NO.

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

FINAL REPORT

MARCH 2002

JAPAN INTERNATIONAL COOPERATION AGENCY
METAL MINING AGENCY OF JAPAN

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JR
02-068

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).

This Project was executed in the 2-Year period of the Japanese fiscal 2000 and 2001.

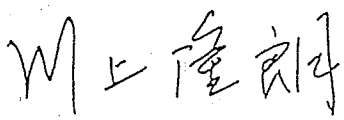
The on-site investigations were carried out in the period from November 21st, 2000 to February 10th, 2001 for the 1st year, and in the period from November 10th, 2001 to December 21st, 2001 for the 2nd year, by the Survey Team (Reader : Mr. Kiyoharu NAKASHIMA) dispatched by JICA and MMAJ, in cooperation with Vietnam National Mineral Corporation.

After the team completed the 2nd Year on-site operation, further studies were made in order to prepare this comprehensive report collecting the whole result of the 2 years period project.

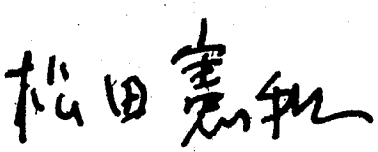
We hope that this report will serve for the development of the Project and contribute to the promotion of friendly relations between the two countries.

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.

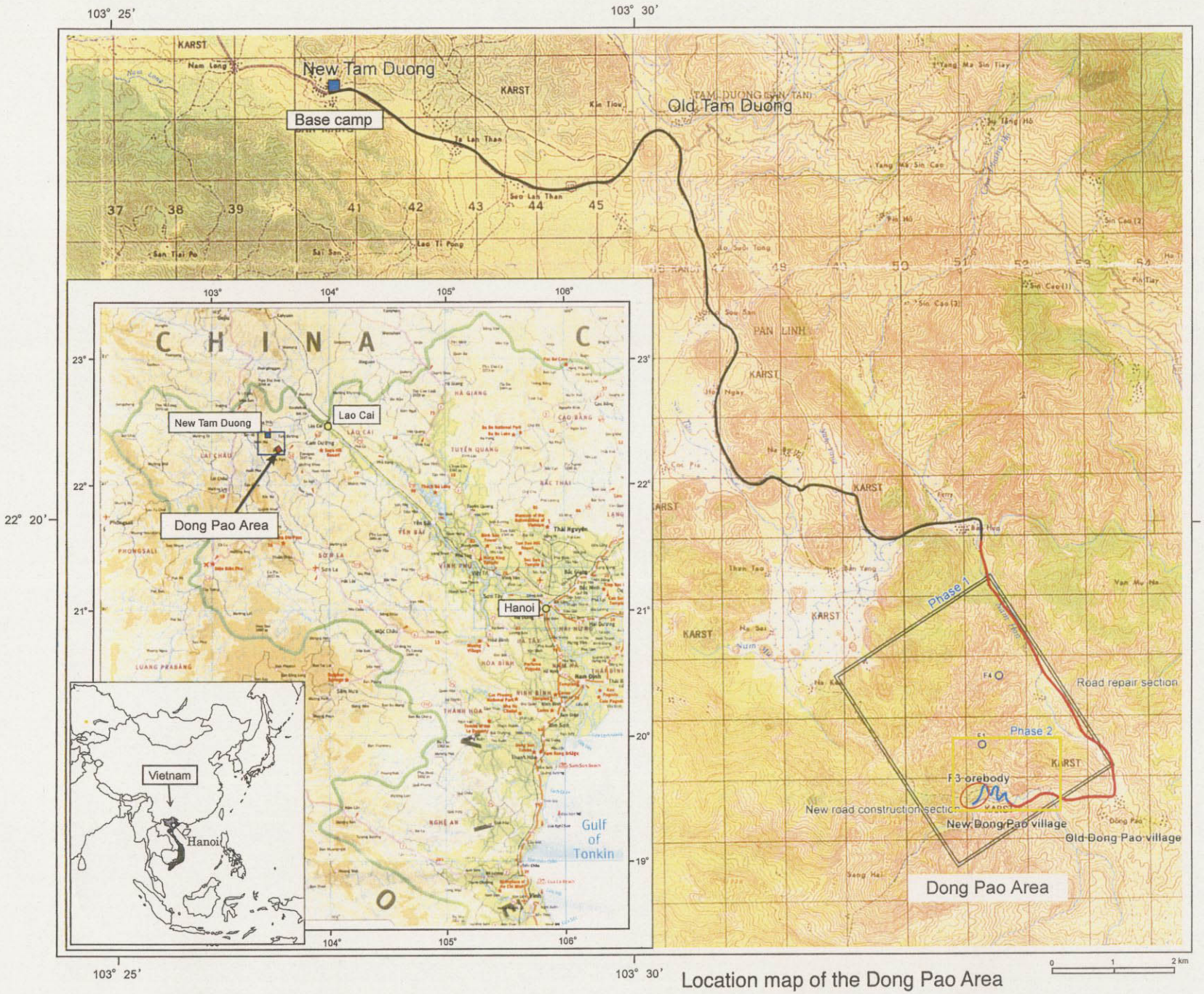
March 2002



Takao KAWAKAMI
President
Japan International Cooperation Agency



Norikazu MATSUDA
President
Metal Mining Agency of Japan



Location map of the Dong Pao Area

Summary

This Project is the Mineral Exploration in the Dong Pao Area in the Socialist Republic of Vietnam and was executed in the 2-Year period of the Japanese fiscal 2000 and 2001.

This report is prepared by collecting the whole results acquired in the course of the Project for the 2-year period.

The on-site investigations were carried out in the period from November 21st, 2000 to February 10th, 2001 for the 1st year, and in the period from November 10th, 2001 to December 21st, 2001, by the Survey Team dispatched by JICA and MMAJ, in cooperation with Vietnam National Mineral Corporation.

The 1st Year Campaign comprised the geological survey for the entire Project Area, the environmental baseline study, the drilling investigation on the F3 Ore Body and the flotation test on the F3 ore samples. The 2nd Year Campaign comprised the geological survey for the F7 Ore Body and its environ, the trench investigation for the western part of the F7 Ore Body, the follow-up environmental base-line study, the additional drilling investigation for the F3 Ore Body, the follow-up flotation test on the F3 ore samples and the on-site data collection for possible future exploitation. The objectives of these investigations were to delineate the rare earth ore deposits in the Dong Pao Area and to preliminarily assess economic viability of the F3 Ore Body for its future exploitation.

According to the past information, the rare earth ore deposits of the dong Pao Area were discovered in 1959, and was geologically investigated by General Department of Geology of Vietnam in the period between 1967 and 1968. The Geology Division of the Ministry of Machinery and Metallurgy, in cooperation with the German Democratic Republic, carried out geological survey and mineral prospecting by trench and pit excavation.

The geology of the Dong Pao Area comprises the Triassic limestone, shale, sandstone, the Palaeogene syenite intrusion and minette dikes, and the Palaeogene alkaline volcanics and tuffs in part. The geological structures are predominated by the fault system trending in the NW-SE direction. A number of lineaments trending in the N-S and E-W directions are also well developed.

A number of soil geochemical anomalies exceeding 2 % RE_2O_3 are located in the Project Area according to the result of the soil geochemical survey that was carried out as a part of the environmental baseline study. Of these anomalies, significant ones exceeding 10 % RE_2O_3 are associated with the ore bodies of F3, F7, F9 and F10. Mineralized outcrops are exposed in the vicinities of some of these anomalies. The rare earth mineralization (T-RE_2O_3) in this area is well correlated with the light rare earth

elements and also with other elements such as Th, Sr, As, Pb, U, F and Ba.

Stream water is weakly alkaline, indicating pH in the range of 6.98 to 8.52 in general. The headwater of the Dong Pao river ranges from 7.70 to 7.90 in pH. Therefore, these pH values are considered as the natural background of the stream water in the region. Temperatures of stream water generally range between 16.7 and 21.2℃, with a slightly higher temperature at 28.9℃ recorded for the spring water in the vicinity of the Nam Hon river. Stream water indicates conductivity ranging from 242 to 645 μS, which is slightly higher than for other areas.

According to the result of the trace element analysis, the stream water is relatively high in As and F contents ranging from 0.25 to 0.32 mg/l and from 0.79 to 2.42 mg/l, which suggests that the terrain of the Project Area has been extensively affected by hydrothermal mineralization to a certain degree. The tracer test result has confirmed that water of the Dong Pao river flows underground and flows out at the headwater of the Nam Hon river. However, there is no evidence for this underground flow to mix with the hot spring water flowing out in the vicinity of the Nam Hon river.

The automatic weather recorder, installed at the Project site for the period of approximately one year in 2001, recorded weekly precipitation exceeding 60 mm including the highest of 154 mm during the wet season. The maximum rainfall intensity was recorded at 32 mm/hour. The maximum instantaneous wind velocity was recorded at 8.0 m/second. The highest of daily maximum temperatures was recorded at 34.4℃, while the lowest of the daily minimum temperatures, at 6℃. The Tam Duong weather observatory recorded the highest daily precipitation at 97 mm for the last two years and the highest weekly precipitation at 384 mm for the last five years.

The vegetation survey has identified 53 common species and 9 rare species of plants in the Project Area. However, none of the rare species exists in the planned mining site. Therefore, it is unlikely that the future mine development endangers these rare species.

Mineralized outcrops, containing 7 to 8 % RE_2O_3, are located in the western part of the F7 Ore Body. The trench investigation for these outcrops identified the flat lying layers of 3 mineralized zones, the lowermost along the Creek, the intermediate along the road and the uppermost in the ascending order. The elevation difference from the bottom to the top is measured at approximately 55 m, which suggests a possibility of significant resources concealed in this part.

A total of 23 drill holes with the aggregated length of 2,300 m were put down to explore the F3 Ore Body at depth. The geology observed in the recovered drill cores comprises syenite, limestone blocks or boulders and minette dikes intruding these rocks. Significant mineralization, containing 10 % or better RE_2O_3, was intersected by 8 holes out of the 23 holes. In addition, other 5 holes encountered moderate mineralization with

the grade ranging from 5 to 10 % RE_2O_3.

The F3 Ore Body, forming an irregular lens, consists of the high grade zone equal to or better than 10 % RE_2O_3 in its center surrounded by the medium grade zone ranging from 5 to 10 % RE_2O_3. Low grade mineralization, surrounding these zones, extends beyond the limit of the drilling grid. Numerous limestone blocks and boulders bound the eastward and westward extensions of the F3 rare earth mineralization. The flat lying high grade zone deepens northward, with the surface elevation increasing, and also weakens in its intensity of mineralization. The lateral extent of the high grade zone is approximately 150 m wide in the east-west and 400 m wide in the north-south.

The ores are rich in light rare earth elements in proportion to medium to heavy rare earths according to the chondrite-normalized REE pattern, which indicates the main rare earth mineral to be bastnaesite. The ore minerals are bastnaesite, hydroxy-bastnesite, synchysite, barite, fluorite and minor monazite and pyrite. The gangues are quartz, calcite, K-feldspar and minor phlogopite, illite, kaolinite, halloysite, smectite and boehmite. Bastnaesite mainly occurs as fine-grained crystals interstitially filling spaces between crystals of barite, fluorite, calcite and other minerals. In part, it forms veinlets crosscutting barite, fluorite and calcite crystals.

In addition to the F3 Ore Body, there are other rare earth ore bodies such as F7, F9 and F10, which may become commercially viable resources. The F1 and F4 ore bodies among others in the Dong Pao area principally consist of fluorite mineralization, with the former being currently mined and the latter having been closed down.

The Triassic system was 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. The high-pressure and high-temperature vapor enriched in volatile matters and rare earths were formed at depth and migrated through cooling-joints, formed in the peripheries of syenite bodies or through fractures mechanically formed in surrounding limestone by intruding forces of the magmas. The high pressure-temperature vapor was cooled down to hydrothermal solution , mixing with meteoric water as it ascended, and precipitated rare earth minerals under favorable conditions. The syenite body has been exposed on the surface as the limestone on the top was eroded out. It has been undetermined whether concentrations of rare earths, barite and fluorite were secondarily formed by weathering-oxidation or the present mode of occurrences exhibits the weathered and oxidized states of the primary concentrations.

Blocks having a dimension of 20m in N-S, 20m in E-W and 5m in height were set up for the extent of the geological ore reserve estimation, based on the drilling result (23 holes, 2300 m). The composite assay runs with an equal length of 5m that were bounded

by block boundaries, were produced to estimate the composite grades by averaging the assay results of original assay runs with the weight of their core length. The specific gravity of 2.6 was adopted for all types of ores and lithological units.

The geological reserves were estimated and collected by changing the cut-off grades from 0 to 15 % RE_2O_3. The table below shows the geological reserves between the cut-off grades of 8 and 11%.

Table Geological Reserves

Cut off graid %	Insitu ore (BCMS)	Insitu ore (Tonnes)	Average Graid (%)		
			RE2O3	CaF2	BaSO4
3	2,836,391	7,374,617	5.23	9.87	34.50
4	1,833,175	4,766,256	6.19	12.06	34.01
5	1,221,250	3,175,249	7.06	12.80	34.97
6	789,018	2,051,446	7.93	13.59	35.40
7	520,980	1,354,549	8.69	14.24	36.16
8	294,291	765,156	9.63	12.74	39.72

The above reserves exclude the expected reserves to the south of the southern limit of the drilled extent.

The 1st year flotation test using a conventional process flow failed to effectively separate rare earth minerals possibly due to the intensely weathered nature of the test samples. In the 2nd year test, a new process flow and reagent scheme was developed. The new approach sequentially float barite, fluorite and rare earth minerals in the progressive order. The flotation results were dramatically improved and achieved the recovery rate of 50 % to produce the 50 % RE_2O_3 concentrate and that of 70 % to produce the 40 % RE_2O_3 concentrates.

The economic viability of the F3 Ore Body was preliminarily assessed, although a great deal of uncertainty was included in the data acquired to-date. The result indicates that it will be possible to produce some 3,000 tons of RE_2O_3 contained in concentrate annually for the period of approximately 13 years. The mine and flotation plant development will require some US $ 15 million of the initial investment. The discounted rate of return to the initial investment is estimated at approximately 16% per annum, which is not necessarily high but suggests a certain economic viability of the exploitation of the F3 Ore Body. A conceptual post-flotation processing cost, assuming to produce mischmetal as the final product, was taken into account in this estimation, however, without any technical and engineering supports. Metallurgical testing for the post-flotation processes is currently being conducted. This estimation has to be comprehensively reviewed after the completion of the testing. A supplemental report will follow after reviewing this economic assessment incorporating the post-flotation metallurgical test result.

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Part I Project Overview

Part I Project Overview

Chapter 1 Introduction

1-1 Background

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 was carried out in the Dong Pao Area in the Socialist Republic of Vietnam for the 2-year period in the Japanese fiscal years of 2000 and 2001.

1-2 Objectives

The Project objectives are to explore the zone of rare earth mineral resources in the Dong Pao Area in the Socialist Republic of Vietnam and to preliminarily assess economic viability for the exploitation of the F3 Ore Body in this zone in the period of 2 years, in order to accelerate the resources development in the region of Northern Vietnam.

1-3 Work Program

The work program of the 1st Year Campaign comprised review and analysis of the existing data, geological prospecting, drilling investigation, environmental baseline study and metallurgical testing of the rare earth ore samples in order to examine the possibility of economic exploitation of rare earth resources, specifically the F3 Ore Body, in the Dong Pao Area.

The work program of the 2nd Year Campaign comprised geological prospecting for an area including the F3 and F7 Ore Bodies, environmental baseline study (tracer test, water quality analysis and meteorologic observation), trench investigation (western part of the F7 Ore Body), drilling investigation(the F3 Ore Body) and economic assessment for possible resource exploitation.

The amounts of the works by category are presented in Table I-1-1 and those of the laboratory tests by type, in Table I-1-2. The work flow is shown in Figure I-1-1 and the flow for selecting promising prospects, in Figure I-1-2.

1-4 Project Period

The project was executed in the following periods.

(1) 1st Year Campaign

- On-site Investigation: from November 21, 2000 to February 10, 2001
- Report Preparation: from February 11, 2001 to March 23, 2001

(2) 2nd Year Campaign

- On-site Investigation: from October 10, 2001 to December 21, 2001
- Report Preparation: from December 22, 2001 to March 15, 2002

1-5 Members of the Survey Team

The members of the Survey team, who contributed to the project planning, the discussion on the 'Scope of Work' and the completion of the Agreement, and the on-site investigations for the exploration and the mine development planning are presented in Table I-1-3.

Table I-1-1 The Amounts of Works by Category

Year	Work Category	Item	Amount
2000 (Phase 1)	Geological investigation	Prospecting	Area : 11km^2
	Drilling Investigation	Road construction	Pao Construction of New Road : From New Dong Pao to the Drilling site
		Drilling operation	Total 16 holes, 1,480m length Core samples : 1,481 samples
	Environmental Baseline study	Soil survey	Area : 11km^2, 1,606 samples
		Hydrology	Sampling : 5 samples, Water temp., EC., Flow rate, and chemical analysis (22 elements)
		Vegetation	Area : 11km^2 , make a list of flora
		Meteorologic observation	Monitoring Temp., Humidity, Precipitation, Wind direction and speed, Acquisition of the weather data form Tam Dong Weather station
	Flotation Test	Sampling	Pitting : 4 pits, Total depth : 15m, Sketching Sampling : 1,431kg
		Flotation test	Sample treatment, Ore test, Flotation test
2001 (Phase 2)	Geological investigation	Prospecting	Area : 1.8 k m^2, Route length : 8.9km
	Environmental Baseline study	Tracer test	Sampling : 50 samples
		Hydrology	Sampling : 14 samples, Water temp., EC., Flow rate, and chemical analysis (22 elements)
		Meteorologic observation	Collecting data of Temp., Humidity, Precipitation, Wind direction and speed, Acquisition of the weather data form Tam Dong Weather station
	Trenching survey	Trench Excavating	Trench Line : 6, Total length : 120m
	Drilling Investigation	Road construction	Access Road to the drilling site
		Drilling operation	Total 7 holes, 820m length Core samples : 819 samples
	Flotation Test	Sampling	4 kinds of ore samples from the drilling core of phase 1, Total : 80kg
		Flotation test	A series of tests with changing reagents and
	Pre Feasibility Study	On-site Investigation	On-site Investigation and Data Collection by Mining and Metallurgical Engineers
		At-Home Study	Ore reserve calculation, Economic Assessment

Table I-1-2 The Types and Amounts of Laboratory Tests

Year	Analysis	Number of Samples
2000	Whole rock analysis	10
	Chemical analysis	50
	Preparation of rock thin section	20
	Preparation of ore thin section	20
	X-ray diffraction	17
	K-Ar Dating(Nothing fresh sample)	0
	Fluid inclusion analysises (homogenization temperatures and	5
	Analyses of soil samples	1,606
	Analyses of core samples	1,481
	Analysis of pits and trench samples	70
	Analysis of water samples	5
2001	Preparation of ore thin section	10
	X-ray diffraction	10
	Analysis of water samples	14
	Fluometric analysis	50
	Analysis of trench samples	127
	Analyses of core samples	819
	Analyses of mineralized outcrop samples	58

Table I-1-3 Members of the Survey Team

Japanese Side			Vietnamese Side	
Discassion of Project Scope and Conclusion of Agreement (2000)				
Project Manager	Toshio SAKASEGAWA	Metal Mining Agency of Japan	Nho Van Troi	Vietnam National Mineral Corporation
	Takashi SUGIURA	Ministry of Trade and Industry	Pham Trung Luong	Ministry of Industry
	Kei UMETSU	Japan International Cooperation Agency	Nguyen Van Chung	Vietnam National Mineral Corporation
	Tetsuo SUZUKI	Metal Mining Agency of Japan	Ngo Manh Hung	Vietnam National Mineral Corporation
	Takeshi MORIYA	Metal Mining Agency of Japan (Bangkok office)	Duong Trong Bong	Rare earth Corporation
Field Supervisor				
	Tetsuo SUZUKI	Metal Mining Agency of Japan		
	Keita KODA	Metal Mining Agency of Japan		
	Tetsuya HONJYO	Metal Mining Agency of Japan		
Field Operator (2000)				
Project Manager	Kiyoharu NAKASHIMA	Sumiko Consultants Co.,LTD.	Nguyen Van Chung	Vietnam National Mineral Corporation
Geology and Environment	Koji UEDA	Sumiko Consultants Co.,LTD.	Ngo Manh Hung	Vietnam National Mineral Corporation
Drilling supervisor	Takashi UENO	Sumiko Consultants Co.,LTD.	Hoang Van Cong	Rare Earth Corp.-TERRAPRODEX
Field Operator (2001)				
Project Manager, Geology	Kiyoharu NAKASHIMA	Sumiko Consultants Co.,LTD.	Nguyen Van Chung	Vietnam National Mineral Corporation
Geology and Environment	Koji UEDA	Sumiko Consultants Co.,LTD.	Hoang Van Cong	Rare Earth Corp.-TERRAPRODEX
Environment	Masao OKUMURA	Metal Mining Agency of Japan	Ngo Manh Hung	Vietnam National Mineral Corporation
Mine Development Plan	Hirofumi NAGATSUKA	Sumiko Consultants Co.,LTD.		
	Yoichi MIZUOCHI	Sumiko Consultants Co.,LTD.		

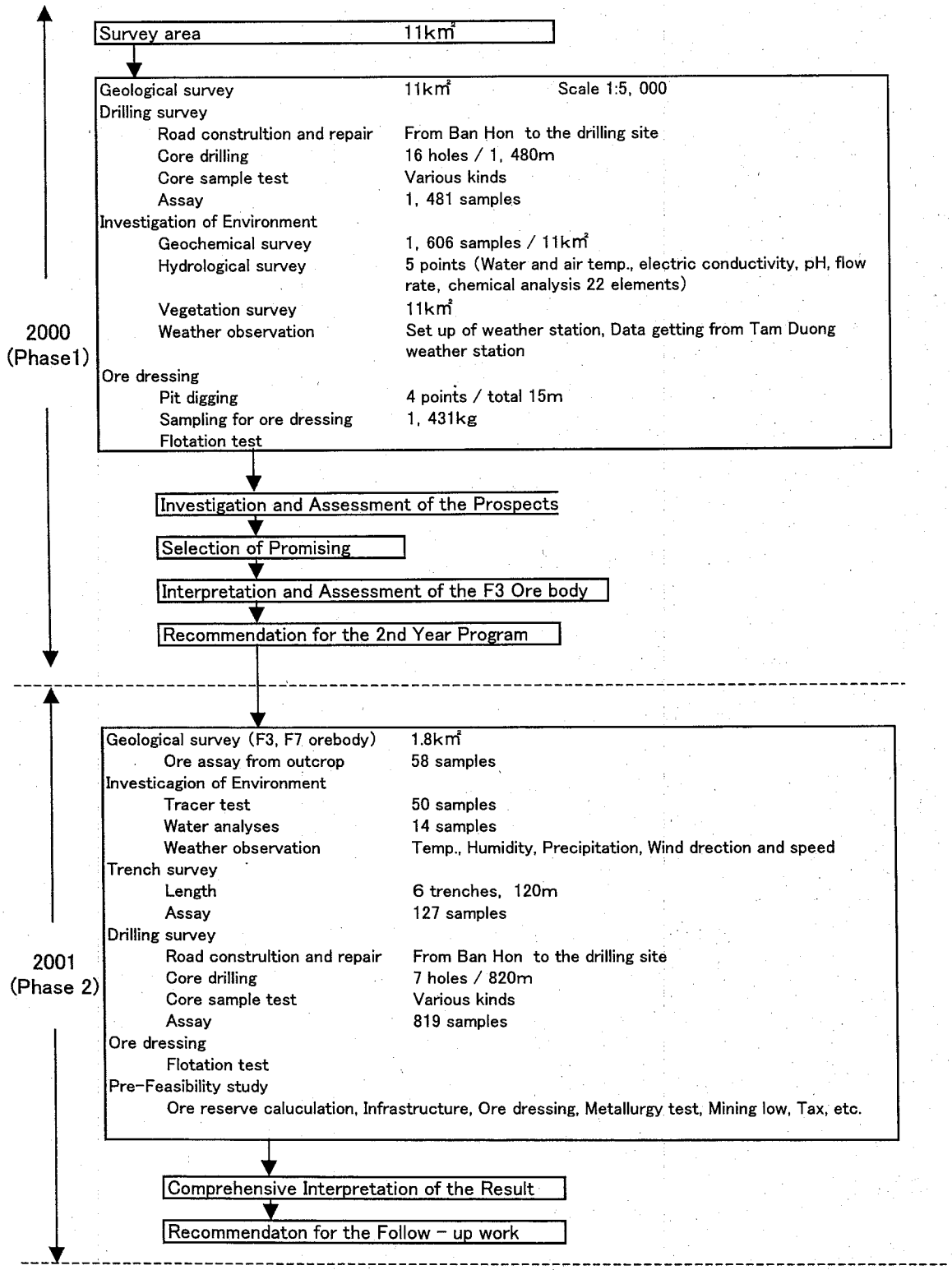


Figure I-1-1 Work Flow

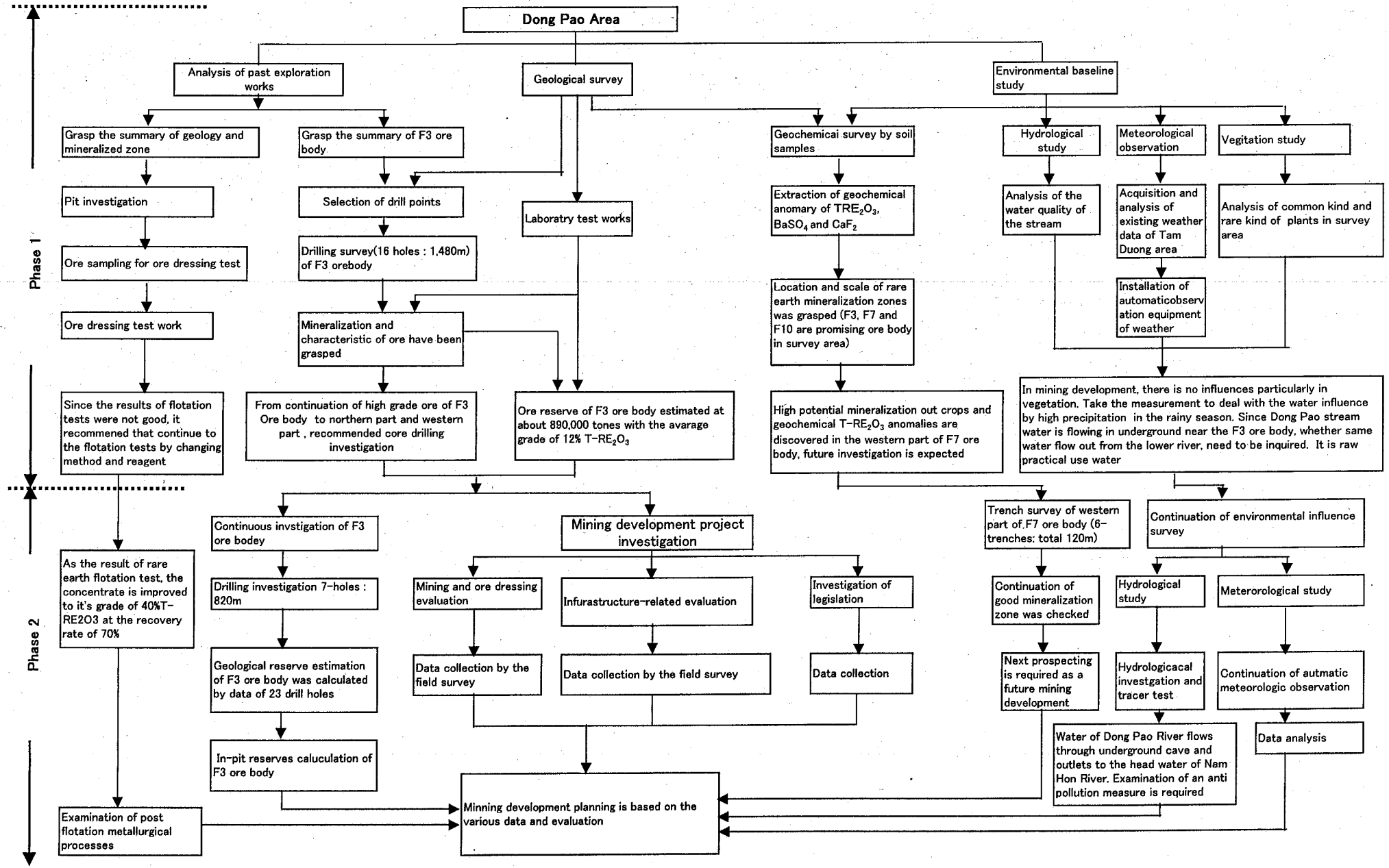


Figure I-1-2 Flow chart of finding high potential area

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 Outline of the Geology and Mineralization

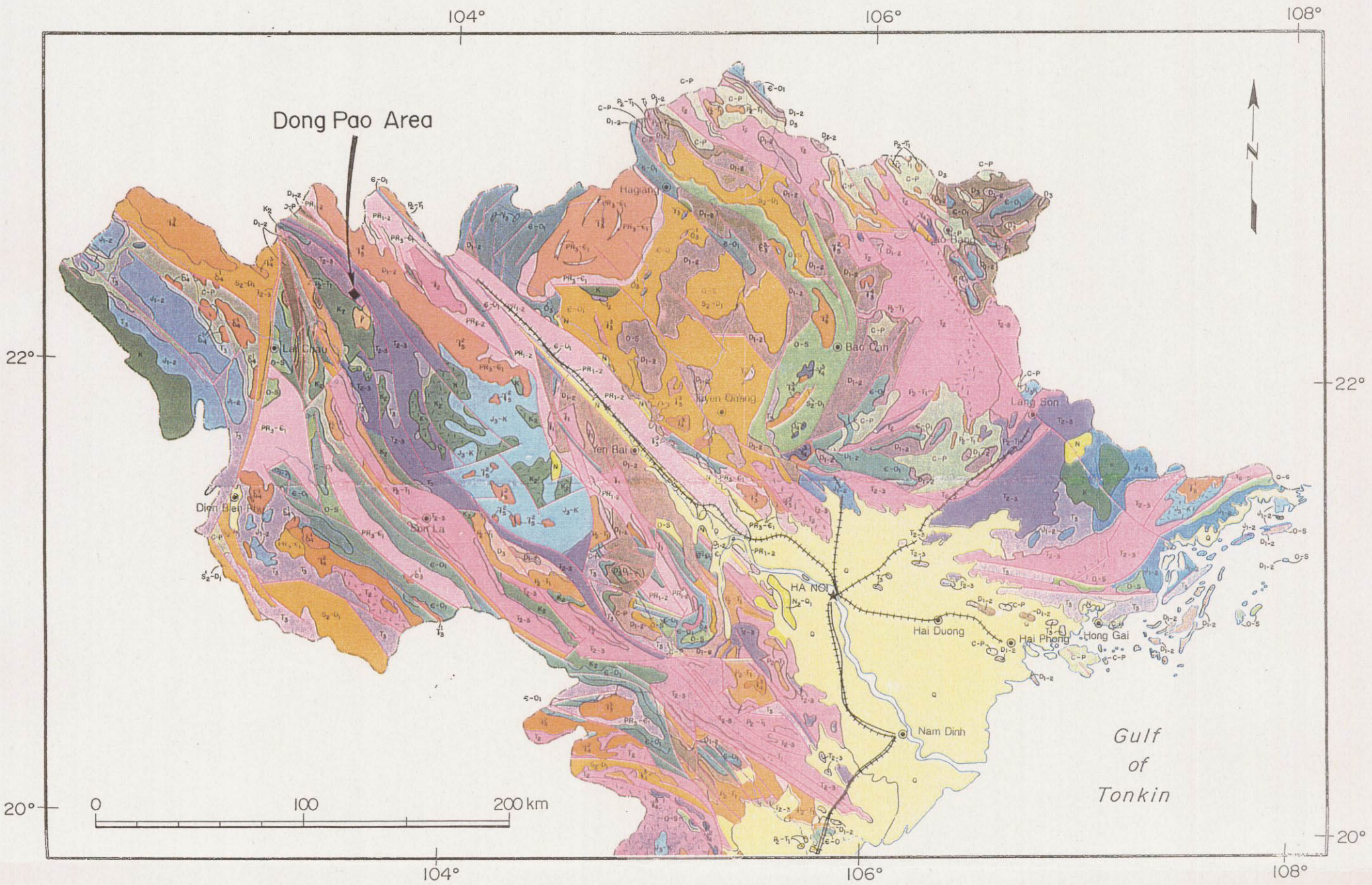
3-1 Regional Geology

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). 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-3-2). 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.

3-2 Mineral Resources

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.

Distribution of various types of ore deposits is illustrated in Figure I-3-3, referring to the geology and geological structures at the time of their formation. The ages of their formations are diagrammatically shown in Figure I-3-4. Locations of major ore deposits in the northern Vietnam are plotted on the geological map in Figure I-3-5. Figure I-3-6 and I-3-7 demonstrate the geology and mineralization of the Nam Xe and the Dong Pao rare earth ore deposits in plan and cross-section.



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

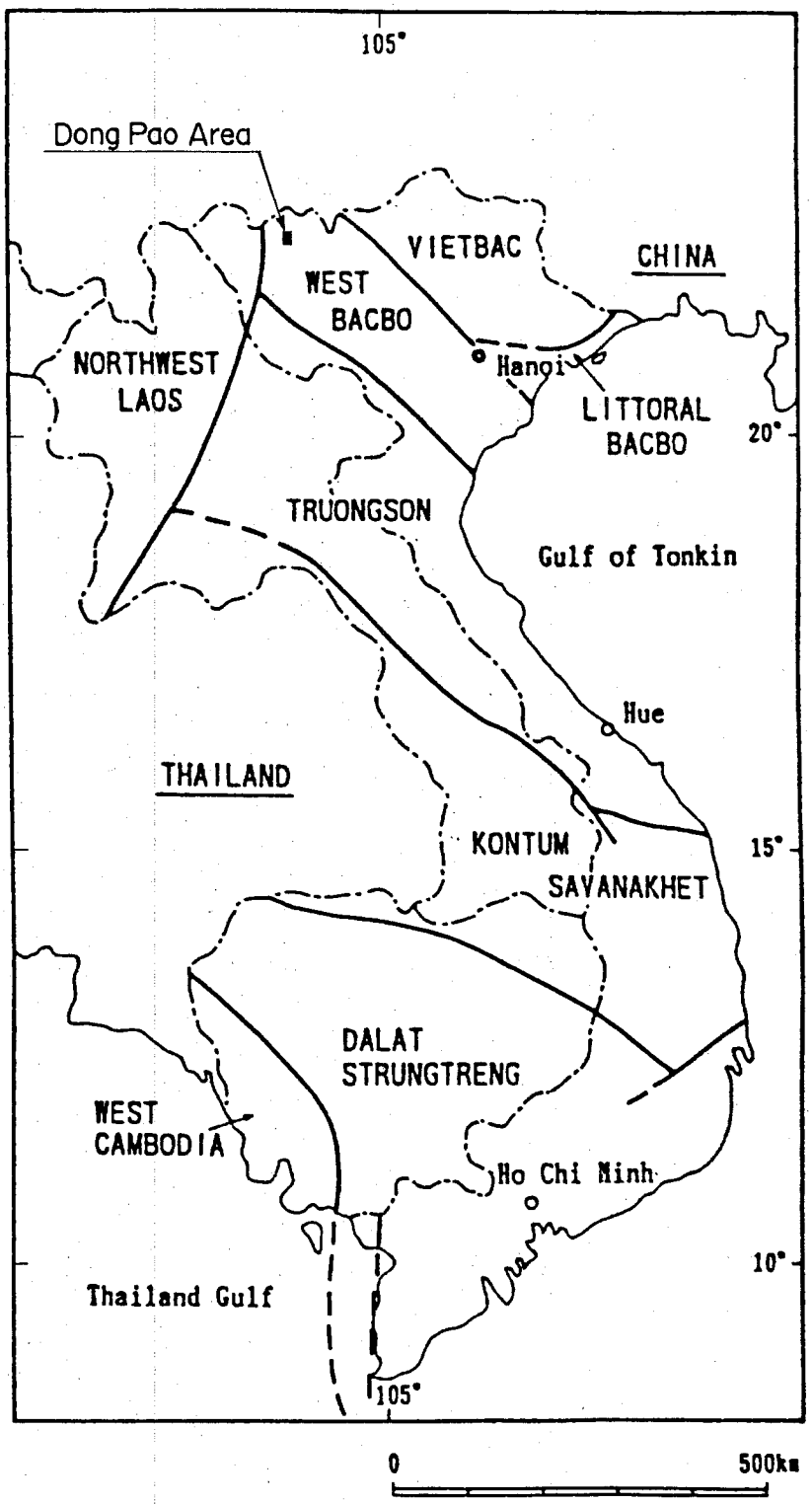
PROTEROZOIC

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

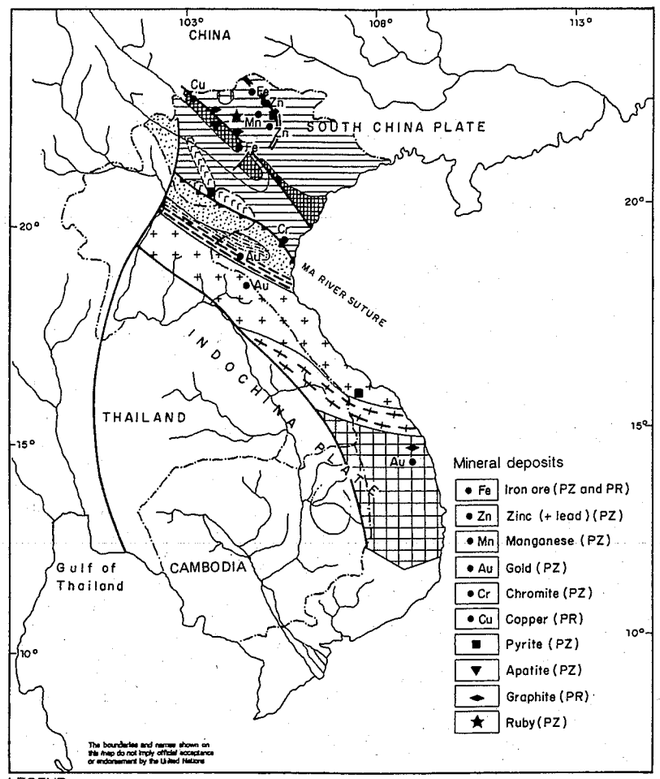
- Felsic volcanics
- Fault
- Railways
- Roads

U: Upper M: Middle L: Lower

Figure1-3-1 Geological map of northern part of Vietnam



Figurel-3-2 Geological setting of Cambodia-Laos-Vietnam



LEGEND

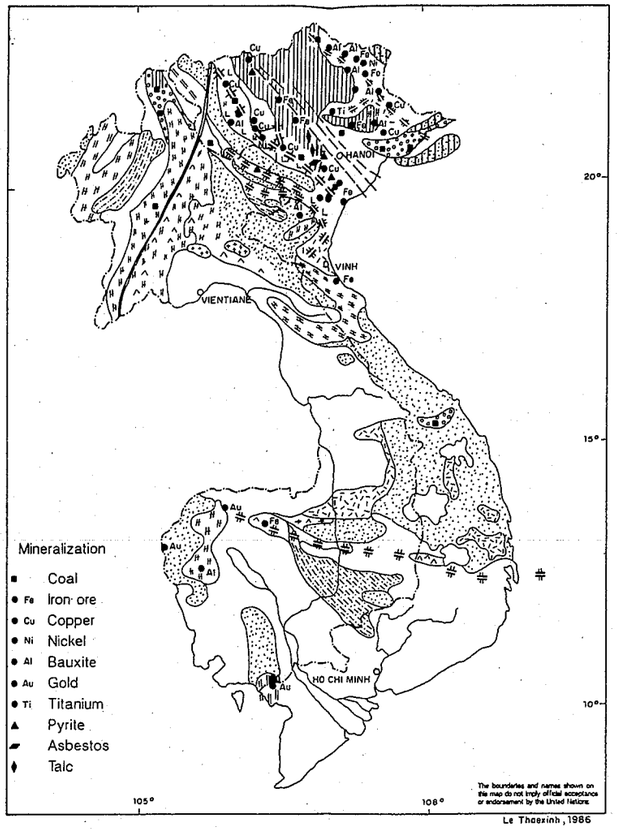
South China plate :

- 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

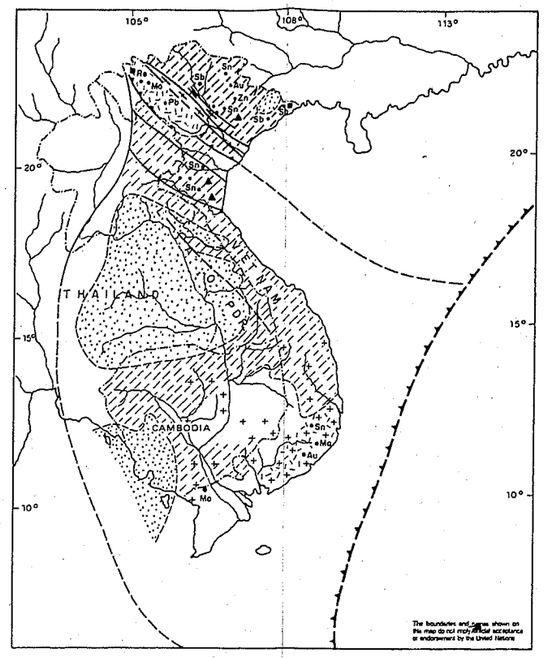
Pre-Indosinian folded basement :

- 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

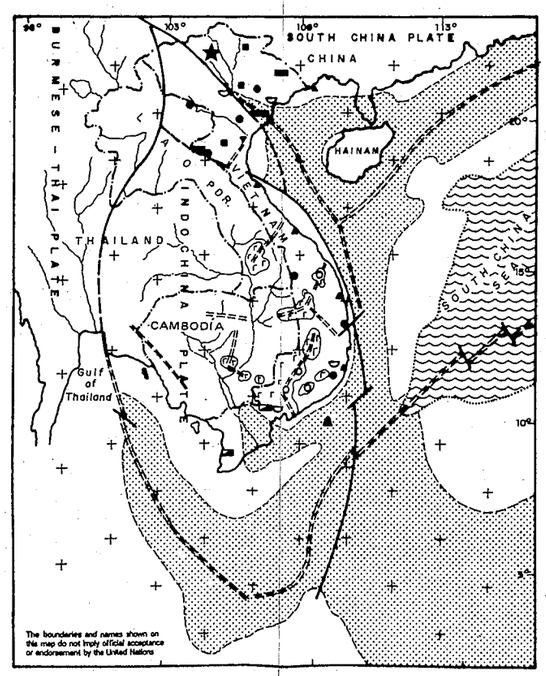
Tectonic setting and mineral distribution during the Indosinian epoch in Indochina



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

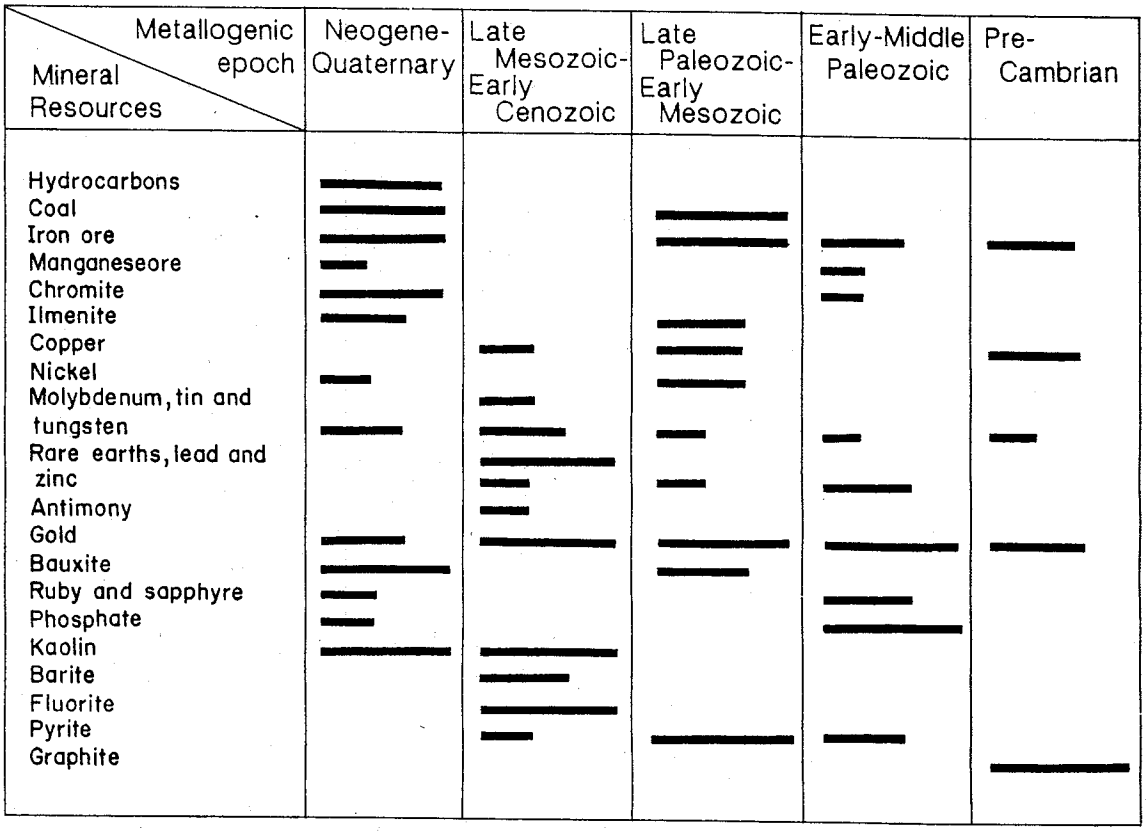


LEGEND

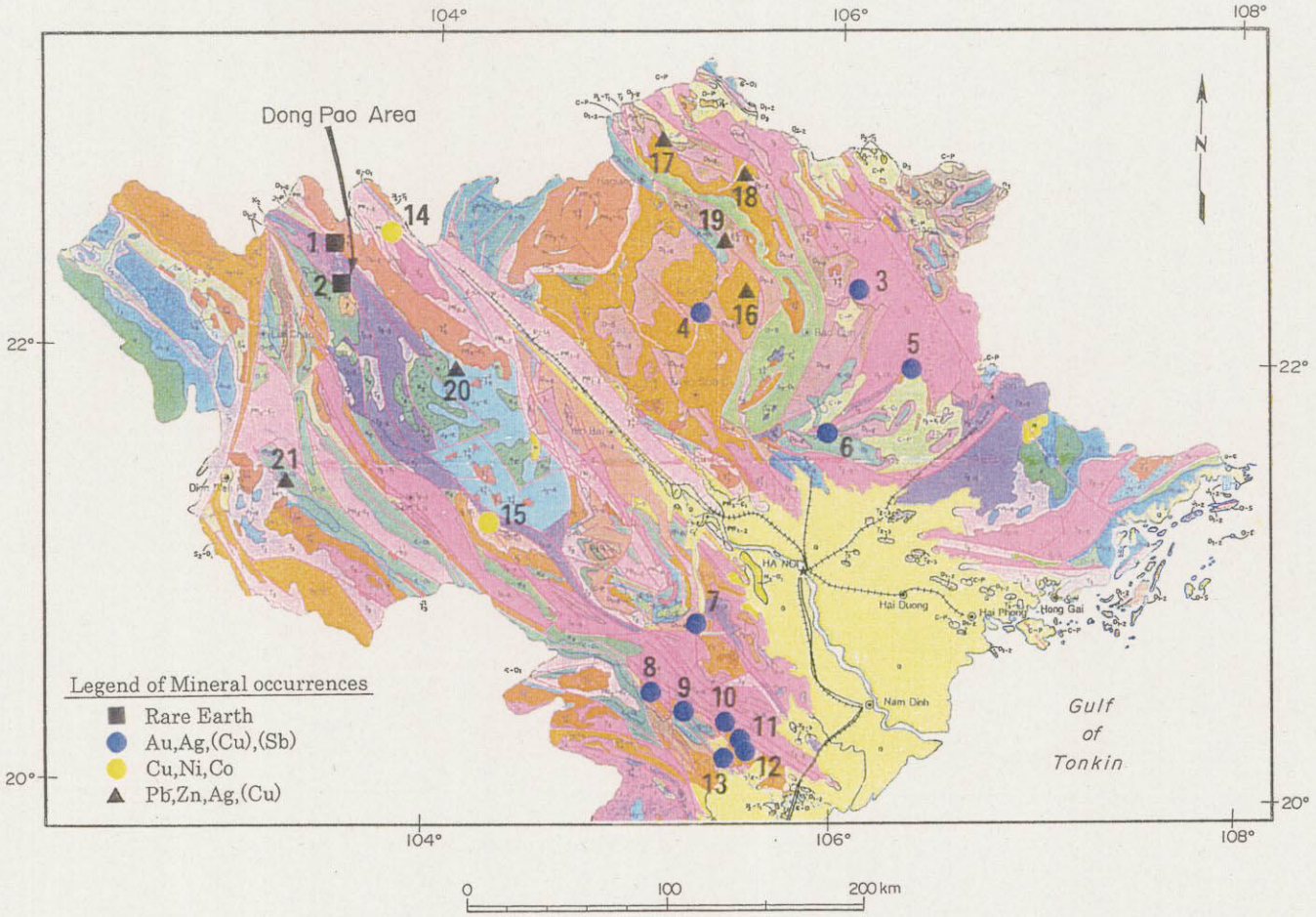
- Continental crust
- Neogene depressions with thick sedimentation on the continental shelf
- Oceanic crust
- Basaltic cover
- Faults and thrusts
- Rift zones
- Gold placers
- Cassiterite placers
- Kaolin deposits
- Lateritic bauxite deposits
- a/ Ilmenite placers ; b/ Chromite placers
- Ruby placers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

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

Figurel-3-3 Tectonic setting and distribution of mineralization map

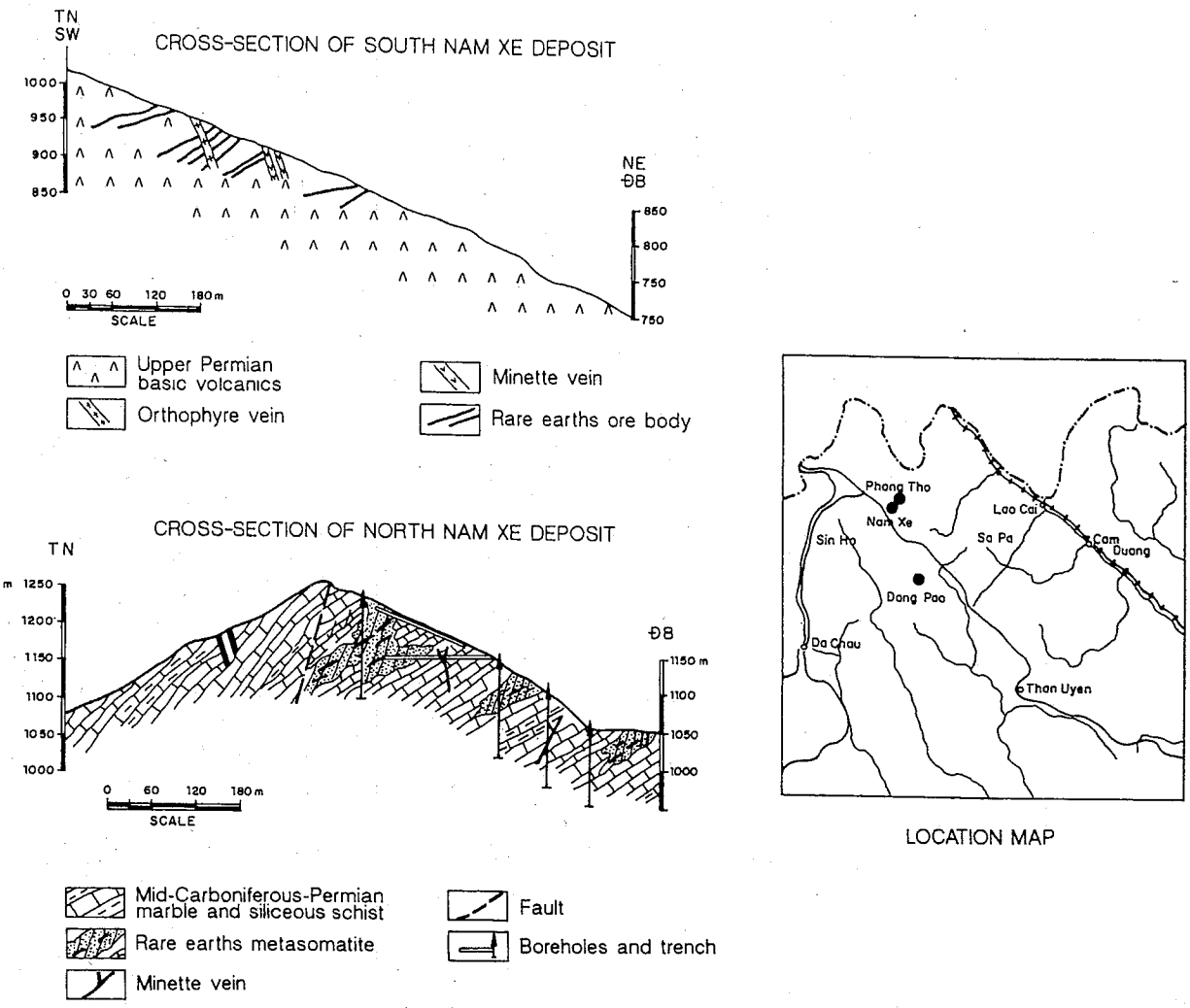


Figurel-3-4 Main mineralization in Vietnam

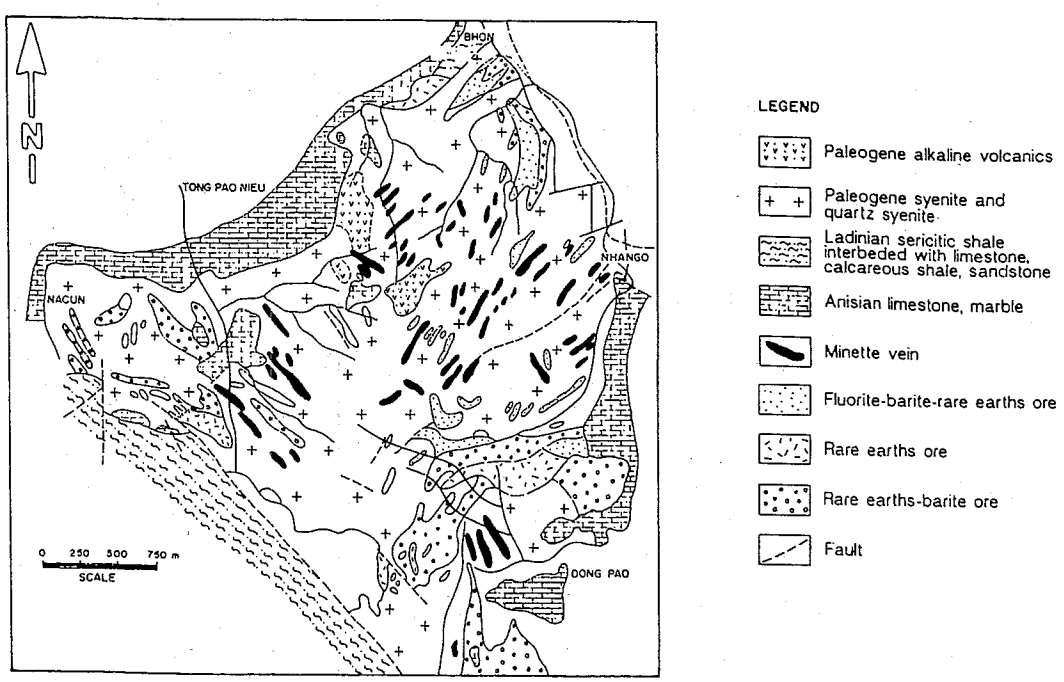


No.	Project	Province	Commodity	Type of Ore
1	Nam Xe (N,S)	Lai Chau	REE	Hyd.
2	Dong Pao	Lai Chau	REE	Hyd.
3	Pac Lang	Coa Bang	Au,Ag	Hyd.Qz-vein
4	Lang Vai	Tuyen Quang	Au,Ag,Sb	Hyd.Qz-vein
5	Na Pai	Lang Son	Au,Ag	Hyd.Qz-vein
6	Bo Cu	Thai Nguyen	Au,Ag	Hyd.Qz-vein
7	Kim Boi Area	Hoa Binh	Au,Ag	Hyd.Qz-vein
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.

Figurel-3-5 Distribution of mineralization in the northern part of Vietnam



Figurel-3-6 Cross section of Nam Xe Rare Earth deposit



Figurel-3-7 Distribution map of Dong Pao Rare Earth deposit

Chapter 4 Past Exploration Works

4-1 General View of Past Exploration

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.

4-2 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 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.

4-2-3 Ore Reserves Estimation based on the Past Exploration Results

(1) 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-4-1.

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 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 respectively.

Table I-4-1 The categorized Ore Resources of F3 ore body (1986)

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

(2) 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 Result of the Class I Ore Reserves of the F3 Ore Body

The re-estimation result is summarized in Table I-4-2.

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 in the range between the two re-estimation results with the safety factors of 10 and 20 %.

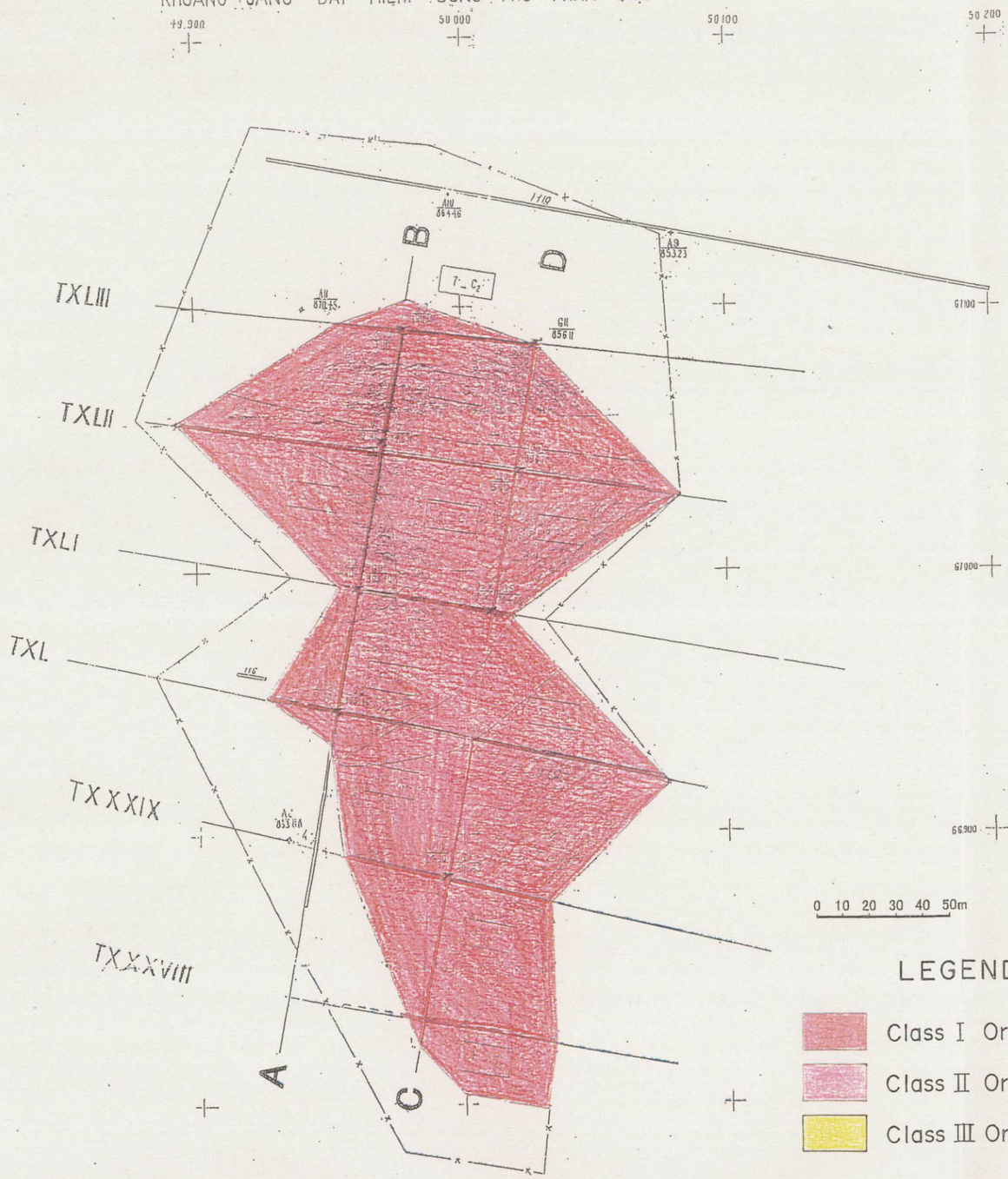
Table I-4-2 Re-estimated Ore Reserves of Class 1 Ores of F3 Ore Body (2001)

	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 ĐỒNG PAO THÂN QUẶNG F.III



LEGEND

- Class I Ore Reserve
- Class II Ore Reserve
- Class III Ore Reserve

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 ĐỒNG PAO THÂN QUẶNG F.III

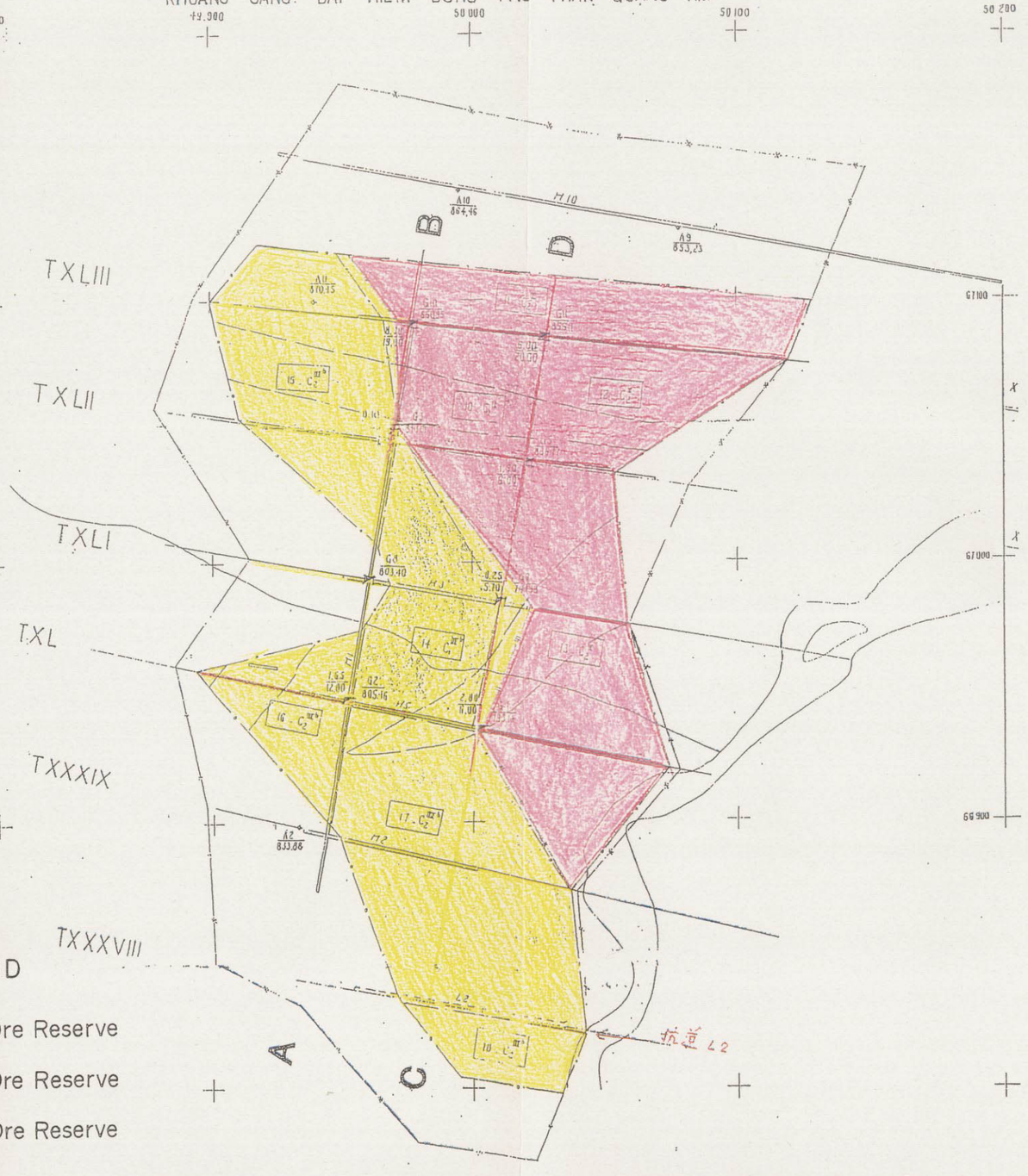


Figure I-4-1 Plane view of ore block of F3 orebody

MẶT CẮT DỌC A-B, C-D

MỎ ĐỒNG KIỂM ĐỒNG PAO - THÂN QUẢNG ĐỊNH

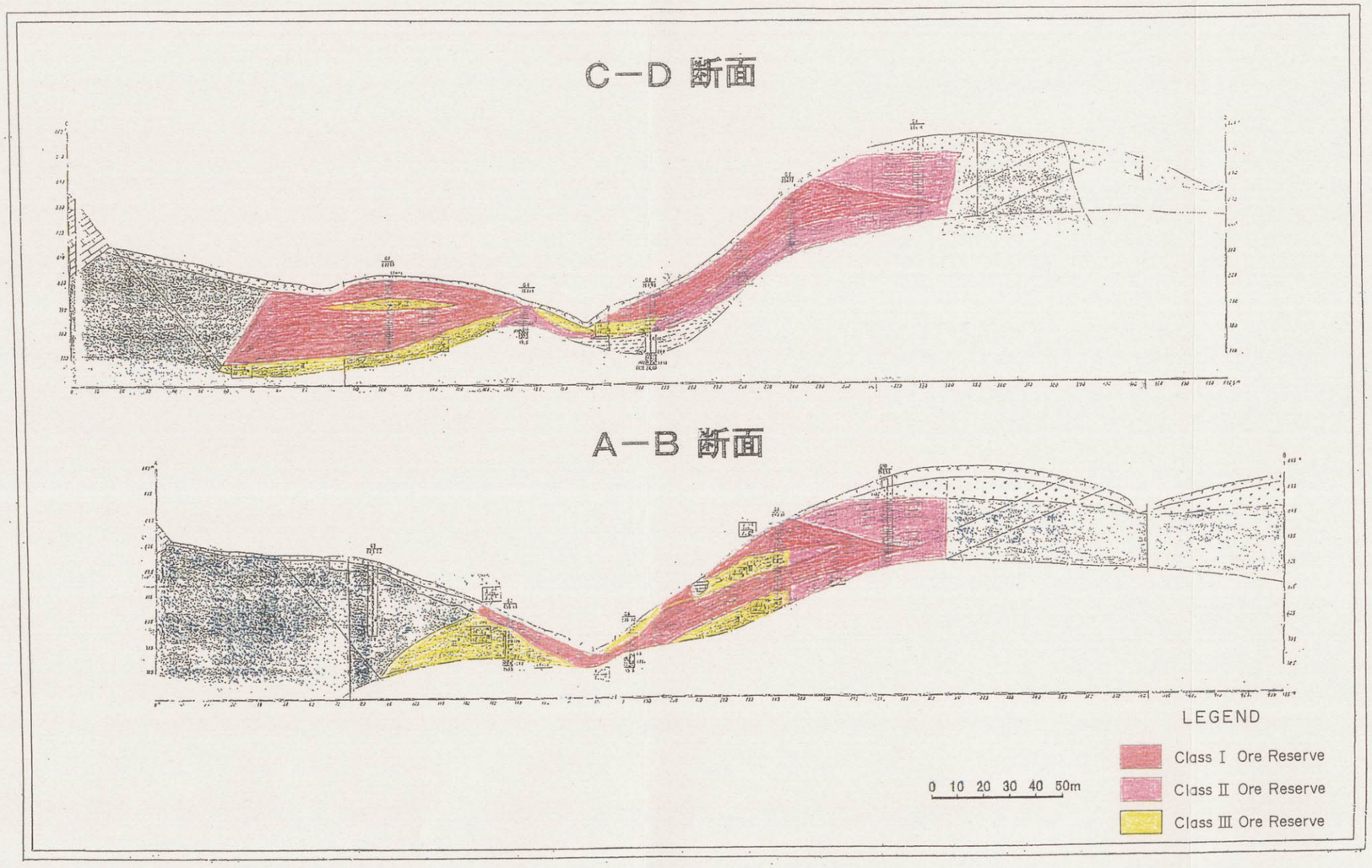


Figure I-4-2 Cross section of ore block diagram of F3 orebody

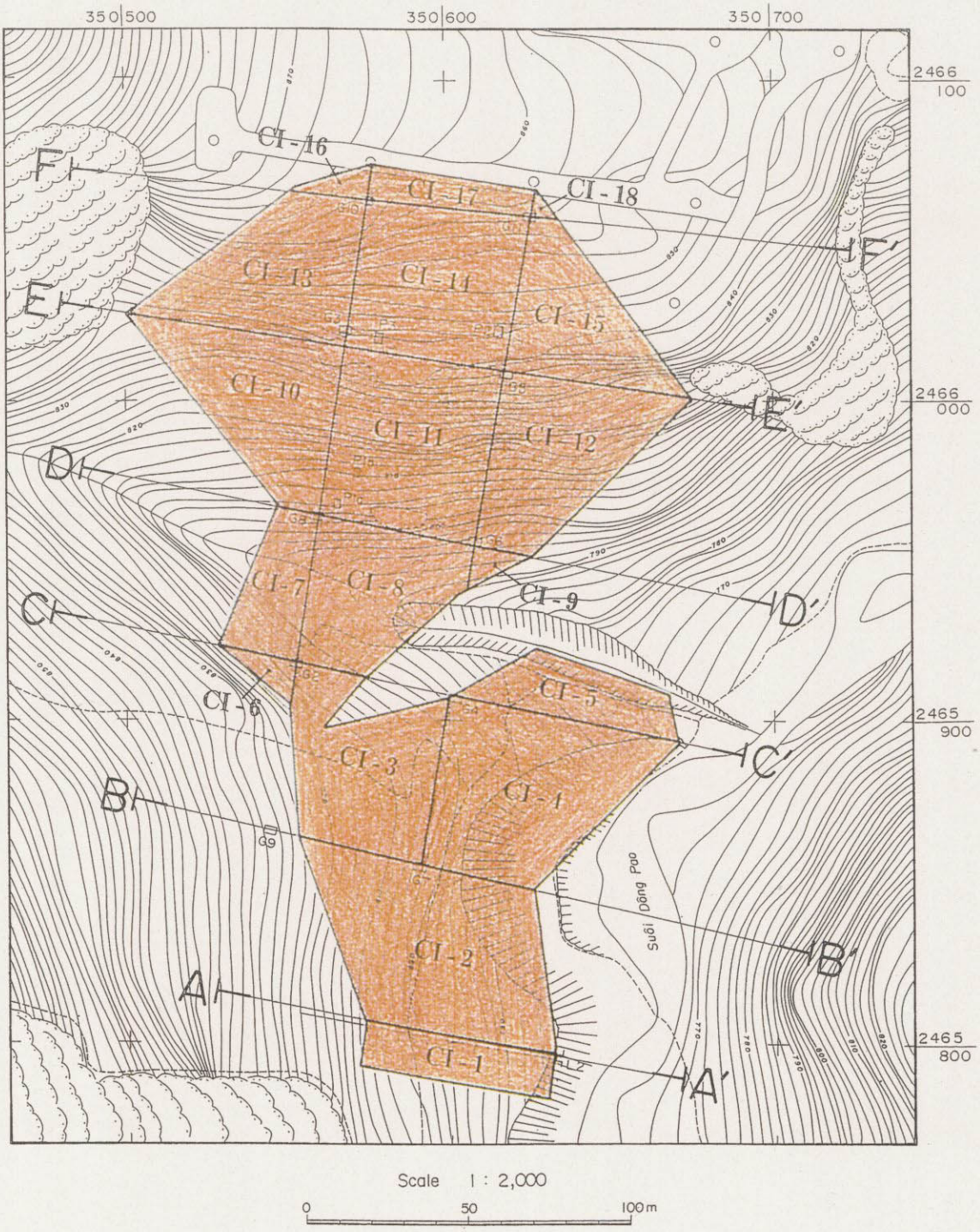
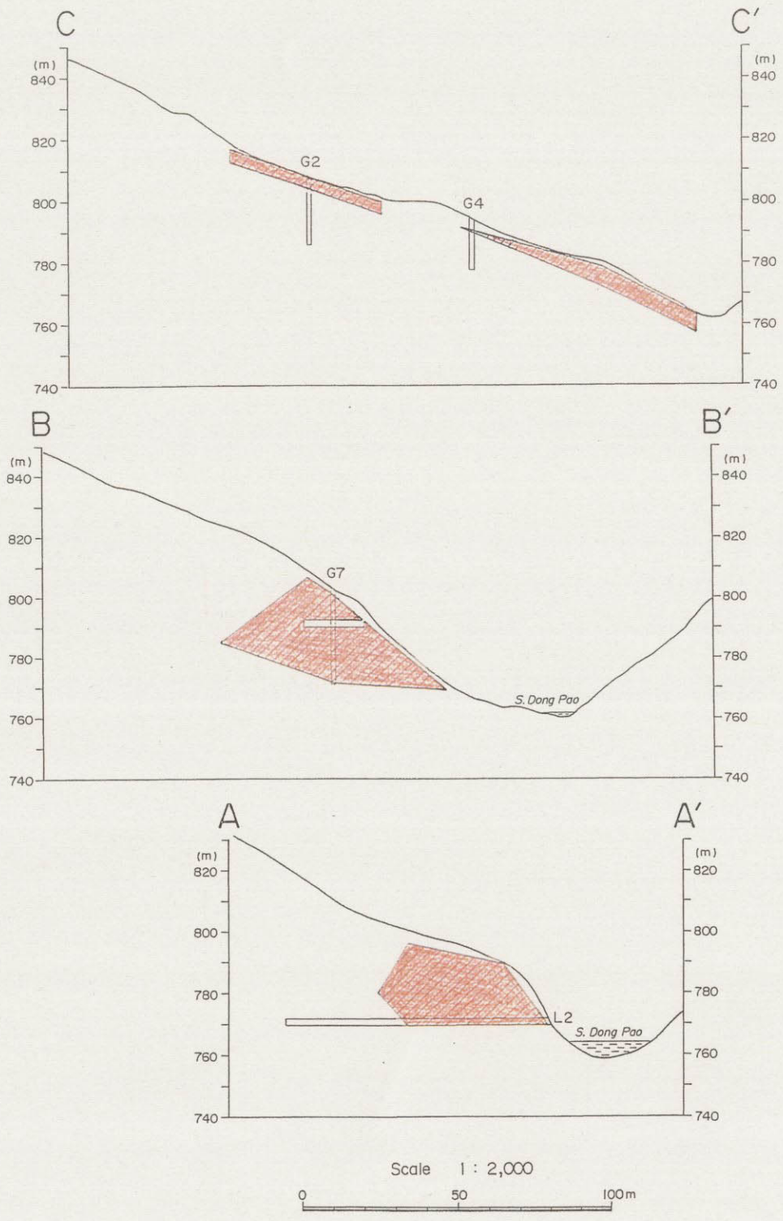
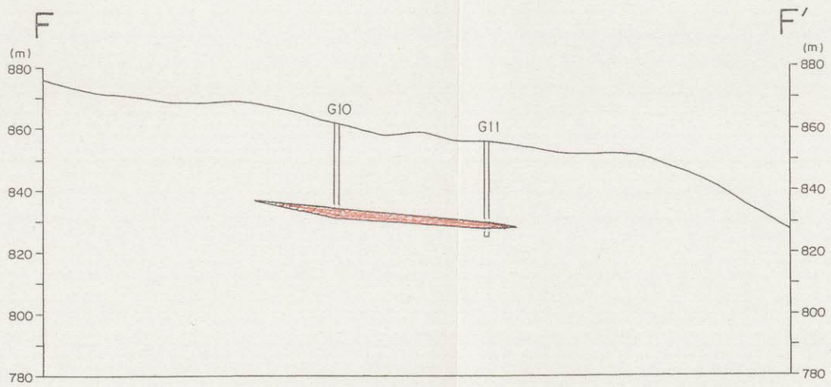
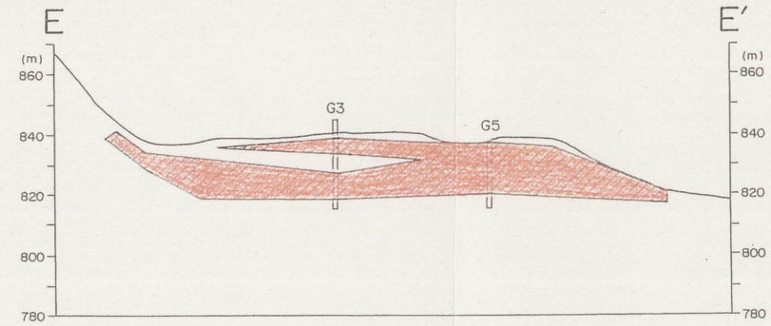


Figure I-4-3 Plane view of ore block class I of south F3 orebody







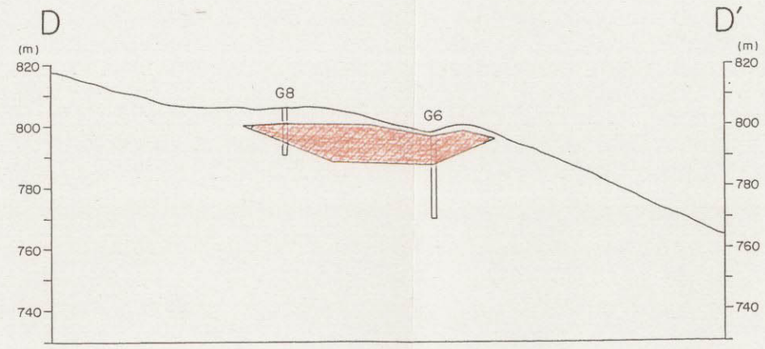


Figure I-4-4 Cross section of ore block class I of south F3 orebody (A-A'～F-F')