marketable intermediate products such as mischmetal, mineral processing procedures will not be required and hence the overall production cost will be reduced. Therefore, it is worthwhile to test hydro- or pyro-metallurgical processes suitable for treatment of this type of crude concentrates.

Ore Reserve Estimation:

Upon completion of the drilling exploration, the ore reserves of the entire ore body of F3 should be re-assessed for the tonnage and grade.

Preparation of Topographic Maps:

It is necessary for the detailed survey of the Project Area to produce appropriate topographic maps at a scale of 1 to 5,000.

(2) Exploration on Other Promising Prospects

The Project Area includes three promising prospects for rare earth resources, namely New Dong Pao in the south including F3 ore body, Ban Hon South in the north and Tong Pao Nieu in the northwest. It will be essential to establish potential REE resources in these prospects in order to secure sufficient mining reserves when carrying out a feasibility study for commercial exploitation of F3 ore body in future.

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Part I Project Overview

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Chapter 1 Introduction

1-1 Background and Objectives

In response to the request of the Government of the Socialist Republic of Vietnam, the Japanese Government sent a preparatory survey mission to the Country in September 2000. The preparatory mission concluded the agreement with the Vietnam National Mineral Corporation on the 'Scope of Work' for the Mineral Exploration Project in the Dong Pao Area, Northern Vietnam, on the day of 27th, September 2000.

The Project objective is to explore the zone of rare earth mineral resources in the Dong Pao Area in the Socialist Republic of Vietnam in the period of 2 years in order to accelerate the resources development in the region of Northern Vietnam.

1-2 Work Program of the 1st Year Campaign

The work of the 1st Year Campaign is categorized into review and analysis of the existing data, geological survey, drilling investigation, environmental baseline study and metallurgical testing in order to examine the possibility of economic exploitation of rare earth resources in the Dong Pao Area. Special emphasis was placed on the F3 ore body in the 1st Year Campaign.

The works that were performed in the field and in the laboratories during the 1st Year Campaign are presented in Tables I-1-1 and I-1-2 respectively.

Tables I-1-1 The Amount of Work according to Work Category

1. Geologic study	Area	11 km^2
2. Drilling survey	1. Construction of road 2. Drilling	Renovation 7.5 km x 4.5 m in width Construction 1,530 m x 4.5 m in width Additional 630m x 4.5m in width 16 drill holes, total drilling depths 1,480 m. Assay : 1,481 samples
3. Study of environmental effect	1. Soil sampling 2. Hydrologic study 3. Vegetation survey 4. Weather monitoring	Study area 11 km^2, number of samples 1,600 5 sites, water temp., pH, Electric conductivity, flow rate and chemical analysis Study area 11 km^2 Temp., Humidity, precipitation, wind direction, and wind speed
4. Ore test	1. Sampling 2. Ore test	Pit ; 4 sites, total length ; 15m, Sketching, Total sample weight ; 1,431kg Sample preparation, Ore analysis, Floatation test

Tables I-1-2 The Type and Amount of Laboratory Work

Investigations	Analyses	Number of samples
Geological survey	Preparation of rock thin sections	20
	Preparation of ore thin sections	20
	X-ray diffraction	20
	Whole rock analyses, 12 minerals and 37 elements	20
	Chemical analysis (ore), 57 elements	50
	Fluid inclusion analyses (homogenization temperatures and salinities)	5
	K-Ar Dating	20
Investigation of environmental effect	Analyses of soil samples, 56 elements	1,606
	Analyses of water quality	5
Drilling	Making thin sections	10
	Chemical analyses (ore) 57 elements	1,481

1-3 Survey Teams

(1) Preparatory Survey Mission

The Japanese preparatory survey mission was sent to the Socialist Republic of Vietnam in the period from September 25th to October 4th, 2000, in order to inspect the Project Area and to discuss and conclude the agreement on the 'Scope of Work' for the Project with the Vietnamese representatives. The members of the Japanese preparatory survey mission and the Vietnamese representatives are as follows ;

Japanese Side

Leader

Toshio SAKASEGAWA	Director General, Mineral Resources Survey Department, Metal Mining Agency of Japan
Takashi SUGIURA	Assistant Chief, Agency of Natural Resources and Energy, Ministry of International Trade and Industry
Kei UMETSU	Program Offer, Energy and Mining Development Study Department, Japan International Cooperation Agency
Tetsuo SUZUKI	Deputy Director, Technical Cooperation Division, Metal Mining Agency of Japan
Takeshi MORIYA	Representative, Bangkok office, Metal Mining Agency of Japan

Vietnamese Side

Nho Van Troi	Director General, Vietnam National Mineral Corporation
Pham Trung Luong	Senior Expert, International Co-operation Department, Ministry of Industry
Nguyen Van Chung	Director, International Co-operation and Marketing Department, Vietnam National Mineral Corporation
Ngo Manh Hung	Senior Executive International Co-operation and Marketing Department,

	Vietnam National Mineral Corporation
Duong Trong Bong	Director
	Rare Earth Corporation

(2) Field Supervisors

Keita KODA	Deputy Director,
	Technical Cooperation Division,
	Metal Mining Agency of Japan
	From December 10 to 16th, 2000
Tetsuo SUZUKI	Deputy Director,
	Technical Cooperation Division,
	Metal Mining Agency of Japan
	From February 1st to 9th

(3) Field Survey Team

The field survey team was sent to the Project Area in the period from November 21st, 2000 to February 10th, 2001.

Japanese Side

Kiyoharu NAKASHIMA	Project Manajor ,
	Geological survey, Drilling survey
	Sumiko Consultants Co., Ltd.
Koji UEDA	Geological survey, Environment survey
	Sumiko Consultants Co., Ltd.
Takashi UENO	Drilling survey
	Sumiko Consultants Co., Ltd.

Vietnamese Side

Nguyen Van Chung	Reader,
	Geological survey, Drilling survey
	International Co-operation and Marketing Department,
	Vietnam National Mineral Corporation
Hoang Van Cong	Drilling survey, Environment survey
	Rare Earth Corp.-TERRAPRODEX
	Vietnam National Mineral Corporation
Ngo Manh Hung	Interpretation , Environment survey
	Vietnam National Mineral Corporation

Chapter 2 Geography of the Project Area

2-1 Location and Access

The Project Area is situated to the northwest of Dong Pao village, approximately 13 km to the east southeast of old Tam Duong village. Dong Pao village is located at approximately 300 km to the northwest of Hanoi and 47.5 km in the direct distance to the west southwest of Lao Kai, the city adjacent to the international border to the People's Republic of China. The Project Area is enclosed by lines connecting the four corner points with the geographic coordination as follows ;

NE Corner : 22° 19' 28" N, 103° 33' 28"

SE Corner : 22° 17' 46" N, 103° 34' 37"

SW Corner : 22° 16' 56" N, 103° 33' 07"

NE Corner : 22° 18' 38" N, 103° 31' 58"

New Tam Duong village, where the base camp for the field survey was settled, is about 8 km west of old Tam Duong village. It takes some 11 hours by driving to reach the village from Hanoi via Lao Cai, Sapa and Binh Lu. Though the road from Hanoi to the midway between Sapa and Binh Lu is paved, the rest to the village is unpaved.

The F3 ore body, being situated in the southern part of the Project Area, is reached from the base camp by 50-minute driving for a distance of about 26 km. The road from the base camp first leads to old Tam Duong village and then to the south of Ban Hon village, and continues for a distance of about 2 km, passing through the north of Dong Pao village, to New Dong Pao village, to the west of which the F3 ore body is located. The road beyond Ban Hon had been unavailable for driving, and was improved and repaired on this occasion for vehicle transportation services for the Project.

2-2 Topography and Drainage Systems

The Project Area is situated in a steep terrain, with the elevations ranging between 700 and 1133 m, on the northeastern slope of Pu Sam Cap mountain (with the peak elevation of 2,111 m) stretching from Fan Si Pan range.

The topography exhibits characteristics of a limestone terrain with extensive development of karstic features such as doline and lapies in the southern part and polje to the north (e.g. flats near Ban Hon village). Structural lineaments with the NW-SE direction are extensively developed in the region. The major river, Nam Hon to the north of the Project Area, flows northwesterly, then changes its flow direction to the east in the vicinity of Ban Hon flowing for a distance of 3.5 km and then turns southeasterly before joining Nam Ma river. In addition to rivers and valleys trending in the NW-SE direction, a number of water courses and steams are developed in the directions of NE-SW or E-W. Dong Pao river in the southern part becomes an underground flow southwards, the outlet of which is not known. A hot spring (29℃) has been located in the northeastern part.

2-3 Climate and Vegetation

The climate in the general area belongs to semitropical-monsoon with the wet season from May to August and the dry season from November to February in the following year. The months of March-April and September-October are the transition from one season to the other and are yearly variable in the precipitation and temperature. It had more rainy days than the normal years in December 2000, while the survey team was on-site. Temperature ranges from 13 to 18℃ from September to April during the dry season, while it ranges from 20 to 24℃ from May to August during the wet season. Humidity in the dry season is in the range between 70 and 80 %, and that in the wet season, in the range between 80 and 94 %. The climate is, in general, humid but moderate in temperature.

Virgin forestlands scarcely remain, having been replaced by extensive agricultural lands. Hill slopes are thickly grown with shrubs and miscellaneous trees, while bushes and grasses develop over gentle slopes and flats. Manioc is grown in cultivated lands. Paddy fields are developed over narrow flood plains along major streams.

Chapter 3 Geology and Mineralization

3-1 Regional Geology

The basement in the northern region of Vietnam is composed of Proterozoic formations, and is overlain by Palaeozoic, Mesozoic and Cenozoic formations in ascending order (Figures I-3-1 and I-3-2).

The basement formations can be divided into the Lower and Upper Proterozoic ; the Lower Proterozoic consists of gneiss, amphbolite, quartzite and crystalline limestone, and the Upper Proterozoic, of schist, quartzite and dolomite. The basement rocks also include intrusions of various stages of the Proterozoic, such as granodiorite, granite and migmatite. The Lower Proterozoic distributes in a narrow belt trending in the NW-SE direction from Lao Chai to Viet, near Hanoi, along Hong river, and also to the southwest of this belt. The Upper Proterozoic distributes also in a NW-SE trending zone from the south of the town of Lao Chai to the east of Dien Bien Phu, continuing further to the southeast.

The Palaeozoic formations, overlying the Proterozoic, comprise sedimentary rocks such as limestone, shale, quartzite, greenstones, chert, conglomerate, sandstone, siltstone and coal, and such volcanic rocks as rhyolite, trachyte, andesite and basalt, all of which range from Cambrian to Permian in ages. Intrusions of gabbro, syenite and granite are also included in the Palaeozoic rocks. These Palaeozoic formations distributes extensively from the central Vietnam northeastwards, and are also observed in the northwestern and the southern parts.

The Mesozoic formations include such sedimentary and volcanic rocks as conglomerate, sandstone, shale, coal, limestone, trachyte, rhyolite, tuff and basalt of Triassic to Cretaceous ages. Included are also intrusions of gabbro, syenite, granite, granodiorite and diorite. These formations and rocks distribute in the west-central, western, eastern and southern parts of Vietnam.

The Cenozoic formations consist of Palaeogene trachyte, of Neogene conglomerate, sandstone, slate and of Quaternary alluvium. They distribute extensively from the vicinity of Hanoi towards the southeastern part along the coast.

3-2 Regional Features of Geological Structures

The northern Vietnam (north of the latitude 20° N) can be divided into 5 geologic provinces ; namely, Littoral Bacbo, Viet Bac, West Bacbo, Truong Son and Northwest Laos (Figure I-3-3).

The most outstanding structural feature in the northern part is the NW-SE trending fault system. Secondarily, the NE-SW trending faults, cross-cutting the former, are also prominent. The Project Area is situated in the northwestern part of the West Bacbo geologic province that is elongated in the NW-SE direction. The geology consists mostly of Triassic limestone, conglomerate, sandstone and shale intruded by syenite of late Mesozoic to early Tertiary. NW-SE trending faults are predominated in the Area.

3-3 Mineral Resources

3-3-1 Mineral Industry

Mineral commodities that have been historically worked in Vietnam regardless of industrial scales include gold, copper, lead, zinc, iron, titanium, tin, tungsten, chromium, bauxite, ilmenite, nickel, manganese and rare earths for metallic minerals, and coal, petroleum, natural gas, phosphorus, quartz, silica sand and graphite for non-metallic minerals. Other commodities than coal, petroleum and natural gas remain mostly unexploited or have been operated in minimal scales, if exploited, due to lack of infrastructures and funds.

3-3-2 Mineral Occurrences

The major mineral deposits in Vietnam have been emplaced in a wide range of the geologic history and can be classified into five stages according to their age of emplacement. Their distribution and relationship with the geological structures are shown in Figure I-3-4. The list of mineral deposits, in terms of their age of emplacement, is presented in Figure I-3-5. The distribution of the major deposits, including the rare earth deposits concerned with the current Project, is also shown in Figure I-3-6.

(1) Precambrian Mineral Deposits

A small number of deposits have been identified in association with metamorphic rocks of lower Proterozoic or Archaean. They are mainly iron deposits, including a few copper bearing magnetite deposits and gold deposits.

(2) Mineral Deposits of Early to Middle Palaeozoic

The South China and Indochina Plates, as well as micro-plates between the two major plates, joined together or separated from each other during this period. Ophiolitic igneous activity occurred along major fault zones. Chromite, pyrite and gold bearing pyrite deposits were emplaced in ophiolitic zones. Gold quartz veins were also formed in meta-sedimentary rocks. Stratiform iron, manganese and lead-zinc deposits were associated with alkaline to felsic volcanism in rift zones during the middle Palaeozoic period. Ruby and sapphire occur along the Que Son thrust fault zone.

(3) Mineral Deposits of Indochina Stage (Early Carboniferous to Late Triassic)

The South China and Indochina plates that had collided in middle Palaeozoic were separated again by the rift zone along Da river in the early Carboniferous to late Triassic period. The sedimentary rocks in this rift zone include basic volcanics and intrusions. Basic and acidic volcanics, as well as granite and gabbro, also distribute in the peripheries of the rift zone. The mineralization of this period is concentrated in northern Vietnam and includes nickel, copper, gold and stratiform pyrite deposits in the Da river rift zone. Ilmenite and lead-zinc deposits are associated with other rift zones. Most of the mineral deposits of this period are characteristically of skarn, hydrothermal or orthomagmatic types.

(4) Mineral Deposits of Late Mesozoic to Early Cenozoic

The mineralization is mainly concentrated in the period of Cretaceous to Palaeogene and is characterized by mineral deposits formed in relation with the plate collision. Tin, gold, molybdenum, base metals and porphyry type copper deposits are associated with intermediate to acidic volcanics and intrusions along the Da Lat zone in southern Vietnam. Molybdenum, rare earth, lead-zinc, gold, uranium and thorium mineralization occurs associated with intermediate to acidic volcanics and intrusions in the Hong Lien Son zone that forms the highest mountain range in Vietnam. Two-mica granite and granodiorite accompany mineralization of tin, tungsten, gold, uranium and fluorite. Mineralization of tin, antimony and lead-zinc are associated with granite and granitic syenite. Ore deposits of antimony, lead-zinc, mercury gold and barite are formed in Palaeozoic to Mesozoic formations along NW-SE trending faults. Major deposits of rare earth are the Dong Pao (the target of the current project) associated with syenite and quartz syenite in northwestern Vietnam and the Nam Xe formed in limestone and basic rocks to the north of the Dong Pao (Figure I-3-5).

(5) Mineral Deposits of Neogene to Quaternary

Placer, sedimentary and residual deposits were formed during this period. There are placer deposits of chromite, cassiterite, wolframite, gold, ruby, ilmenite, monazite and xenotime. Coal, natural gas and petroleum are sedimentary deposits that are important resources for the national economy. Among the residual deposits, kaolinite and bauxite deposits are economically significant.

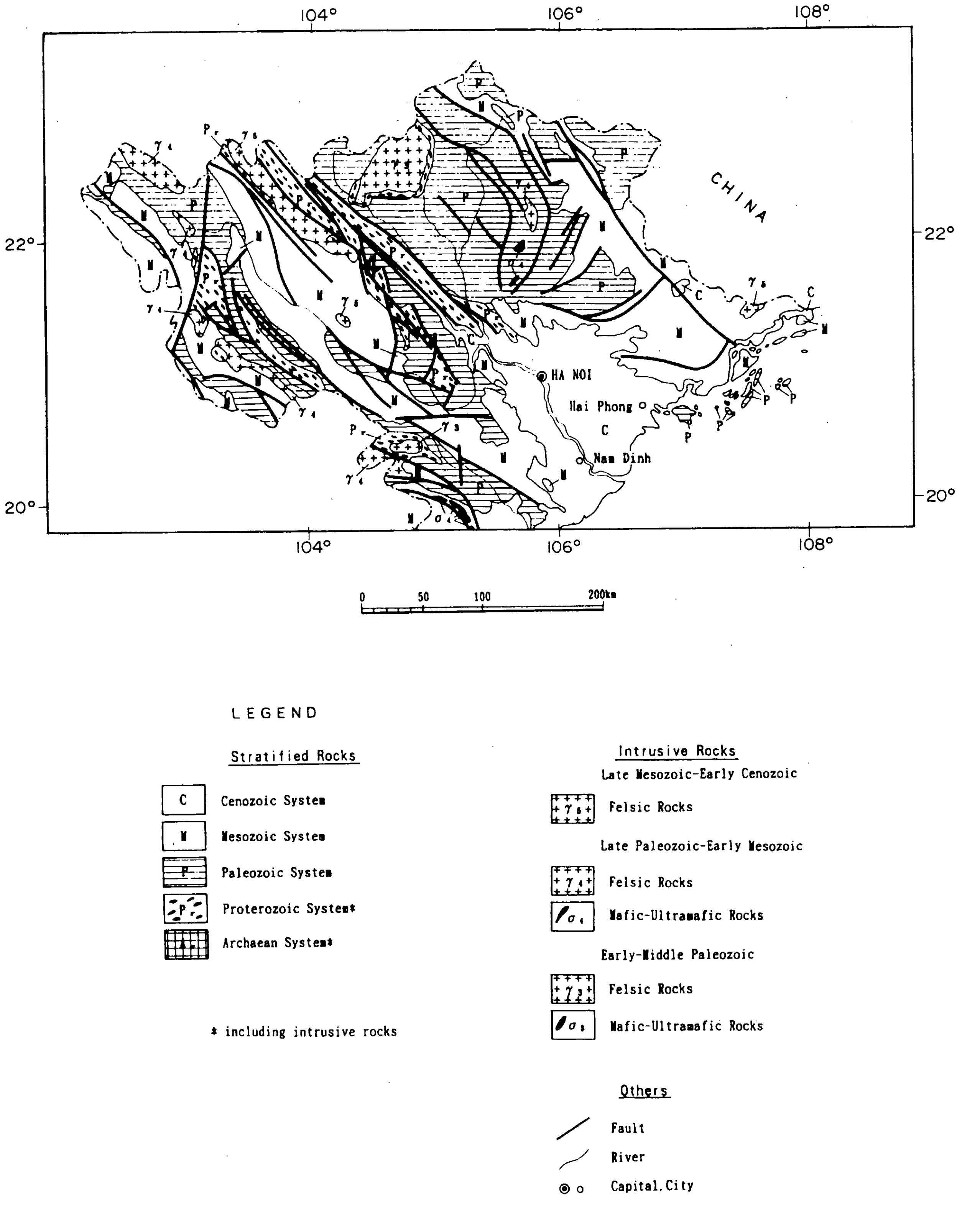
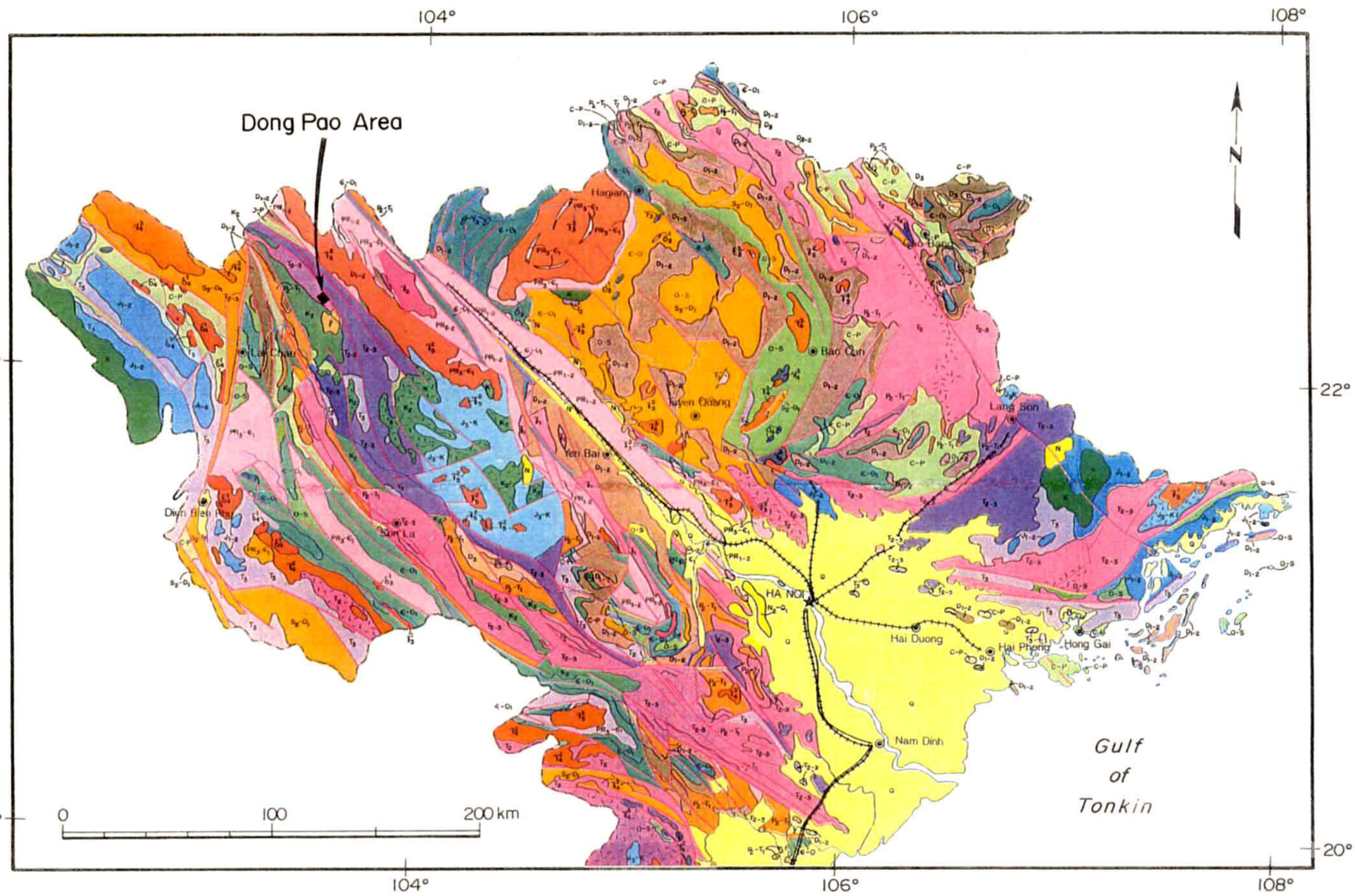


Figure I-3-1 Simplified geological map of northern part of Vietnam



LEGEND

STRATIFIED ROCKS

- Quaternary: Alluvium with marine deposits in coastal area, βQ: Basalt
- U.Neogene - Quaternary: Gravel, clay, pebble, laterite
- Neogene: Conglomerate, sandstone, claystone, lignite
- Paleogene: Trachyte, leucitophyre
- U.Cretaceous: Red continental deposits - conglomerate, sandstone, siltstone
- Cretaceous: Red continental deposits of conglomerate, sandstone, siltstone, rhyolite
- U.Jurassic - Cretaceous: Orthophyre, tuff, basalt, rhyolite
- L - M.Jurassic: Continental deposits of conglomerate, sandstone, siltstone
- U.Triassic: Conglomerate, sandstone, marly shale, coal
- M - U.Triassic: Shale, limestone, conglomerate, sandstone, basalt, rhyolite
- M.Triassic: Conglomerate, sandstone, shale, limestone, rhyolite
- U.Permian - L.Triassic: Conglomerate, siltstone, siliceous limestone, shale, coal, basalt
- Carboniferous - Permian: Shale, coal, limestone, chert with andesite and basalt
- U.Devonian: Limestone, chert, shale
- L - M.Devonian: Conglomerate, sandstone, shale, limestone
- U.Silurian - L.Devonian: Sandstone, shale, limestone, rhyolite, chert
- Ordovician - Silurian: Conglomerate, sandstone, shale, chert, rhyolite, orthophyre
- Cambrian - L.Ordovician: Limestone, shale, quartzite, greenstone, chert
- U.Proterozoic - L.Cambrian: Schist, quartzite, dolomite
- L - M.Proterozoic: Gneiss, amphibolite, quartzite, marble

INTRUSIVE ROCKS

LATE MESOZOIC - EARLY CENOZOIC

- Granodiorite, granite, granosyenite / Diorite, granodiorite, granite

LATE PALEOZOIC - EARLY MESOZOIC

- Biotite granite, granophyre, granodiorite, diorite
- Gabbro, granophye / Diorite, granodiorite
- Dunite, peridotite

EARLY - MIDDLE PALEOZOIC

- Biotite granite
- Nepheline syenite, granosyenite
- Gabbro - diabase, gabbro / Serpentinite, dunite

PROTEROZOIC

- Granodiorite, granite, migmatite / Plagiogranite, granodiorite, granite, migmatite

- Felsic volcanics
- Fault
- Railways
- Roads

U: Upper M: Middle L: Lower

Figure I-3-2 Geological map of northern part of Vietnam

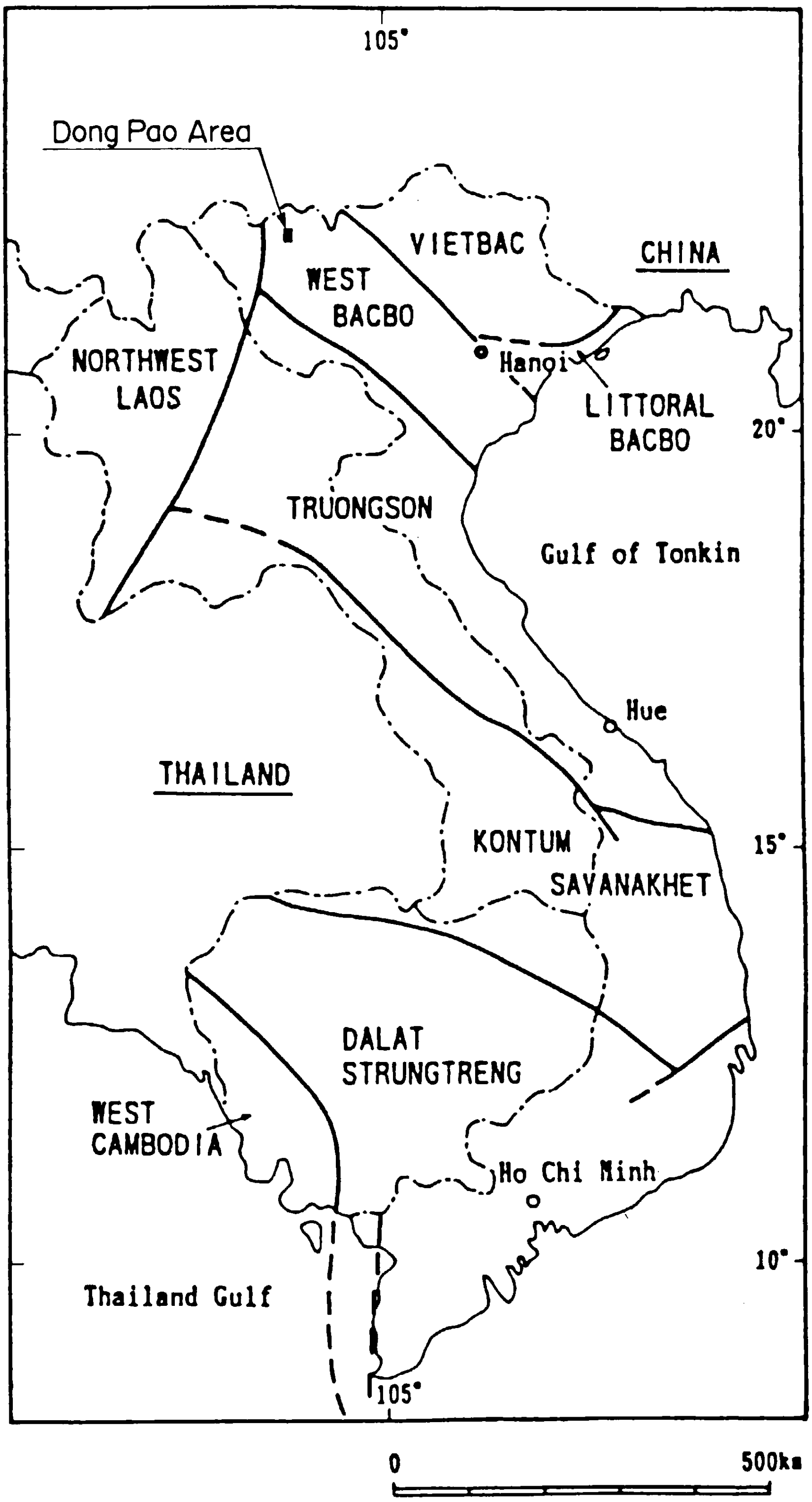
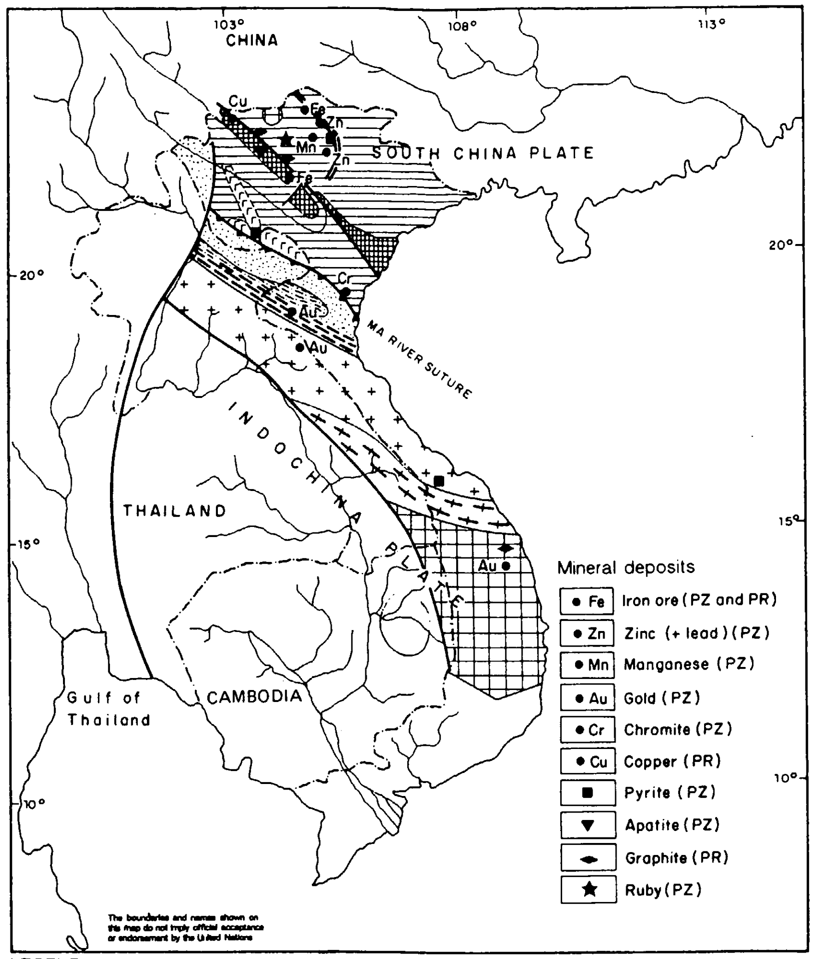


Figure I-3-3　Geological setting of Cambodia-Laos-Vietnam



LEGEND

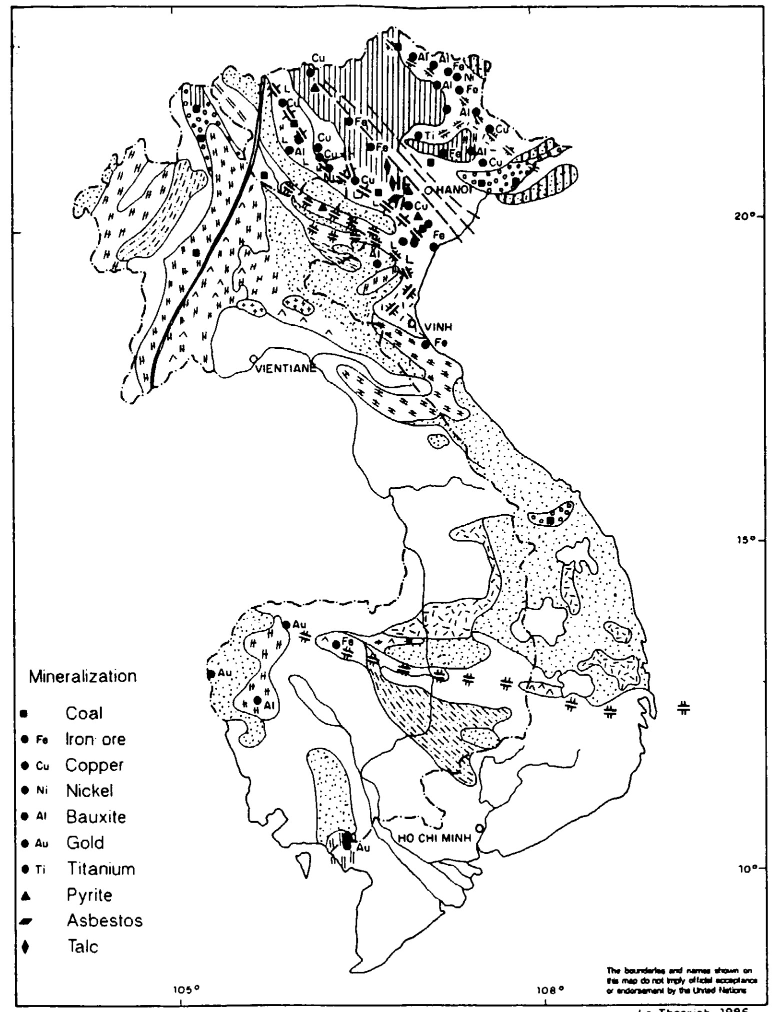
South China plate :

- Phanerozic stages
- Outcrop of Pre-Cambrian basement along the Red River zone
- Lower Paleozoic ophiolite along the Ma River zone
- Mid Paleozoic rift of Tong Ba-Phu Ngu

Indochina plate :

- Uplifted Kontum massif
- Mesozoic-Paleozoic cover of Khorat-Da Lat
- Back arc thrust of Que Son
- Truong Son volcanic arc
- Foreland basin of Ca River
- Outer island of Phu Hoat
- Outer Trough of Sam Nua
- Suture zone of Ma River

Tectonic setting and mineralization of the Lower - Mid Paleozoic and Pre - Cambrian epochs



EXPLANATION

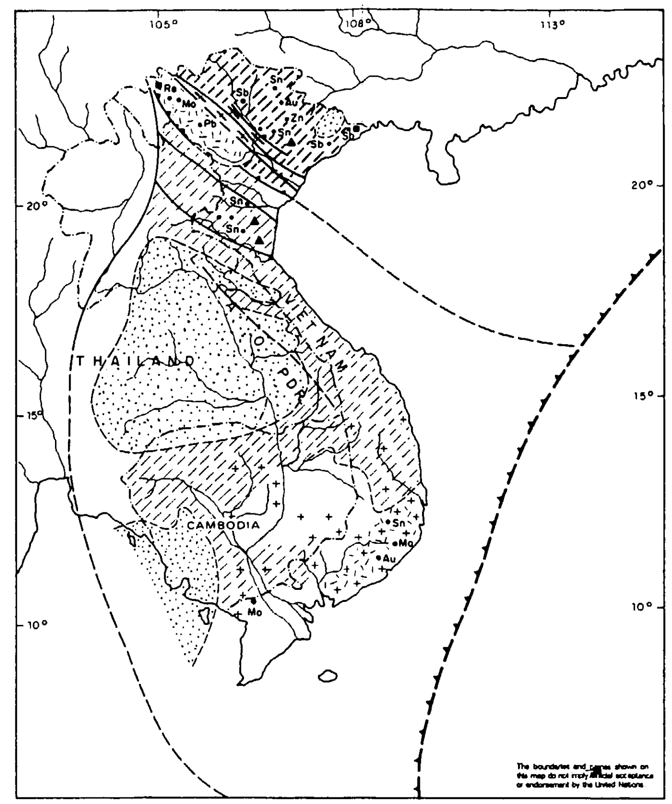
Pre-Indosinian folded basement :

- Indochina plate
- South China plate
- Post-Indosinian stage

Indosinian stages :

- Lower stage (Carboniferous-Lower Permian)
- Middle stage (Upper Permian-Carnian)
- Upper stage (Norian-Rhaetian)
- Basic volcanics
- Intermediate volcanics
- Acid volcanics
- Granitoid
- Boundary of Indochina plate
- Da river rift
- Marginal rift

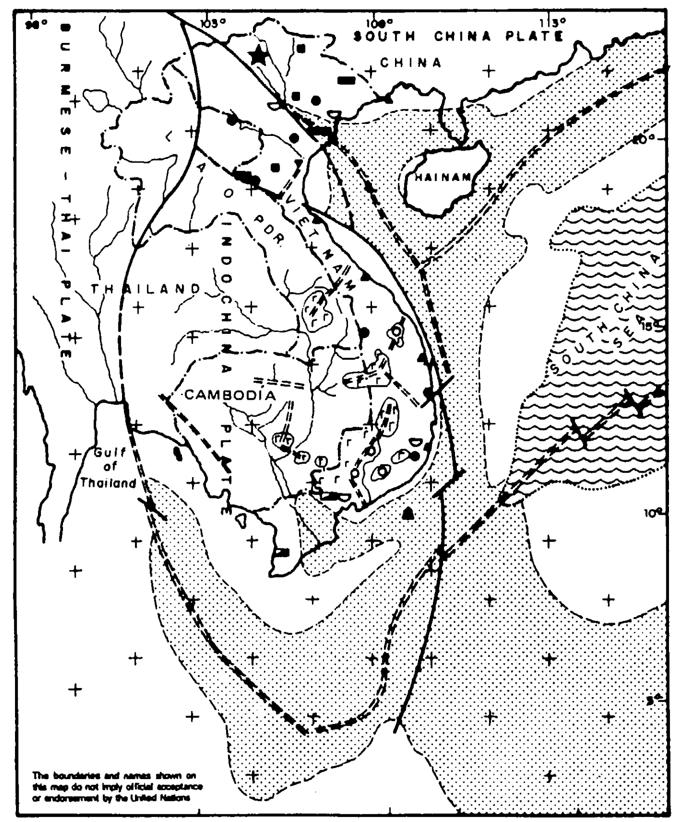
Tectonic setting and mineral distribution during the Indosinian epoch in Indochina



LEGEND

- South China Plate
- Indochina plate
- Acidic and intermediate volcanics
- Granitoids
- Intercontinental basins of Jurassic-Cretaceous
- Metallic deposits : Au-gold, Sn-tin, Mo-molybdenum, Sb-antimony, RE-rare earths, Pb-lead and zinc
- Non-metallic deposits: a/ kaolin b/ barite
- Benioff zone : a/ inferred, b/ established
- a/ back arc thrusts, b/ faults

Tectonic setting and distribution of mineralization during the Mesozoic - Early Cenozoic epoch



LEGEND

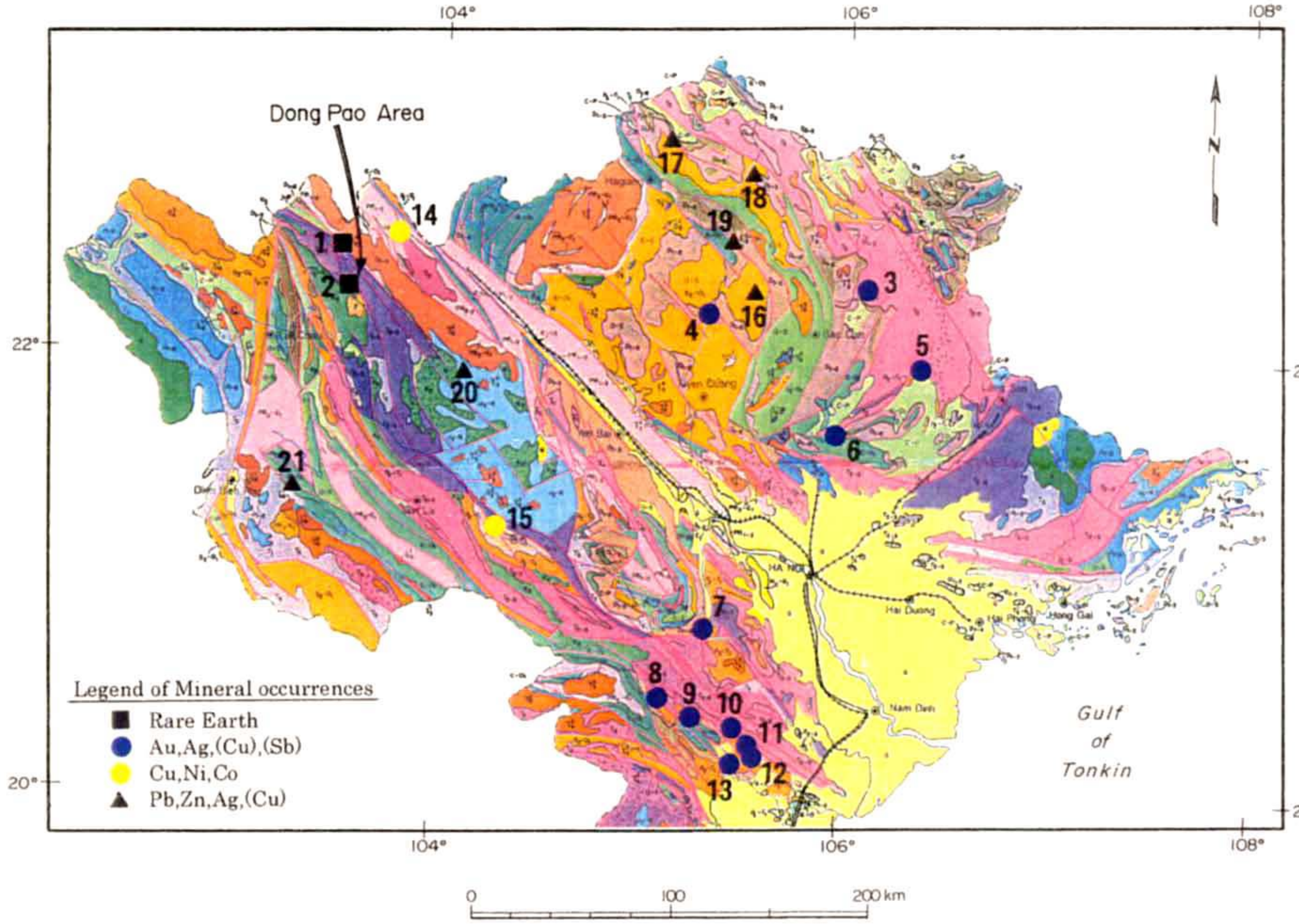
- Continental crust
- Neogene depressions with thick sedimentation on the continental shelf
- Oceanic crust
- Basaltic cover
- Faults and thrusts
- Rift zones
- Gold placers
- Cassiterite placers
- Kaolin deposits
- Lateritic bauxite deposits
- a/ Ilmenite placers ; b/ Chromite placers
- Ruby placers
- Hydrocarbon deposits
- a/ Lignite;b/ Peat

Tectonic setting and distribution of mineralization in the Neogene - Quaternary epoch

Figure I-3-4 Tectonic setting and distribution of mineralization map

Mineral Resources \ Metallogenic epoch	Neogene-Quaternary	Late Mesozoic-Early Cenozoic	Late Paleozoic-Early Mesozoic	Early-Middle Paleozoic	Pre-Cambrian
Hydrocarbons	▬				
Coal	▬		▬		
Iron ore	▬		▬	▬	▬
Manganeseore	▬			▬	
Chromite	▬			▬	
Ilmenite	▬		▬		
Copper		▬	▬		▬
Nickel	▬		▬		
Molybdenum, tin and tungsten	▬	▬	▬	▬	▬
Rare earths, lead and zinc		▬	▬	▬	
Antimony		▬			
Gold	▬	▬	▬	▬	▬
Bauxite	▬		▬		
Ruby and sapphyre	▬			▬	
Phosphate	▬			▬	
Kaolin	▬	▬			
Barite		▬			
Fluorite		▬			
Pyrite		▬	▬	▬	
Graphite					▬

Figure I-3-5 Main mineralization in Vietnam



No.	Project	Province	Commodity	Type of Ore
1	Nam Xe (N,S)	Lai Chau	REE	Hyd.
2	Dong Pao	Lai Chau	REE	Hyd.
3	Pac Lang	Coa Bang	Au,Ag	Hyd.Qz-vein
4	Lang Vai	Tuyen Quang	Au,Ag,Sb	Hyd.Qz-vein
5	Na Pai	Lang Son	Au,Ag	Hyd.Qz-vein
6	Bo Cu	Thai Nguyen	Au,Ag	Hyd.Qz-vein
7	Kim Boi Area	Hoa Binh	Au,Ag	Hyd.Qz-vein
8	Lang Neo	Thanh Hoa	Au,Ag	Hyd.Qz-vein
9	Lang Buong	Thanh Hoa	Au,Ag	Hyd.Qz-vein
10	Lang Mo	Thanh Hoa	Au,Ag	Hyd.Qz-vein
11	Khe Mon	Thanh Hoa	Au,Ag	Hyd.Qz-vein
12	Thach Kam	Thanh Hoa	Au,Ag	Hyd.Qz-vein
13	Kam Tam	Thanh Hoa	Au,Ag	Hyd.Qz-vein
14	Sin Quyen	Lao Cai	Au,Ag,Cu	Hyd.(vein/lenses)
15	Ban Phuc	Son La	Cu,Ni,Co	Mam.Lay
16	Cho Dien	Bac Thai	Ag,Pb,Zn	Strf(oxide & Sulfide
17	Na Son	Ha Giang	Pb,Zn	Strf
18	Tung Ba-Bac Me	Cao Sang & Ha Giang	Au,Pb,Zn,Cu	Strf(Pb,Zn),Hyd.(Au,Cu)
19	Ngan Son District	Cao Bang	Pb,Zn	Hyd.
20	Tu Le	Lao Cai	Ag,Pb,Zn	Hyd.
21	Phu Ta	Lai Chau	Pb,Zn	Hyd.

Figure I-3-6 Distribution of mineralization in the northern part of Vietnam

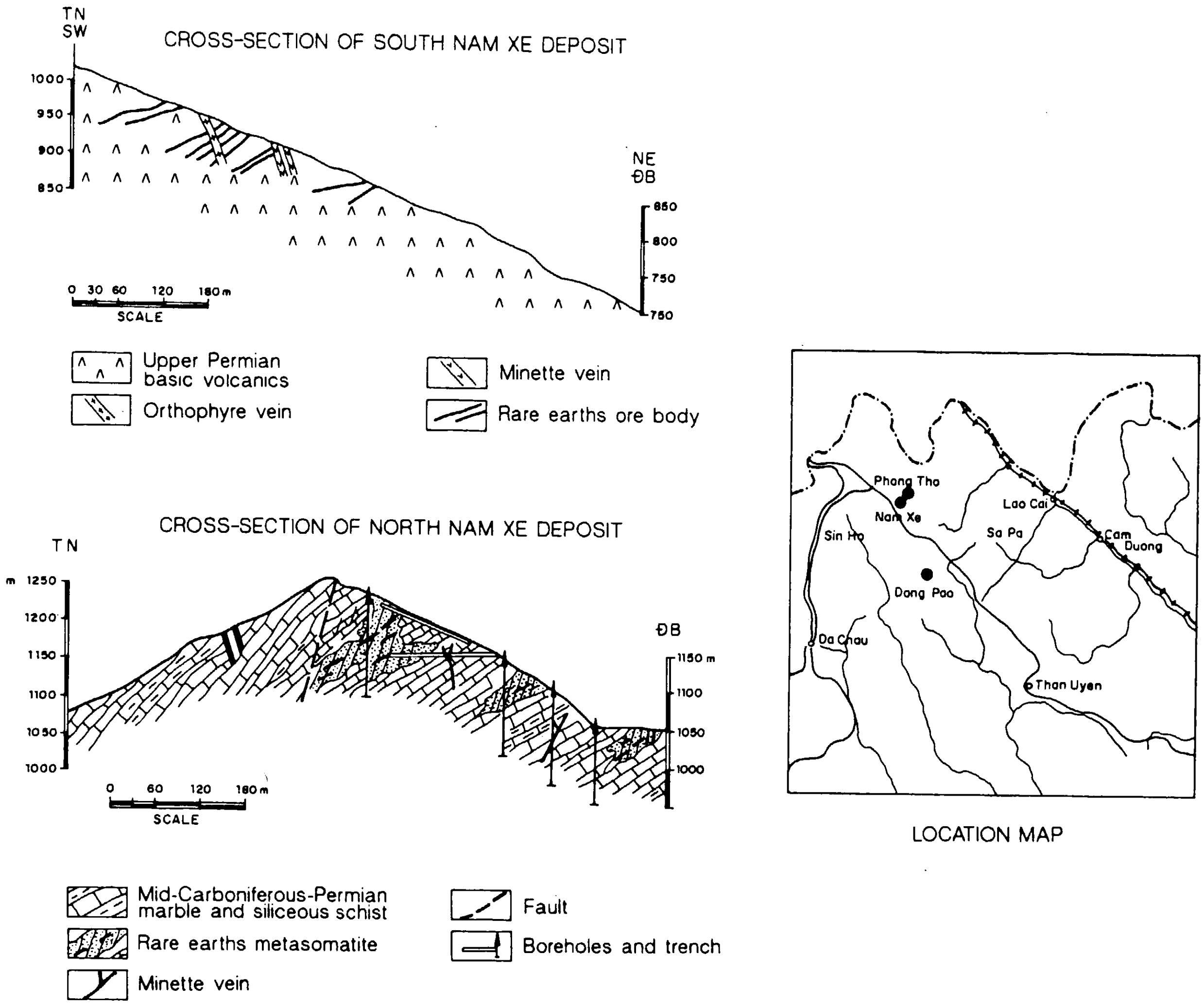


Figure I-3-7 Cross section of Nam Xe Rare Earth deposit

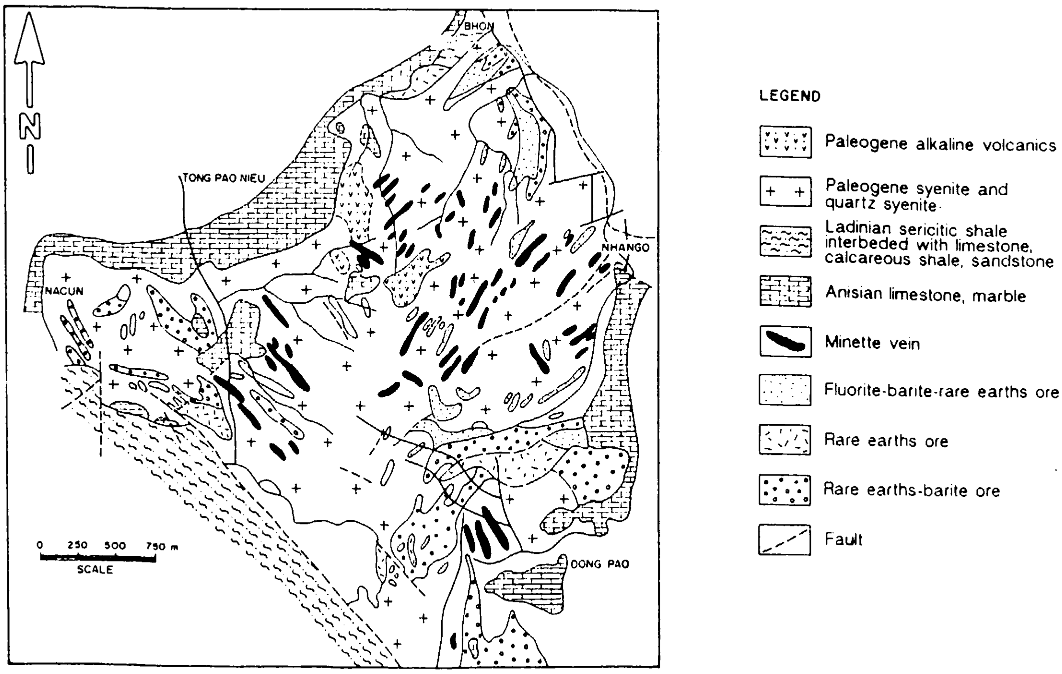


Figure I-3-8 Distribution map of Dong Pao Rare Earth deposit

Chapter 4 Past Exploration Works

4-1 General View of Past Exploration

4-1-1 Exploration History

The exploration history of the Dong Pao and surrounding areas are outlined as follows ;

1950s : A preliminary geological survey was carried out by French geologists. The result was followed up by geologists of the Union of Vietnam.

1959 : Mineral indications of rare earths and fluorite were discovered.

1964-1968 : A systematic geological survey for prospecting mineral resources was conducted under the direction of General Department of Geology of Vietnam. The result was compiled into the report published in 1972.

1984-1985 : The detailed investigation on the F3 South ore body was carried out in cooperation with the former German Democratic Republic, which led to estimation of the ore reserves. The result was compiled into the report published in 1986.

1995 : VIMICO (Vietnam National Minerals Corporation) mined a small amount of rare earth minerals (a total of 50 tons) for trial use as a row material for rolled steel. Also, INTERGIO, an affiliate of DGMV (Department of Geology and Minerals of Vietnam), carried out a geological survey for prospecting rare earth mineral occurrences in the area including Dong Pao and produced geological maps of 1 to 50,000 scale.

1997 : A Korean private enterprise, LG, which had been interested in the rare earth resources in Vietnam, established a joint-venture with VIMICO according to the agreement with the Government of the Socialist Republic of Vietnam. Although the joint-venture planned to produce 6,000 to 10,000 tons per year of rare earth minerals, this plan was cancelled due to the economic crisis in the Asian region. It is said that the LG collected 3 tons of ore samples from 4 pits and sent them to Korea for metallurgical testing. However, no record of the metallurgical test is available.

4-1-2 The Geological Survey in the Period from 1964 to 1968

The geological survey was carried out in two stages. In the 1st stage between 1964 and 1966, the geological survey and mineral prospecting at a scale of 1 to 10,000 was conducted for an area of 10 km^2 including the Dong Pao, Nha Ngo and Na Cua prospects. In the 2nd stage between 1966 and 1968, the detailed prospecting was concentrated on the major five ore bodies, F 1, F 2, F3, F 4 and F 5. The work performance is summarized in Table I-4-1 and I-4-2.

Table I-4-1 Overall Work Performance (1964-1968)

Method	for Geological survey	for Ore deposit survey	Geophysical survey	Total
Pit	2,959.20 m^3	103.35 m		3,062.55 m
Trench	6,009.60 m	5,245.93 m^3		11,255.53 m^3
Deep pit	158.30 m			158.30 m
Tunnel		223.30 m		223.30 m
Channel samples	1,395 pcs	1,321 pcs		2,716 pcs
Chemical analysis	162 pcs	974 pcs		1,136 pcs
Geochemical soil samples	1,956 pcs			1,956 pcs
Heavy mineral assay	230 pcs			230 pcs
Petrographic samples	101 pcs			101 pcs
Ore dressing sample		4,406.01 kg		4,406.01 kg
Surface gamma measuring			50 km	50 km

Table I-4-2 Work Performance for Each Ore Body (1964-1968)

Method	FI	FII	FIII	FIV	FV	Total
Pit	16.50m	-	45.25m	41.60m	-	103.30m
Trench	284.02m	155.00m^3	3,282.71m^3	1,419.2m^3	105.00m^3	5,245.93m^3
Tunnel	122.80m	-	87.00m	13.50m	-	223.30m
Channel samples	190pcs	18pcs	440pcs	320pcs	6pcs	974pcs

4-1-3 Detailed Investigation in the Period between 1984 and 1985

The investigation was carried out by the Geology Division, the Ministry of Machinery and Metallurgy in cooperation with the German Democratic Republic. The objective were to explore F3, the most promising of the rare earth deposits in the Dong Pao area, in detail and to estimate its ore reserves. The exploration was focused on the weathered zone of F3 South ore body. The work performance is summarized in Table I-4-3.

Table I-4-3 Work Performance for F 3 Ore Body (1984-1985)

Method of survey	Quantity of survey work	Note
Survey area	25 ha	Including F3 ore body
Shafting (deep pit)	251.5 m	10 place, maximum depth is 30m
Trenching	1,800 m	
Channel samples	397 pcs	Sampling from shaft
Chemical analysis	391 pcs	Elements: T-RE_2O_3, $BaSO_4$, CaF_2
Petrography samples	43 pcs	
Mineralogical samples	13 pcs	
Ore dressing sample	9,700 kg	97samples

4-2 Review of the Past Exploration Result

4-2-1 Geology and Geological Structures

The geology of the Dong Pao area, where the geological survey and mineral prospecting have been carried out for an area of 10 km^2, comprises middle Triassic limestone and schist intruded by Palaeogene syenite and quartz syenite, all of which are overlain by Palaeogene alkaline volcanics. Minette dikes are also observed.

The limestone formation distributes in the northwestern and southeastern parts of the area and is gray-white to dark gray in color and massive, often forming steep cliffs. The schist formation mostly distributes in the southwestern part and consists of argillaceous schist interbedded with thin layers of sandstone and limestone. Its beddings strike in the NW-SE direction and dip 30 to 50° to southwest. The alkaline volcanic unit, overlying the syenite, distributes in a limited area in the northern part and consists of trachytic tuff and agglomerate.

The intrusions, syenite and quartz syenite, occur extensively in the area and exhibit gray to light color on fresh surfaces that turns into yellow to brown where weathered. K-feldspar is most abundant, accounting for 80 % of rock forming minerals of the syenite-quartz syenite. Plagioclase, biotite and clino-pyroxene are also contained in subordinate amount. Quartz rarely occurs, which gives a name of 'quartz syenite'. Accompanied accessories are titanite, garnet and magnetite. The syenite gradually changes its facies to porphyritic syenite and trachyte. Rare earth, fluorite and barite deposits are formed in association with the syenite.

The minette dikes, though insignificant in their widths and lengths, occur in abundance within syenite intrusions and show dark gray to dark green color on fresh surfaces that turns into dark brown where weathered. Biotite is one of the characteristic mineral constituents of the minette.

The most prominent structural feature is the NW-SE trending fault system, the same as for the regional structure. A number of minor faults, striking in the NE-SW direction, are also observed crosscutting this major fault system.

4-2-2 Ore Deposits

A number of the trenches and pit that were excavated in the course of the geological survey during the period from 1964 to 1968 revealed rare earth, fluorite and barite ore bodies at 60 localities in the prospected area. Among these ore bodies, F3, F7, F 9, F 10, F 15, F 16 and F 17 are relatively large in their sizes. As aforementioned, F3 was further explored in detail by additional deep pits and trenches in the period between 1984 and 1985. The ore bodies such as F 1, F 4 and F 5 have been exploited to date in this area for mining mainly fluorite. F 1 is still being mined, while F 4 is currently suspended for its operation and F 5 is mined out.

The ore bodies are mostly formed within syenite intrusions, though the mineralization occasionally extends out to intruded limestone. Ore bodies of relatively large sizes tend to occur in the peripheral zones of syenite intrusions. The mineralization occurs as veins, disseminations and lenses. Rare earth minerals are bastnaesite, synchysite, Lanthanite, Prisite, Xenotime and monazite, accompanied by fluorite, barite, calcite, quartz, siderite and hollandite.

The ores occurring in the Dong Pao area can be grouped into the following four categories according to the proportions of rare earth minerals, fluorite and barite ;

a) Rare Earth Ore

b) Rare Earth-Barite Ore

c) Fluorite-Barite-Rare Earth Ore

d) Fluorite bearing Rare Earth Ore

The most promising ore body is F3 that is high in the rare earth content and has a size of 450 to 650 m in length and 200 to 300 m in width. A preliminary ore reserve estimation was made for the ore bodies of F 1, F 2, F3, F4 and F 5 in 1972 based on the exploration result in the period from 1964 to 1968. The ore reserves of the ore body F3 were estimated in 1986 according to the result of the detailed exploration in the period between 1984 and 1985.

The ore reserve estimation is based on the standards denoted in the 'Regulations with Respect to the National Mineral Resources Committee' set by the Committee and enacted on February 5th, 1955. The definitions of the categories C 1 and C 2 are as follows ;

Category C 1 : the resource that is approximated for its appearance, shape and content based on sufficient investigation and research works. The conditions for exploitation of the area of mining right include its natural state, rank in significance for industrial row materials, grades in contained elements and technological characteristics for exploitation, as well as the surrounding natural environment. The boundary of the resource shall be defined according to the geological and geophysical data collected through the investigation and the research works.

Category C 2 : the resource that is roughly estimated for its appearance, shape and distribution based on geological and geophysical data locating ores on-sites or comparing its similarity with other investigated areas of mining right. The grades in contained elements are estimated by analysis of individual samples or bulk samples collected on site, or by comparing data with those in the adjacent areas of mining right. The boundary of the resource shall be defined, taking account of 'the geological structures and the complex distribution of the host rocks.

a) Reserve Estimation based on the Result of the 1964-1968 Exploration

According to the 1972 report that compiled the 1964-1968 exploration works, the reserves of the five ore bodies, F 1, F 2, F3, F 4 and F 5, are summarized as follows and shown in Table I-4-4 in detail.

1) The total ore reserves of the fluorite-rare earth-barite zone, inclusive of the categories C 1 and C 2, are estimated at 2,691,611 tons with the grades of 7.86 % T-RE2O3 and 33.34 % $BaSO_4$.
2) The total ore reserves of the rare earth-barite zone of the category C 2, are estimated at 4,500459 tons with the grades of 9.63 % T-RE2O3 and 43.18 % BaSO4.
3) The total ore reserves of the fluorite zone, inclusive of the categories B, C 1 and C 2, are estimated at 2,691,612 tons with the grade of 34.94 % CaF2.

Table I-4-4 The Categorized Ore Reserves of F 1 to F 5 Ore Bodies (1972)

Fluorite - Rare earth - Barite Zone							
Category	Ore body	F1	F2	F3	F4	F5	Total
C1 category	Reserve of dry ore(t)	67,283	-	1,200,491	420,627	-	1,688,401
	RE_2O_3 (%)	5.12	-	9.57	4.19	-	8.05
	$BaSO_4$ (%)	26.98	-	33.78	33.08	-	33.33
C2 category	Reserve of dry ore(t)	46,079	1,687	613,278	338,721	3,445	1,003,210
	RE_2O_3 (%)	5.57	7.29	9.57	4.19	2.51	7.54
	$BaSO_4$ (%)	31.82	32.06	33.78	33.08	6.02	33.36
Total	Reserve of dry ore(t)	113,362	1,687	1,813,769	759,348	3,445	2,691,611
	RE_2O_3 (%)	5.3	7.29	9.57	4.19	2.51	7.86
	$BaSO_4$ (%)	28.95	32.06	33.78	33.08	6.02	33.34

Rare earth - Barite Zone							
Category	Ore body	F1	F2	F3	F4	F5	Total
C2 category	Reserve of dry ore(t)	88,654	313	3,578,299	833,229	-	4,500,495
	RE_2O_3 (%)	6.17	4.43	11.53	1.84	-	9.63
	$BaSO_4$ (%)	31.04	17.34	50.11	14.75	-	43.18

Fluorite							
Category	Ore body	F1	F2	F3	F4	F5	Total
B category	Reserve of dry ore(t)	15,565	-	-	-	-	15,565
	CaF_2	54.71	-	-	-	-	54.71
C1 category	Reserve of dry ore(t)	51,719	-	1,200,491	420,627	-	1,672,837
	CaF_2	49.57	-	32.17	39.49	-	34.55
C2 category	Reserve of dry ore(t)	46,079	1,687	613,278	338,721	3,445	1,003,210
	CaF_2	41.31	43.38	32.17	39.49	88.24	35.27
Total	Reserve of dry ore(t)	113,363	1,687	1,813,769	759,348	3,445	2,691,612
	CaF_2	46.92	43.38	32.17	39.49	88.24	34.94

b) Ore Reserve Estimation based on the Result of the 1984-1985 Exploration

The ore reserves of the southern weathered zone of F3 ore body are summarized below, quoted from the 1986 report that compiled the result of the 1984-1985 exploration works. The ore reserve plans and the ore block cross-sections are shown in Figures I-4-1 and I-4-2 respectively. The categorized ore reserves are presented in Table I-4-5.

The combined C1 and C2 reserves of Class I (rare earth- barite-fluorite) ores are estimated at 422,359 tons with 13.89 % T-RE_2O_3, 22.81 % CaF_2 and 42.46 % $BaSO_4$, containing 58,673 tons, 96.360 tons and 179,301 tons of each compound respectively.

The total combined C 1 and C 2 reserves, inclusive of Class I, II and III ores, are estimated at 1,068,257 tons with 8.79 % T-RE_2O_3, 19.54 % CaF_2 and 47.29 % $BaSO_4$, containing 93,953 tons, 208,709 tons and 505,136 tons of each compound respectively.

Table I-4-5 The categorized Ore Resources of F3 orebody

Ore class	Reserve category	Reserve of dry ore (t)	T-RE_2O_3 (%)	T-RE_2O_3 (t)	CaF_2 (%)	CaF_2 (t)	$BaSO_4$ (%)	$BaSO_4$ (t)
I (rare earth - barite - fluorite)	C1	374,745	14.01	52,502	22.10	82,819	43.46	162,864
	C2	47,614	12.96	6,171	28.44	13,541	34.52	16,436
	Sub-total	422,359	13.89	58,673	22.81	96,360	42.46	179,301
II (rare earth - barite)	C1	79,065	4.66	3,684	6.13	4,847	60.91	48,158
	C2	260,470	5.09	13,258	6.12	15,941	56.85	148,077
	Sub-total	339,535	4.99	16,942	6.12	20,787	57.80	196,236
III (rare earth - fluorite)	C1	39,363	7.72	3,039	30.00	11,809	38.59	15,190
	C2	267,000	5.73	15,299	29.87	79,753	42.85	114,410
	Sub-total	306,363	5.99	18,338	29.89	91,562	42.30	129,600
Grand-total		1,068,257	8.79	93,953	19.54	208,709	47.29	505,136

c) Re-estimation of the Reserves of Class I Ores of F3 Ore Body

The reserves of Class I ores, as above explained, are reviewed and re-estimated in the course of the review and analysis of the existing data. The re-estimation is limited to the Class I of the three ore categories described in the geology-mineralization cross-sections of F3 ore body in the 1986 report (Figures I-4-3 and I-4-4.

The re-estimation procedures are as follows ;

1) Determination of Reserve Blocks

Define the Class I ore zone on each cross-section, which is projected on plans to estimate its horizontal distribution. The ore zone is broken down into 18 ore blocks taking account of the assay results of the pits and tunnels.

2) Volume Estimation

- Estimate the area of each ore block on the relevant cross-section. Where the ore block continues to the neighboring cross-section, the volume is calculated by multiplying the average area of the ore blocks on the neighboring cross-sections by the distance between the two sections.
- Where the ore block does not continue to the neighboring block, the volume is calculated by multiplying the cross-section area of the ore block by half of the distance to the neighboring section.
- Where it is geologically interpreted that the ore block wedges out towards the neighboring section, the volume is calculated by multiplying the cross-section area of the ore block by one-third of the distance to the neighboring section.

3) Ore Density

The dry ore density of 1.93 is used for tonnage estimation, which is the same as that used in the 1986 reserve estimation.

4) Tonnage Estimation

The tonnages of the ore blocks are estimated by multiply the block volumes by the density of 1.93 and summed up.

5) Grade Estimation

The averages of assay results of pits and tunnels are assigned to the ore blocks. Where assay results of two or more pits and tunnels are available for one ore block, the weighted averages by the sampling distances are calculated for the block ore grade. Assay results of trenches are excluded for the grade estimation, because they may have been secondarily enriched or may represent only the surficial part of the lenticular ore body.

The re-estimation result is summarized in Table I-4-6.

The total reserves of the Class 1 ores in the weathered zone to the depth of 30 m from the surface is estimated at 510,233 tons with the average grade of 13.81 % T-RE_2O_3, containing 70,458 tons of T-RE_2O_3. Since continuity of rare earth mineralization is not necessarily stable, estimations applying 10 and 20 % of safety factors result in the following figures;

Safety factor 10 % : reserves at 459,209 tons containing 63,412 tons of T-RE_2O_3 with the average grade of 13.81 % T-RE_2O_3.

Safety factor 20 % : reserves at 408,186 tons containing 56,366 tons of T-RE_2O_3 with the average grade of 13.81 % T-RE_2O_3.

The ore reserves estimated in 1986, at 422,359 tons containing 58,673 tons.

T-RE_2O_3 with the average grade of 13.89 % T-RE_2O_3, are compared to intermediate of the two re-estimation results with the safety factors of 10 and 20 %.

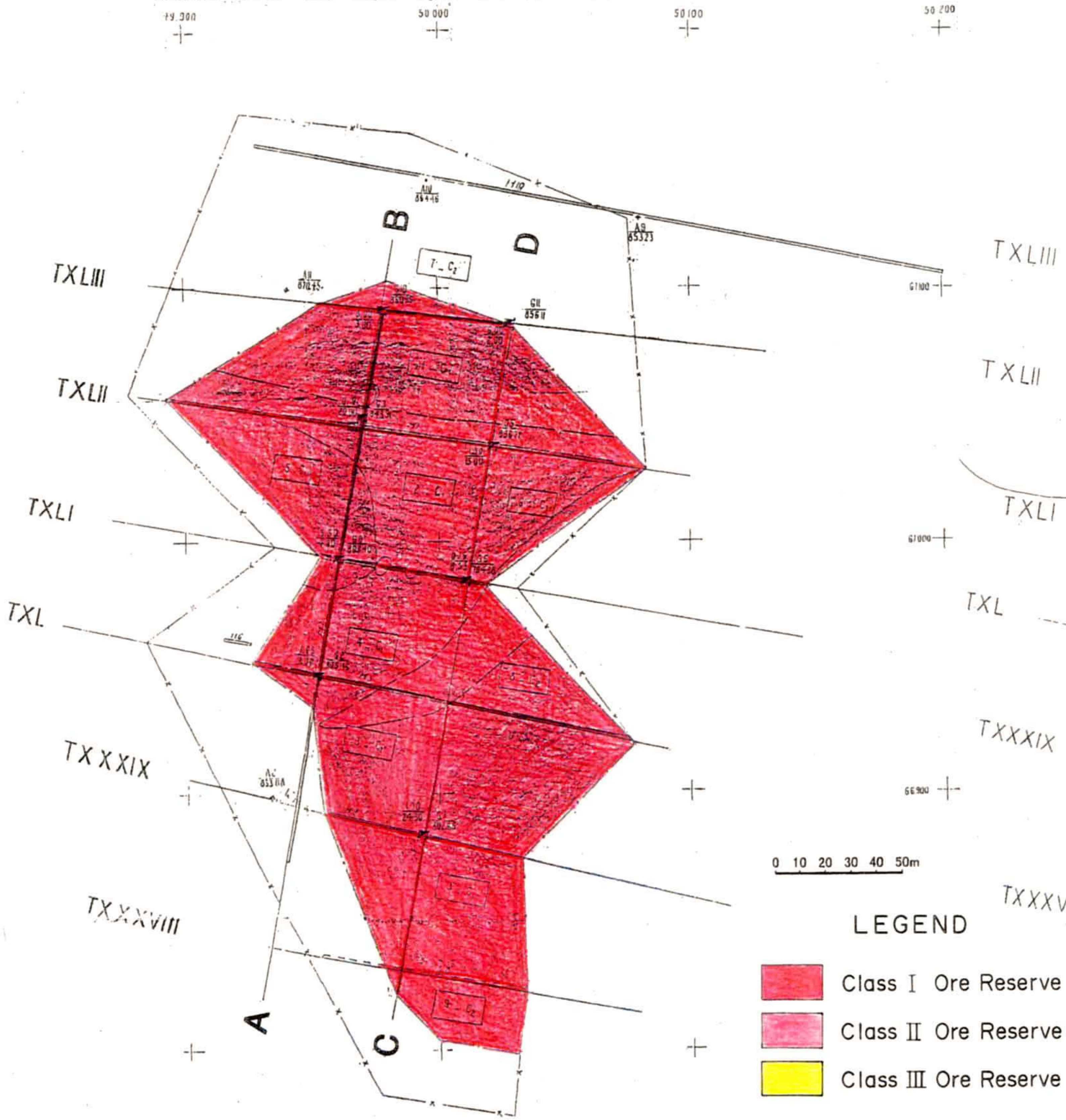
Table I-4-6 Re-estimated Ore Reserves of Class 1 Ores of F 3 Ore Body (2001)

	Volume (m^3)	Gravity	Reserve (t)	TRE_2O_3 (%)	TRE_2O_3 (t)	Pit,Tunnel
CI-1	6,305	1.93	12,169	14.80	1,801	L2
CI-2	54,800	1.93	105,764	12.90	13,646	L2, G7
CI-3	19,850	1.93	38,311	12.73	4,876	G2,G4,G7
CI-4	21,735	1.93	41,949	12.73	5,340	G7
CI-5	2,770	1.93	5,346	12.73	681	G7
CI-6	504	1.93	973	12.70	124	G2
CI-7	2,585	1.93	4,989	15.20	758	G2,G8
CI-8	13,360	1.93	25,784	12.29	3,168	G2,G6,G8
CI-9	802	1.93	1,547	9.90	153	G6
CI-10	22,008	1.93	42,476	15.68	6,661	G3,G8
CI-11	35,656	1.93	68,816	14.29	9,832	G3,G5,G6G8
CI-12	23,419	1.93	45,199	12.87	5,816	G5,G6
CI-13	19,013	1.93	36,694	15.71	5,765	G3,G10
CI-14	23,153	1.93	44,684	15.09	6,744	G3,G5,G10,G11
CI-15	17,533	1.93	33,839	14.26	4,825	G5,G11
CI-16	203	1.93	391	17.77	69	G10
CI-17	625	1.93	1,206	15.46	187	G10,G11
CI-18	50	1.93	97	12.00	12	G11
		Ore reserve	510,233	Total	70,458	
				Ore grade	13.81	
Case of safety factor 10%		Ore reserve	→ 459,209	TRE_2O_3 (t)	→ 63,412	
Case of safety factor 20%		Ore reserve	→ 408,186	TRE_2O_3 (t)	→ 56,366	
				Ore grade	13.81	

F3鉱体南部クラスI鉱量計算平面

BÌNH ĐỒ TÍNH TRỮ LƯỢNG QUẶNG LOẠI I

KHOÁNG SÀNG ĐẤT HIẾM ĐÔNG PAO THÂN QUẶNG F.III



F3鉱体南部クラスII, III鉱量計算平面

BÌNH ĐỒ TÍNH TRỮ LƯỢNG QUẶNG LOẠI II III

KHOÁNG SÀNG ĐẤT HIẾM ĐÔNG PAO THÂN QUẶNG F.III

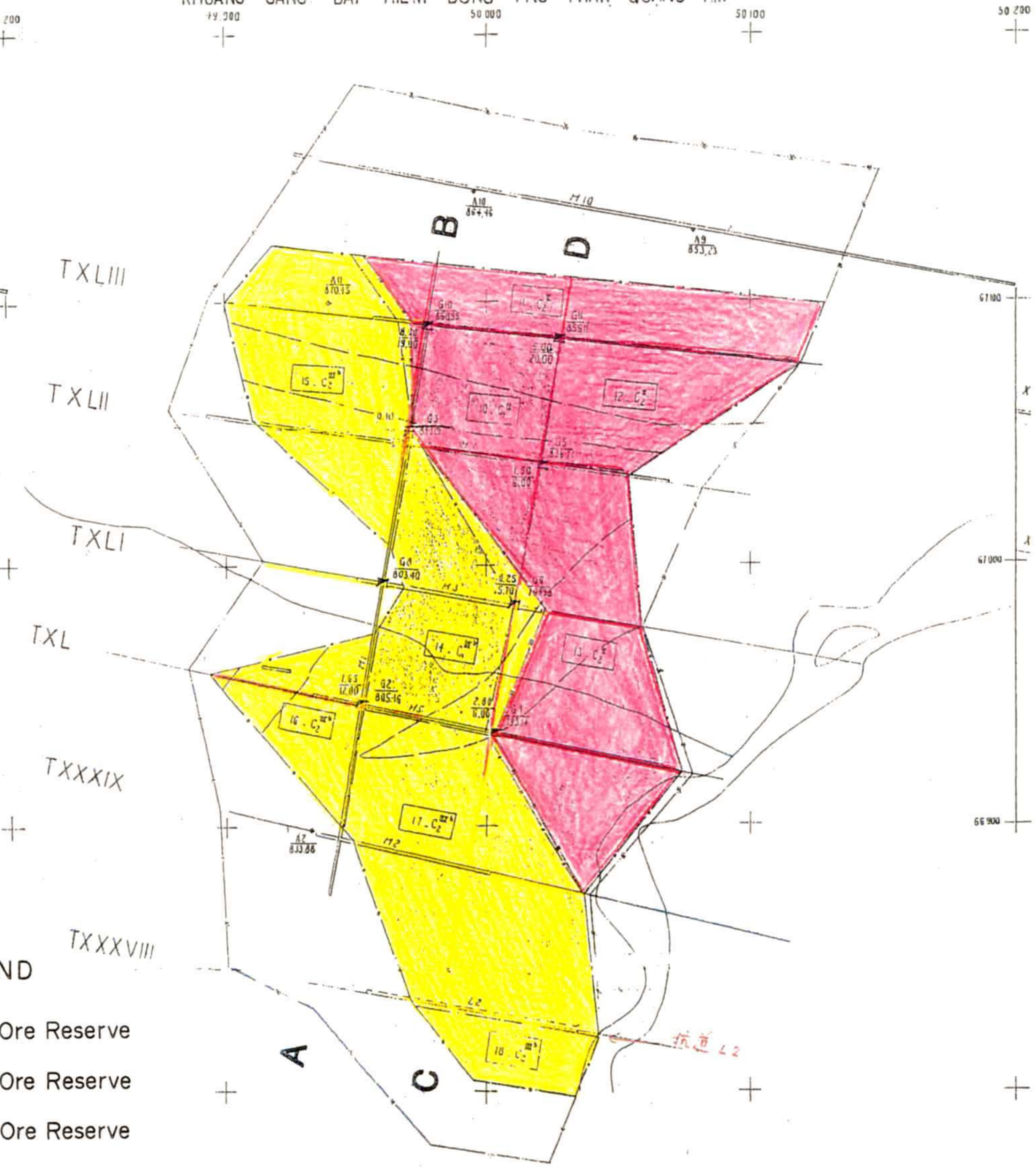


Figure I-4-1 Plane view of ore block of F3 orebody

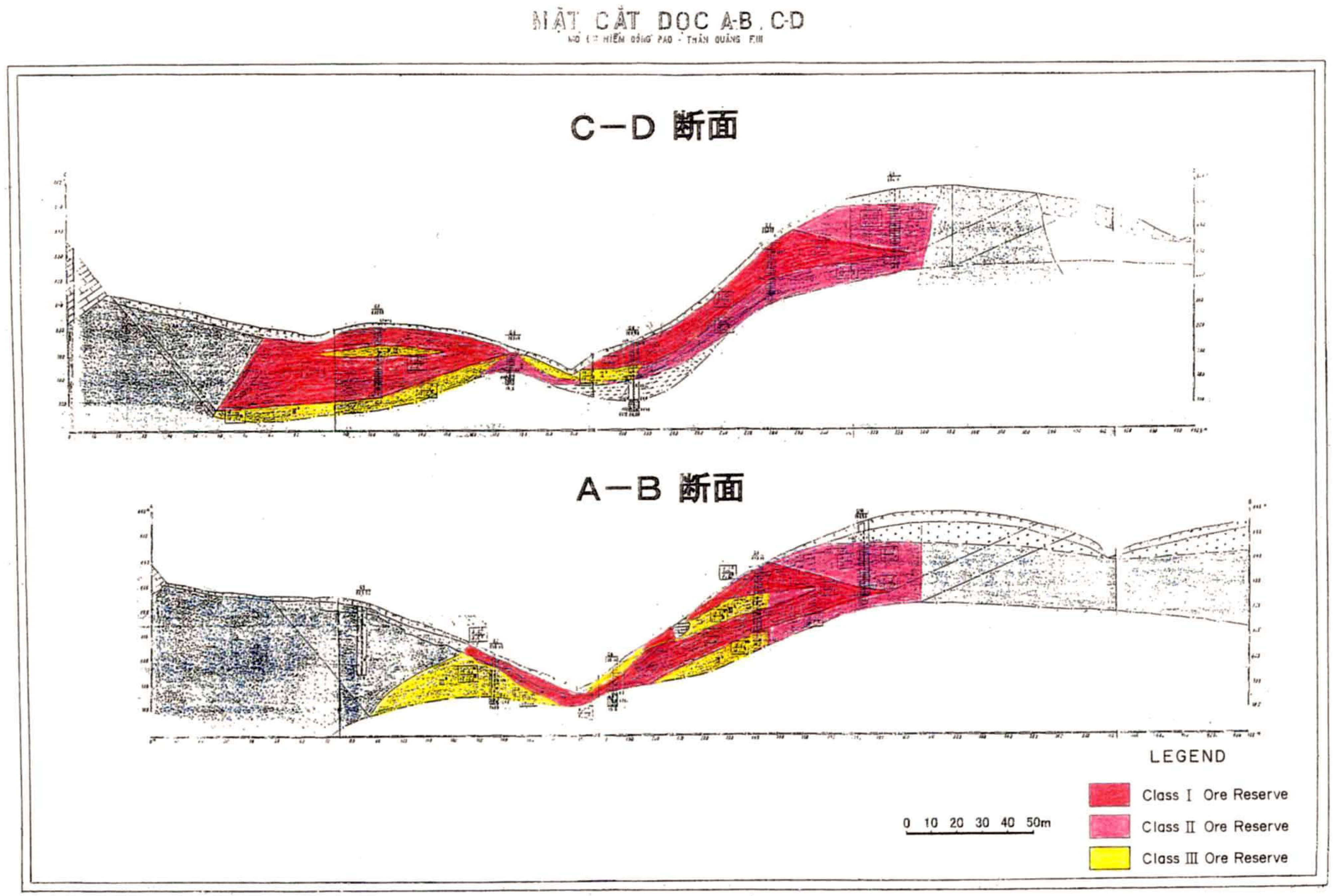


Figure I-4-2 Cross section of ore block diagram of F3 orebody

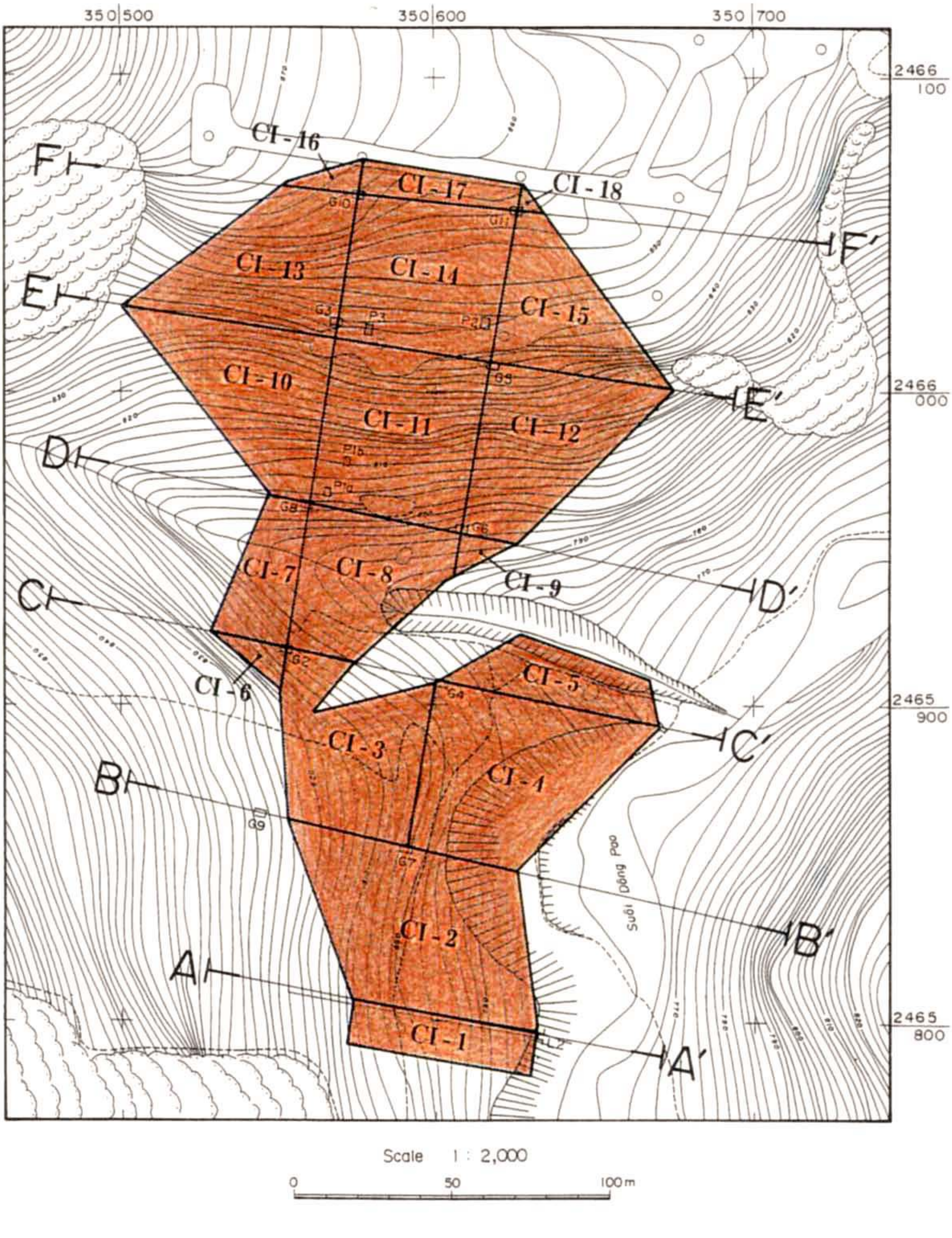


Figure I-4-3 Plane view of ore block class I of south F3 orebody

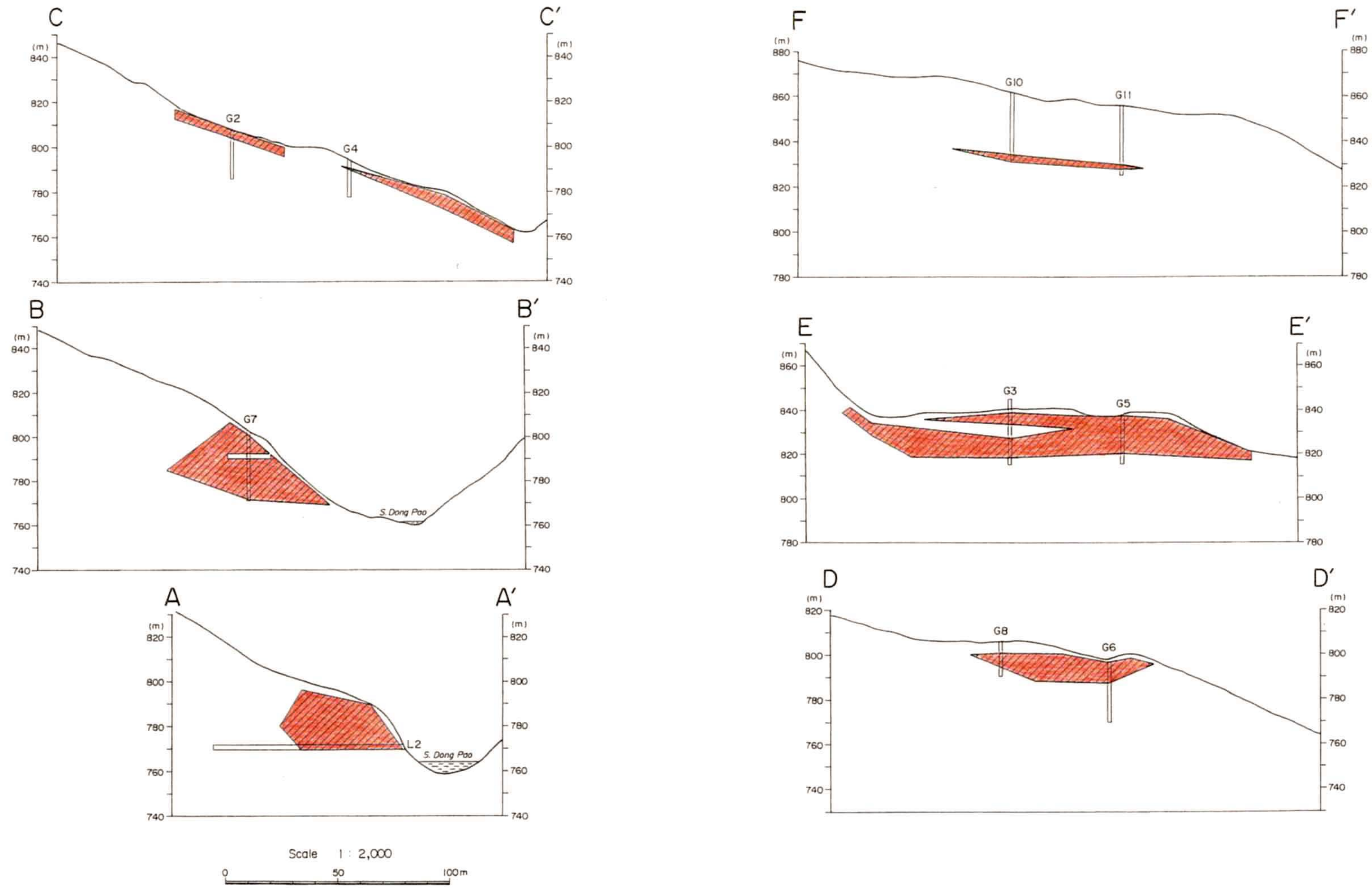


Figure I-4-4 Cross section of ore block class I of south F3 orebody (A-A'~F-F')

Chapter 5 Summary of The Result of the 1st Year Campaign

5-1 Geological Survey

The geology of the Project Area consists of limestone, shale, siltstone and sandstone of Triassic system, alkaline volcanics and tuffs of Palaeogene age and Palaeogene syenite intrusions. A number of minor minette dikes occur within the syenite intrusions. The syenite intruded along the regional structural system of NW-SE trend is predominated in the Project Area. Lineaments in the N-S and the E-W directions are extensively developed, which have probably resulted from conjugated shear stress of the regional structural system of NW-SE trend.

5-2 Environmental Baseline Study

(1) Soil Survey

Soil samples, totaling 1,606 in number, were collected from the B horizon or transition between B and C horizons of the soil profile.

According to the analytical result of the soil samples, significant soil anomalies in T-RE_2O_3, the major commodities of the ore deposits, are associated with such known ore bodies as F1, F3, F 4, F7, F 9, F 10, F 14 and F 16. Soil anomalies in $BaSO_4$ and CaF_2 well coincide with those of T-RE_2O_3 as far as their distributions concern, which suggest that these minerals were formed almost in the same period of the geologic event. The content of T-RE_2O_3 is significantly correlated with light rare earth elements and, among other elements than rare earths, with Th, Sr, As, Pb, U, F and Ba, based on the result of the correlation analysis of the analytical data.

(2) Hydrological Survey

Water quality was measured at five localities of the selected drainages. Most of small streams were dried out at the time of the field operation except the main stream of Dong Pao river, the major river in the eastern part of this area, and a few of branch streams. Running water in part of major streams flows into underground and again springs out at places such as observed in the eastern part. Therefore, there are numerous underground caves in the areas where limestone extensively distributes. The stream water is weakly alkaline to neutral, indicating pH ranging from 7.33 to 8.55. Its temperature and conductivity range from 16.7 to 21.2℃ and from 214 to 303 μS/m respectively, while the hot spring water at the locality DW-4 indicates the temperature of 28.9℃ and the conductivity of 625 μS/m, which are higher than those of stream water. Among trace elements analyzed, arsenic and fluorine are high ranging from 0.25 to 0.32 mg/l and from 0.79 to 2.42 mg/l respectively, which may reflect the mineralization of this area. Stream water is high in Ca among cations and in HCO_3 and CO_3 among anions, possibly due to extensive distribution of limestone.

(3) Meteorologic Survey

The meteorologic observation system has been installed at New Tam Duong in order to automatically take continuous records of temperature, humidity, precipitation and wind direction and velocity for the one-year period. This area belongs to a humid-subtropical zone of the Asian-Monsoon region. A regular climatic cycle is observed through the year according to the meteorologic data for the last five years recorded at the Tam Duong meteorologic observatory. The climate of this area is high temperature (20 to 24℃) and high precipitation (200 to 800 mm/month) for the months from May to August, and low temperature (13 to 18℃) and low precipitation (0.3 to 200 mm/month) for the months from September to April in the following year. Local roads and trails will often become impassable due to flooded water courses during the wet season between May and August.

(4) Vegetation Survey

Virgin forest lands have been diminishing with increasing areas of farm lands, paddy fields and wastelands due to the agricultural development for over 100 years. Most of flat lands along major rivers and streams are cultivated for paddy or rice fields.

The study on the major and rare plant species in the area was carried out with the cooperation of to Tran Ninh, Professor of Vietnam National University in Hanoi.

The study on the major and rare plant species in the area has been commissioned to Dr. Tran Ninh, Professor of Vietnam National University in Hanoi. A total of 165 species that belong to 110 genera of 71 classes in 4 phyla have been identified in the course of this study. Among these species, 53 common species and 9 rare species are confirmed to exist. Although 9 rare species have been identified, they distribute beyond the premises of the Project Area. Their distribution is by far broader than the extent of an area for possible mining development. Therefore, the future mining development in New Dong Pao area would have least risks to endanger these species.

5-3 Drilling Investigation

A total number of 16 holes with the aggregated length of 1,480 m were drilled to explore F3 ore body at depth. The holes were drilled principally with the hole diameter of HQ. One quarter of each 1-m section drill core was continuously sampled and submitted for chemical analysis.

The hole geology comprises mineralized and altered syenite, limestone blocks taken into the syenite and intruding minette dikes. Of the 16 holes, 7 holes intersected mineralized zones with the grades better than 10 % T-RE_2O_3, and other 5 holes, those with the grades ranging between 5 and 10 % T-RE_2O_3.

5-4 F3 Ore Body

F3 ore body is principally of a rare earth ore deposit accompanied by fluorite and barite mineralization. The zone of mineralization with the grades better than 10 % T-RE_2O_3 encompasses an area approximately 300 m long in the north-south and 100 m wide in the east-west. The current exploration has not define the northern and the western limits of the mineralized zone.

This zone enriched in rare earth minerals forms an irregular lens that thins out to the east and tends to deepen northwards and southwards. Although its continuation to the north and west has not been determined, the ore body is very attractive in its size and grade according to the result of the drilling exploration of the current project and of the past exploration. The rare earth mineralization is closely related to the fluorite and barite mineralization. However, there appears to be differences in the mineralization stages of the three types, because their mineralization centers are slightly shifted from each other in their positions.

Representative rare earth ore zones that have been intersected by the drill holes of the current project are the 52-m section in the hole MJVD-10 with the average grade of 10.44 % T-RE_2O_3 and the 45 m section with the average grade of 10.82% T-RE_2O_3, both in the western part of the ore body.

The ores are more enriched in light rare earths than heavy rare earths according to the chondrite normalized REE pattern based on the analytical results, suggesting that the main rare earth mineral is bastnaesite. The major ore minerals identified under microscope are bastnaesite, synchysite, barite and fluorite, accompanied by such gangue minerals as quartz, calcite, K-feldspar and minor phlogopite, illite, kaolinite, halloysite, smectite and boehmite. Bastnaesite mostly occurs in fine crystals filling interstices between barite, fluorite and quartz grains or forming micro-veins within barite and fluorite crystals.

The combined reserves of F3 and F3 South ore bodies with the grade better than 10% T-RE_2O_3 are preliminarily estimated at approximately 890,000 tons with the average grade of 12 % T-RE_2O_3 containing 100,000 tons of T-RE_2O_3, based on the data obtained to date (excluding the duplicated ore bocks in the two ore bodies). Since the northern and western limits of the ore body has not been determined, there is a possibility that the reserves may substantially increase if its continuation to these directions is proved.

5-5 Ore Bodies Other Than F3

There are 6 major ore bodies, other than F3, among more than 60 rare earth-fluorite-barite ore bodies that have been located in this area.

F 1 ore body is principally of fluorite and forms a lenticular shape with the width of more than 50m. The ores contain 69.04 to 71.10 % CaF_2 and 0.42 to 3.76 % T-RE_2O_3. This ore body is currently being mined.

F4 ore body is principally of fluorite and forms a lenticular shape with the width of more than 80m. The ores contain 43.36 to 57.74 % CaF_2 and 0.78 to 4.87 % T-RE_2O_3. This ore was mined in the past.

F7 ore body is about 1.5 km long in the east-west and 0.5 km wide in the north-south, and may continue to the southwest joining F3 ore body. An outcrop of ores concentrated in barite and fluorite in the western part indicated an assay result of 11.09 % T-RE_2O_3, 24.35 % CaF_2 and 47.78 % $BaSO_4$. The soil geochemical anomaly associated with this ore body is most significant in its extent and rare earth content. This ore body, with its extensive zone of mineralization, is expected to grow both in size and grade to the depth.

F 9 ore body is 0.7 km long and 0.3 km wide. A mineralized outcrop indicated an assay result of 4.44 % T-RE_2O_3, 40.79 % CaF_2 and 25.92 % $BaSO_4$. The associated soil geochemical anomaly is significant in its extent and mineral contents.

F 10 ore body is 0.7 km long and 0.2 km wide. A mineralized outcrop indicated an assay result of 4.54 % T-RE_2O_3, 15.82 % CaF_2 and 23.45 % $BaSO_4$. The associated soil geochemical anomaly is significant in its extent and mineral contents.

F 16 ore body is 0.6 km long and 0.4 km wide. The associated soil geochemical anomaly, indicating the maximum rare earth content of 16.79 T-RE_2O_3, is significant in its extent and rare earth content.

5-6 Genetic Model of the Rare Earth Deposits

Limestone and interbedded shale and sandstone of the Triassic system in this region were subjected to the Alpine Orogenic Movement and broken into a number of blocks by major fault and fracture systems trending mostly in the NW-SE direction. In the early Palaeogene, intrusion of alkaline magmas initiated along the NW-SE trending fault systems at depth in the Dong Pao area and then formed syenite bodies containing limestone fragments and blocks. Magmatic melt at the bottom was enriched in volatile matters and then in rare earth elements as the vapor pressure increased. The high-pressure and high-temperature vapor enriched in volatile matters migrated through cooling-joints, formed in the peripheries of syenite bodies or though fractures formed in surrounding limestone. The vapor, as ascending through joints and fractures, was mixed with groundwater and cooled down to precipitate rare earth minerals, barite and fluorite under certain pressure and temperature conditions, which resulted in formation of ore deposits in this area. The syenite body has been exposed on the surface as the limestone on the top was eroded out. Its present dimension is measured at approximately 4 km in the east-west and at 5 km in the north-south. The ore deposits are located in the northern, southern and western peripheries of the syenite body.

5-7 Metallurgical Testing

The ore samples with the total weight of 1,431 kg were collected from four pits excavated over the surface of F3 ore body for the metallurgical testing. The analytical result indicated the averages of 9.25 % T-RE_2O_3, 62.7 % $BaSO_4$ and 4.7 % CaF_2. In the flotation tests, various conditions such as flotation sequences, kinds and amounts of reagents and flotation temperature were examined, however, the result was unsuccessful to separate and concentrate rare earth minerals compared to the feed grade of 9.25 % T-RE_2O_3. The magnetic separation tests resulted in unsuccessful as well.

The reasons for the poor recovery and concentration in the flotation tests are ;

1) the ores are highly weathered, containing very fine-grained bastnaesite,
2) bastnaesite occurs interstitially between fluorite and/or barite, or is attached to rims of other minerals, forming middlings so that it is difficult to be liberated,
3) bastnaesite tends to form bastnaesite-calcite micro-veins within fluorite and /or barite crystals, which is also difficult to be liberated

The size analysis of the crushed products proved that rare earth minerals were concentrated in the fine fractions with sizes less than 8 or 10 μm. The -8 μm fractions of the crushed and ground samples are assayed at 32.5 % T-RE_2O_3 with the size distribution of 32 % and at 22.1 % T-RE_2O_3 with that of 51 % respectively. Therefore, it is possible to produce crude rare earth concentrates with the grade better than 30 % T-RE_2O_3 by separating and concentrating the fine fractions. It is worthwhile to examine a possible hydro- or pyro-metallurgical process to produce marketable intermediate product such as mischmetal using the fine fraction at a grade of some 30 % T-RE_2O_3 as raw materials.

The sample for the current metallurgical testing were collected form the surface portion of F3 ore body and might have contained an excessive amount of fine-grained bastnaesite for a representative sample. It is desirable to repeat flotation tests for drill core samples representing unweathered part of the ore body.

Chapter 6 Conclusion and Recommendation

6-1 Conclusion

1) Outline of the 1st Year Campaign

The field operation of the 1st Year Campaign was carried out in the period from November 21st, 2000 to February 4th, 2001. The 1st Year program comprised geological survey, environmental baseline study (soil, hydrology, meteorology and vegetation), drilling prospecting, metallurgical testing and laboratory tests (whole rock analysis, ore analysis, microscopic observation of rock and ore thin sections, X-ray diffraction analysis and fluid inclusion analysis for homogenization temperature and salinity measurements).

2) Geological Survey

The geological survey was carried out in combination with the environmental baseline study. The geology of the Project Area consists of limestone, shale, siltstone and sandstone of Triassic system and Palaeogene syenite intrusions, partly overlain by alkaline volcanics and tuffs of Palaeogene age. A number of minor minette dikes occur within the syenite intrusions.

The regional structural system of NW-SE trend is predominated in the Project Area, represented by two major faults located in the northeastern corner and the southern part of this area. Lineaments in the N-S and the E-W directions are extensively developed, which have probably resulted from conjugated shear stress of the regional structural system of NW-SE trend.

3) Environmental Baseline Study

Soil, hydrological, meteorological and vegetation surveys were carried out for the environmental baseline study.

Significant soil anomalies in T-RE_2O_3, the major commodities of the ore deposits, are associated with such known ore bodies as F1, F3, F 4, F7, F 9, F 10, F 14 and F 16. Soil anomalies in $BaSO_4$ and CaF_2 well coincide with those of T-RE_2O_3 as far as their distributions concern. The content of T-RE_2O_3 is significantly correlated with light rare earth elements and, among other elements than rare earths, with Th, Sr, As, Pb, U, F and Ba, according to the result of the correlation analysis of the analytical data.

Water quality was measured at five localities of the selected drainages. Most of small streams were dried out at the time of the field operation except the main stream of Dong Pao river, the major river in the eastern part of this area, and a few of branch streams. Running water in part of major streams flows into underground and again springs out at places such as seen in the eastern part. The stream water is weakly alkaline to neutral, indicating pH ranging from 7.33 to 8.55. Its temperature and conductivity range from 16.7 to 21.22℃ and from 214 to 303 μ mS respectively, while the hot spring water at the locality DW-4 indicates the temperature of 28.9℃ and the conductivity of 625 μ mS, which are higher than those of stream water. Among trace elements analyzed, arsenic and fluorine are high ranging from 0.25 to 0.32 mg/l and from 0.79 to 2.42 mg/l respectively, which may reflect the mineralization of this area. Stream water is high in Ca among cations and in HCO_3 and CO_3 among anions, possibly due to extensive distribution of limestone.

The meteorologic observation system has been installed at New Tam Duong in order to automatically take continuous records of temperature, humidity, precipitation and wind direction and velocity for the one-year period. This area belongs to a humid-subtropical zone of the Asian-Monsoon region. A regular climatic cycle is observed through the year according to the meteorologic data for the last five years recorded at the Tam Duong meteorologic observatory. The climate of this area is high temperature (20 to 24℃) and high precipitation (200 to 800 mm/month) for the months from May to August, and low temperature (13 to 18℃) and low precipitation (0.3 to 200 mm/month) for the months from September to April in the following year.

Virgin forest lands have been diminishing with increasing areas of farm lands, paddy fields and wastelands due to the agricultural development for many years. A total of 165 species that belong to 110 genera of 71 classes in 4 phyla have been identified in the course of this study. Among these species, 53 common species and 9 rare species are confirmed to exist. Although 9 rare species have been identified, they distribute beyond the premises of the Project Area. Their distribution is by far broader than the extent of an area for possible mining development. Therefore, the future mining development in New Dong Pao area would have least risks to endanger these species.

4) Drilling Investigation

A total number of 16 holes with the aggregated length of 1,480 m were drilled to explore F3 ore body at depth. The hole geology comprises mineralized and altered syenite, limestone blocks taken into the syenite and intruding minette dikes. Of the 16 holes, 7 holes intersected mineralized zones with the grades better than 10 % T-RE_2O_3, and other 5 holes, those with the grades ranging between 5 and 10 % T-RE_2O_3.

5) F3 Ore Body

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This zone enriched in rare earth minerals forms an irregular lens that thins out to the east and tends to deepen northwards and southwards. Although its continuation to the north and west has not been determined, the ore body is very attractive in its size and grade according to the result of the drilling exploration of the current project. The rare earth mineralization is closely related to the fluorite and barite mineralization. However, there appears to be differences in the mineralization stages of the three types, because their mineralization centers are slightly shifted from each other in their positions.

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The reserves of F3 ore body with the grade better than 10% T-RE_2O_3 are preliminarily estimated at approximately 890,000 tons with the average grade of 12 % T-RE_2O_3 containing 100,000 tons of T-RE_2O_3, based on the data obtained to date. Since the northern and western limits of the ore body has not been determined, there is a possibility that the reserves may substantially increase if its continuation to these directions is proved.

6) Ore Bodies Other Than F3

There are 6 major ore bodies, other than F3, among more than 60 rare earth-fluorite-barite ore bodies that have been located in this area.

F 1 ore body is principally of fluorite and forms a lenticular shape with the width of more than 50m. The ores contain 69.04 to 71.10 % CaF_2 and 0.42 to 3.76 % T-RE_2O_3. This ore body is currently being mined.

F4 ore body is principally of fluorite and forms a lenticular shape with the width of more than 80m. The ores contain 43.36 to 57.74 % CaF_2 and 0.78 to 4.87 % T-RE_2O_3. This ore was mined in the past.

F7 ore body is about 1.5 km long in the east-west and 0.5 km wide in the north-south, and may continue to the southwest joining F3 ore body. An outcrop of ores concentrated in barite and fluorite in the western part indicated an assay result of 11.09 % T-RE_2O_3, 24.35 % CaF_2 and 47.78 % $BaSO_4$. The soil geochemical anomaly associated with this ore body is most significant in its extent and rare earth content. This ore body, with its extensive zone of mineralization, is expected to grow both in size and grade to the depth.

F 9 ore body is 0.7 km long and 0.3 km wide. A mineralized outcrop indicated an assay result of 4.44 % T-RE_2O_3, 40.79 % CaF_2 and 25.92 % $BaSO_4$. The associated soil geochemical anomaly is significant in its extent and mineral contents.

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F 16 ore body is 0.6 km long and 0.4 km wide. The associated soil geochemical anomaly, indicating the maximum rare earth content of 16.79 T-RE_2O_3, is significant in its extent and rare earth content.

7) Genetic Model of the Rare Earth Deposits

The Triassic system in this region were subjected to the Alpine Orogenic Movement and broken into a number of blocks by major faults and fracture systems trending mostly in the NW-SE direction. In the early Palaeogene, intrusion of alkaline magmas initiated along the NW-SE trending fault systems at depth in the Dong Pao area and then formed syenite bodies. Magmatic melt at the bottom was enriched in volatile matters and then in rare earth elements as the vapor pressure increased. The high-pressure and high-temperature vapor enriched in volatile matters migrated through cooling-joints, formed in the peripheries of syenite bodies or though fractures formed in surrounding limestone. The vapor, as ascending through joints and fractures, was mixed with groundwater and cooled down to precipitate rare earth minerals, barite and fluorite under certain pressure and temperature conditions, which resulted in formation of ore deposits in this area. The syenite body has been exposed on the surface as the limestone on the top was eroded out. Its present dimension is measured at approximately 4 km in the east-west and at 5 km in the north-south. The ore deposits are located in the northern, southern and western peripheries of the syenite body.

8) Metallurgical Testing

The ore samples with the total weight of 1,431 kg were collected from four pits excavated over the surface of F3 ore body for the metallurgical testing. The analytical result indicated the averages of 9.25 % T-RE_2O_3, 62.7 % $BaSO_4$ and 4.7 % CaF_2.

The size analysis of the crushed products proved that rare earth minerals were concentrated in the fine fractions with sizes less than 8 or 10 μm. The -8mm fractions of the crushed and ground samples are assayed at 32.5 % T-RE_2O_3 with the size distribution of 32 % and at 22.1 % T-RE_2O_3 with that of 51 % respectively. The -8mm fractions of the crushed and ground samples are assayed at 32.5 % T-RE_2O_3 with the size distribution of 32 % and at 22.1 % T-RE_2O_3 with that of 51 % respectively. Therefore, it is possible to produce crude rare earth concentrates with the grade better than 30 % T-RE_2O_3 by separating and concentrating the fine fractions.

In the flotation tests, various conditions such as flotation sequences, kinds and amounts of reagents and flotation temperature were examined, which was unsuccessful to separate and concentrate rare earth minerals to a satisfactory degree. The magnetic separation tests resulted in unsuccessful as well.

The reasons for the poor recovery and concentration in the flotation tests are ;

1) the ores are highly weathered, containing very fine-grained bastnaesite,
2) bastnaesite occurs interstitially between fluorite and/or barite, or is attached to rims of other minerals, forming middlings so that it is difficult to be liberated,
3) bastnaesite tends to form bastnaesite-calcite micro-veins within fluorite and /or barite crystals, which is also difficult to be liberated

The sample for the current metallurgical testing were collected form the surface portion of F3 ore body and might have contained an excessive amount of fine-grained bastnaesite for a representative sample.

6-2 Recommendation

The follow-up works in the next stage of the current project are proposed below, in order to further investigate the possibility of the commercial exploitation of F3 and other ore bodies in Duong Pao area.

6-2-1 Investigation for F3 Ore Body

1) Drilling Exploration

The northern and the western continuations of F3 ore body have not been drill-explored, although a number of the drill holes of the current project intersected high grade zones of rare earth mineralization. It is essential for the economic assessment of F3 ore body to firmly delineate the ore body in its lateral and vertical extensions.

An initial set of drill holes comprises 7 holes for the western extension and 6 holes for the northern extension, as shown in Figure II-7-1. Additional holes may become necessary to define the limits of the ore body, if the high grade zones are further extended.

2) Metallurgical Testing (Mineral Processing)

The metallurgical testing for the surface sample of F3 ore body resulted in unsuccessful, although the flotation and the magnetic separation processes were tested under various conditions. The poor recovery and concentration of rare earths are attributed to fine-grained nature of bastnaesite in the test sample due mainly to intense weathering. It is necessary to carry out the flotation and magnetic separation tests, further in detail, for unweathered representative samples collected from drill cores at depth. The test samples should be collected from ore sections of drill holes deeper than 30 m from their collars, and should represent various mineral compositions in the ore body. The ultimate objective is to identify the optimum process for recovery and concentration of rare earth minerals.

3) Hydro- and/or Pyro-metallurgical Testing

Although the flotation tests for the intensely weathered surface sample resulted in unsuccessful, the size analysis proved that the $-8\mu m$ fractions of the crushed and ground samples contained 32.5 % and 22.1 % of T-RE_2O_3 respectively. If crude concentrates with the grade of this order can be used as raw materials to produce marketable intermediate products such as mischmetal, mineral processing procedures will not be required and hence the overall production cost will be reduced. Therefore, it is worthwhile to test hydro- or pyro-metallurgical processes suitable for treatment of this type of crude concentrates. The objectives are to identify the optimum metallurgical process and to assess its economic viability in comparison with other processes.

4) Ore Reserve Estimation

Upon completion of the drilling exploration, the ore reserves of the entire ore body of F3 should be re-assessed for the tonnage and grade.

5) Preparation of Topographic Maps

It is necessary for the detailed survey of the Project Area to produce appropriate topographic maps at a scale of 1 to 5,000.

6-2-2 Exploration on Other Promising Prospects

The Project Area includes three promising prospects for rare earth resources, namely New Dong Pao in the south including F3 ore body, Ban Hon South in the north and Tong Pao Nieu in the northwest (Figure II-7-2). It will be essential to establish potential REE resources in these prospects in order to secure sufficient mining reserves when carrying out a feasibility study for commercial exploitation of F3 ore body in future.

1. New Dong Pao Prospect

A number of significant soil geochemical anomalies exceeding 2 % T-RE_2O_3 are outlined in association with F 7 ore body. The one in the western part is correlated to the northern extension of F 3 ore body, suggesting that the two ore bodies join to each other. An outcrop sample in the western part of F 7 ore body yielded an assay result of 11.09 % T-RE_2O_3, indicating a possibility of concealed rare earth mineralization with appreciable concentrations. Significant soil geochemical anomalies are also located in the northern and central parts of New Dong Pao prospect.

F 7 ore body is located adjacent to F 3 and may be developed together with F 3 if its mode of occurrence permits.

2. Ban Hon South and Tong Pao Nieu Prospects

F9 and F 10 ore bodies are located in Ban Hon South prospect and F 16 is in Tong Pao Nieu prospect. A number of significant soil geochemical anomalies exceeding 2 % T-RE_2O_3 are outlined in these prospects. Outcrops with rare earth mineralization are associated with these ore bodies, suggesting that sizable ore bodies are concealed in these prospects.