ESTADOS UNIDOS MEXICANOS
CONSEJO DE RECURSOS MINERALES

REPORT ON GEOLOGICAL SURVEY OF THE PACHUCA-ZIMAPAN AREA, CENTRAL MEXICO

(CONSOLIDATED REPORT)

MARCH 1983

JAPAN INTERNATIONAL COOPERATION AGENCY
METAL MINING AGENCY OF JAPAN
GOVERNMENT OF JAPAN

PREFACE

The Government of Japan, in response to the request of the Government of the Estados Unidos Mexicanos, decided to conduct geological survey and other survey works related to ore deposit exploration in order to confirm the potentiality of mineral resources in the Pachuca area of the State of Hidalgo, Mexico, and entrusted its execution to Japan International Cooperation Agency. The Agency, considering the nature of the works to belong to special field of the investigation of geology and mineral resources, sought the cooperation of the Metal Mining Agency of Japan to accomplish the task.

These survey works were carried out during four years from July 1979 to March 1983, and those were completed as scheduled under close cooperation with the Government of Mexico and its various agencies, and especially with El Consejo de Recursos Minerales.

This report summarizes the results of these surveys for four years.

We wish to express our appreciation to the Government of the Estados Unidos Mexicanos, its agencies concerned and El Consejo de Recursos Minerales as well as the Ministry of International Trade and Industry, the Ministry of Foreign Affairs, Embassy of Japan in Mexico and the persons concerned for the cooperation and support extended to the Japanese survey team.

March 1983

Keisuke Arita
President
Japan International Cooperation Agency

Masayuki Nishiie
President
Metal Mining Agency of Japan

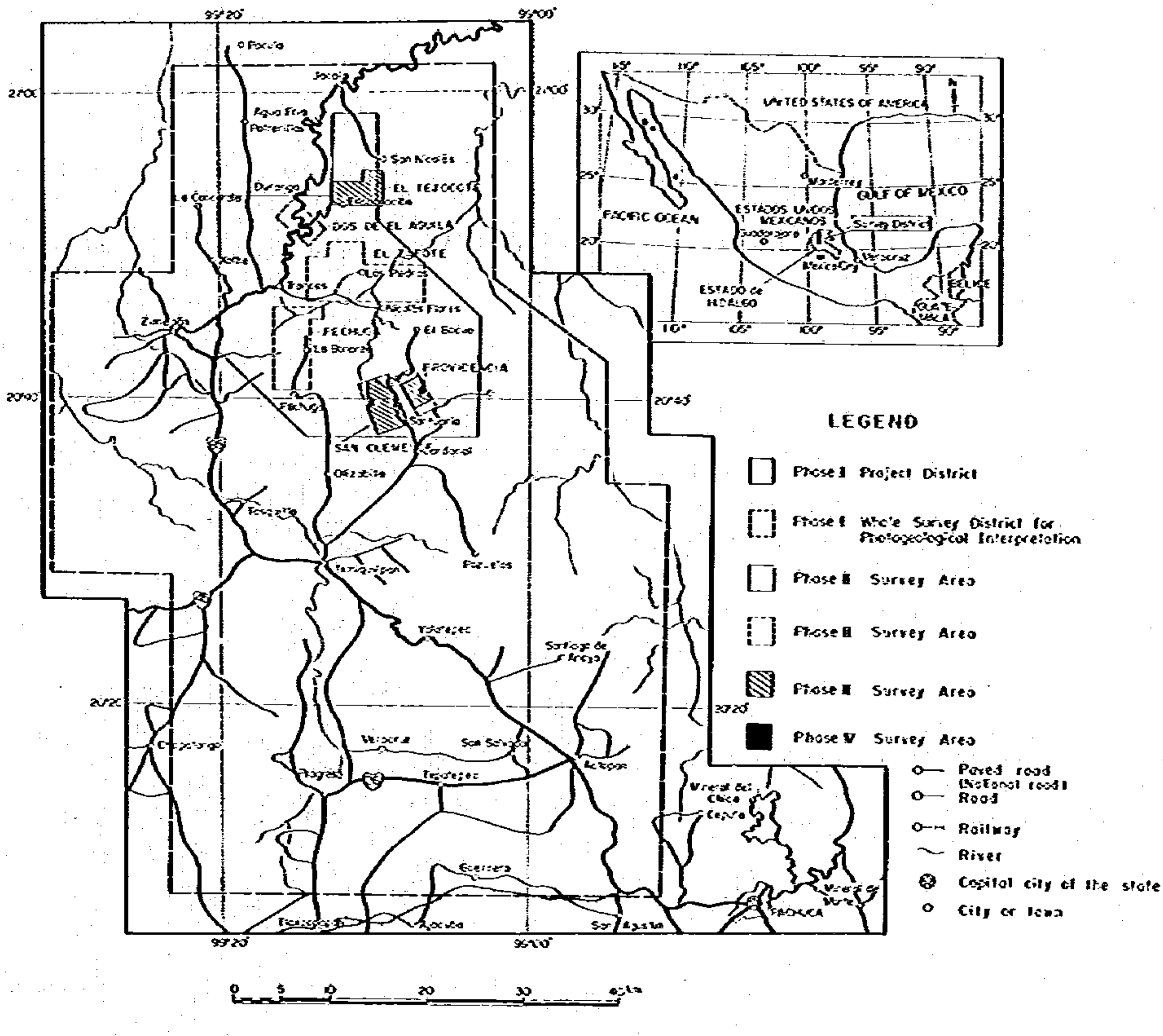


Fig. G-1 Location Map of the Survey District

ABSTRACT

The report is a comprehensive compilation of the result of investigation regarding the mineral resources development cooperative basic survey in the Pachuca District of the United Mexican States conducted for four years from 1979 to 1982.

The purpose of the investigation was to make clear the geology and geologic structure and the relationship between them and the mineralization, and to obtain an effective guidance for the exploration and development of the mine in the next stage.

The Pachuca District is situated in the northwestern part of the State of Hidalgo in the central part of Mexico, at a distance about 165 kilometers from Mexico City, the capital city of Mexico, to the center of the surveyed area which occupies an area of 5,250 km^2.

In the area, the regional survey composed of preparation of topographical map, photogeological interpretation and field reconnaissance, then geological survey, geophysical survey and geochemical prospecting were successively carried out step by step. These surveys resulted in to extract contact metasomatic type iron and copper showings at three localities, irregularly massive to vein type silver, lead and zinc showings at two localities and network to dissemination type gold and silver showings at one locality.

Among these, detailed geological survey, geochemical prospecting (soil sampling) and electric survey (IP method) were carried out for the silver, lead and zinc showings. In the PROVIDENCIA area, which is contained in the above, diamond drillings consisting of two 300-meter holes was conducted.

In the SAN CLEMENTE area, which is included in the area of gold and silver showings, geochemical prospecting by rock sampling was carried out beside geological survey, raising successively the sampling density.

In the final phase, diamond drillings of three 300-meter holes was conducted.

Thus the conditions of mineralization in the depths were investigated in two areas of PROVIDENCIA and SAN CLEMENTE.

In the Sierra Madre Oriental zone of the central part to the northern half of the surveyed district, pre-Tertiary calcareous to pelitic sedimentary rocks are dominantly distributed and the scattering distribution of stock-like dioritic intrusive rock intruded the above sedimentary rocks is also observed.

The contact metasomatic type mineralized zones are found adjacent to the contact between these intrusive rocks and the pre-Tertiary. Whereas, the silver, lead and zinc mineralized zones considered to be hydrothermal type are distributed in the pre-Tertiary sedimentary rocks in a distant surrounding part of the intrusive rocks, and the relation with the intrusive rocks and other igneous rocks has not been made clear.

The network to dissemination type gold and silver mineralized zone is found in a part of potash rhyolite mass which is distributed only in one locality in the district, and considered to be closely related to the activity of the rock.

During the period of project for four years, 946 stream sediments samples, 443 soil samples, 1,706 rock samples, 300 drill core samples and 278 ore samples from surface outcrops were analyzed for geochemical prospecting. Beside these, research and investigation were made on 12 samples for K-Ar age determination, 107 for whole rock analysis, 516 for microscopy, 92 for macro-fossils and 254 for nannofossils, which provided with the basic data for investigation of geology and mineralization.

These comprehensive survey resulted in to make clear the geologic structure of the district, igneous activity, mineralized zone, distribution of showings, the characteristics of mineralization and the mutual relationship between them.

Especially, the detailed geological survey, geochemical prospecting and diamond drillings on gold and silver mineralized zone carried out concentratedly in the SAN SEVERIANO mineralized zone (200 m x 400 m) of the SAN CLEMENTE area contributed to make clear the tendencies of zonal arrangement of gold, silver, copper, lead and zinc mineralization, and of intermittent distribution of gold showings in the geochemically anomalous zones on the surface.

In the PROVIDENCIA area, the result of diamond drillings led to elucidate a fact that the oxides zone in the area extends to a considerable depth.

CONTENTS

List of Tables

List of Illustrations

List of Attached Sheets

List of Appendices

CHAPTER 1 INTRODUCTION

This is a comprehensive report which compiled the results of each year's survey of the project conducted for four years from 1979 to 1983 by the both Governments of Japan and Mexico in the Pachuca district.

Since the details of the surveys have annaully been reported, a general summarization of the results and the outline of the various kinds of surveys will be described in this report.

1-1 Progress of Survey

The progress of survey works in each phase is summarized as Fig. 1-1.

Thus the survey process of the project was to successively upgrade the density of survey works by narrowing down the target areas to smaller ones which seemed to be promising on the basis of the survey results of previous phase.

Concretely speaking, the main targets of exploration were (1) contact metasomatic iron and copper deposits emplaced at the contact skarn zone of Cretaceous limestone and the Tertiary quartzdioritic intrusive rocks intruded into the former, (2) silver bearing lead and zinc deposits in Cretaceous limestone in a shape of irregular mass to manto (seems to be epithermal type) and (3) dissemination type gold and silver deposit in the potash rhyolite which occurs only in one locality in the surveyed area. Comparative evaluation of the potentiality on these mineralized zones was made every year, and the PROVIDENCIA area of the (2) type and the SAN CLEMENTE area of the (3) type were successively surveyed and prospected until the final year.

Fig. 1-1 Progress of Survey Work

PHASE (I) 1979-1980

Preparation of photogrammetric topographic map; area: 7,500km^2 --- whole project district scale: 1 : 25,000

Photogeological interpretation; area: 5,250km^2, scale of interpretation map 1 : 100,000

Collection and compilation of published data

Ground truce and regional geological reconnaissance; area: 3,750km^2 scale 1 : 100,000

PHASE (II) 1980-1981

<u>Semi-detailed geological and geochemical surveys</u> for the northern part of the district; area: 750km^2, scale of geological map 1 : 25,000, number of stream sediments sample: 416

Preparation of detailed topographic maps, and semi-detailed geological and geochemical surveys in the following five areas;

Name	Area (km^2)	No. of geochem. sample: Stream sediments	No. of geochem. sample: rock	map scale
(1) DOS DE EL AGUILA	12.5	51		1 : 10,000
(2) EL ZAPOTE	62.5	200		ditto
(3) PECHUGA	38.0	210		ditto
(4) PROVIDENCIA	10.0	69		ditto
(5) SAN CLEMENTE	24.0		379	ditto
total	147.0	530	379	

PHASE (III) 1981-1982

<u>Detailed geological and geochemical surveys;</u>

Name	(km^2)	stream sediments	rock	map scale
(1) EL TEJOCOTE	32	215		1 : 10,000
(2) PROVIDENCIA	6	230		1 : 5,000
(3) SAN CLEMENTE	14		302	1 : 5,000
total	52	443	302	

<u>Geophysical survey (I.P. method)</u>

(1) EL TEJOCOTE 15 line-kms covering 2.7km^2
(2) PROVIDENCIA 15 line-kms covering 2.7km^2

PHASE (IV) (final) 1982-1983

<u>Targets investigations</u>

<u>(1) SAN CLEMENTE mineralized zone (200m x 400m)</u>

a) 50mts. grid line-spacing trench -----3,625mts.; 725 channel samples were taken along the trench line. Each sample occupies five meters length of the trench line.
b) Detailed mapping of the trench lines
c) Diamond drilling by wireline all coring method, three holes by 300mts. each, 900 meters in total.

<u>(2) PROVIDENCIA mineralized zone (600m x 800m)</u>

Detailed mapping of mineralized outcrop and old mines.
Diamond drilling by wireline all coring method, two holes by 300mts. each, 600 meters in total.

1-2 Members

The following table 1-1 shows the members participated in the project.

Table 1-1 Member's List

Phase, Year	Japanese mission	Mexican counterparts
(I) 1979 ∫ 1980	(1) The planning conference (May, 1979)	
	Toshitsu Hojo --- Head of the mission, Japan International Cooperation Agency (JICA) Kenji Sawada --- Metal Mining Agency of Japan(MMAJ) Yukio Harada --- MMAJ, representative of Mexico office	Guillermo P. Salas --- Director general del Consejo de Recursos Minerales (CRM) Jose L. Lee Moreno --- Gerente de Gerencia de Estudios Especiales del CRM Gustavo Camacho Ortega --- Sub-Gerente de Gerencia de Estudios Especiales del CRM
	(2) Field works, laboratory examinations and preparation of the report	
	Motomu Kiyokawa -- Head of the survey team, Geologist MMAJ-Sumiko Consultants (SUMICON) Kiyoharu Nakashima --- Geologist, MMAJ-SUMICON Tetsuo Sato ---------- Geologist, MMAJ-SUMICON Akio Abe ----------- Geologist, MMAJ-SUMICON	Panfilo Sanchez Alvarado --- Jefe, Ing. Geologo del CRM Jose de Jesus Rodorigues Salinas --- Ing. Geologo del CRM Mario Ernesto Vazquez Meneses --- Ing. Geologo del CRM Luis Tarcisio Arteaga Pineda ---- Ing. Geologo del CRM
(II) 1980 ∫ 1981	(1) The planning conference (May, 1980)	
	Shozo Sawaya --- Head of the mission, MMAJ Kenji Sawada --- MMAJ Kenjiro Takehata --- MMAJ, representative of Mexico office Motomu Kiyokawa --- MMAJ-SUMICON	Guillermo P. Salas --- CRM Jose L. Lee Moreno --- CRM Gustavo Camacho Ortega --- CRM
	(2) Field works, laboratory examinations and preparation of the report	
	Motomu Kiyokawa --- Head of the survey team, MMAJ-SUMICON Kiyoharu Nakashima --- MMAJ-SUMICON Testuo Sato ---------- MMAJ-SUMICON Akio Abe ----------- MMAJ-SUMICON Takamasa Horikoshi --- MMAJ-SUMICON	Panfilo Sanchez Alvarado --- Jefe, CRM Meliton Figueroa Palacios -- Ing. Geologo del CRM Jose de Jesus Rodorigues Salinas --- CRM Mario Ernesto Vazquez Meneses ------ CRM Luis Tarcisio Arteaga Pineda ------ CRM
(III) 1981 ∫ 1982	(1) The planning conference (May, 1981)	
	Yozo Nakamura --- Head of the mission, MMAJ Hideaki Mukai --- JICA Kenji Sawada --- MMAJ Kenjiro Takehata --- MMAJ, representative of Mexico office Motomu Kiyokawa --- MMAJ-SUMICON	Guillermo P. Salas ----- CRM Jose L. Lee Moreno ----- CRM Gustavo Camacho Ortega --- CRM Cesar J. Villegas --- Gerente de Gerencia de Geofisica del CRM
	(2) Field works, laboratory examinations and preparation of the report	
	Motomu Kiyokawa --- Head of the survey team, MMAJ-SUMICON Mitsuya Takahashi -- Geophysicist, MMAJ-SUMICON Kiyoharu Nakashima --- MMAJ-SUMICON Tetsuo Sato --------- MMAJ-SUMICON Akio Abe ----------- MMAJ-SUMICON	Panfilo Sanchez Alvarado ---- CRM Meliton Figueroa Palacios --- CRM Noel Arnold Reyes Reyes ----- Ing. Geologo del CRM Felipe Ramires ------------ Ing. Geofisico del CRM Luis Tarcisio Arteaga Pineda -- CRM
(IV) 1982 ∫ 1983	(1) The planning conference (May, 1982)	
	Shozo Sawaya ---- Head of the mission, MMAJ Nobuhisa Nakajima --- MMAJ Kenjiro Takehata ---- MMAJ, representative of Mexico office Motomu Kiyokawa ----- MMAJ-SUMICON	Guillermo P. Salas ---- CRM Jose L. Lee Moreno ----- CRM Gustavo Camacho Ortega --- CRM Raul Cruz Rios --- Jefe de departoment de Estudios Regionales del CRM
	(2) Field works, laboratory examination and preparation of the report	
	Motomu Kiyokawa --- Head of the survey team, MMAJ-SUMICON Yasunori Yoshioka --- Drilling engeneer, MMAJ-SUMICON Kiyoharu Nakashima -- MMAJ-SUMICON Akihiko Murase ------ Drilling engineer, MMAJ-SUMICON	Panfilo Sanchez Alvarado ---- CRM Meliton Figueroa Palacios --- CRM Luis Tarcisio Arteaga Pineda -- Ing. Geologo del CRM Victor Manuel Luna Castillo --- Ing. Geologo del CRM Lucio Perez Colin --- Departmento de perforacion del CRM

1-3 Outline of Surveyed District

1-3-1 Location and Access (Ref. Fig. G-1)

The surveyed district takes a rectangular form having an area of 5,250 square kilometers extending from the central part to the northwestern part of the State of Hidalgo, which is contained within 20°07' - 20°01' north latitude and 98°51' - 99°32' west longitude.

The following two courses can be used from the Mexico City to Ixmiquilpan City in the central part of the surveyed district; (1) after going up north along the National Highway 57 for about 100 kilometers, enters the State Highway leading to Tula, and reaches Ixmiquilpan through Progreso and (2) after going up north along the National Highway 85 to Pachuca, heads toward northwest to reach Ixmiquilpan. The distance by road is about 165 kilometers through either course. The roads are completely paved and can be used through the year, which can be driven within about two hours.

The means of traffic and transportation in the surveyed district having an extent approximately 50 km in E-W by 100 km N-S are by the National Highway 85, as an only trunk road in the district, and other local access branched off from it.

As shown in Fig. G-1, the National Highway 85 runs through from the southeastern part of the surveyed district diagnoally to the northwest, then turns toward northeast crossing the northern part of the district.

The eastern to the northern side of the Highway from Actopan in the southeastern part of the district to Zimapán in the northwest is mountainous region of the Sierra Madre Oriental. Because of its steep topography, the course by car is limited and it is required to set up advance camps for the survey. On the other hand, the western and the southern sides are the regions of volcanic rocks, which have made develop a relatively a great deal of road traffic making easy of access.

1-3-2 Climate and Vegetation (Ref. Fig. 1-2)

The topography of the district is divided into two types such as the steep landform belonging to the mountainous region of the Sierra Madre Oriental and the central plateau of the volcanic zone, and the climate and vegetation are also divided into two categories reflecting the difference of topography. The annual mean temperature of the former is about 17°C and the latter about 19°C, showing no great difference, though a great difference is shown in the annual precipitation; that of the latter is 300 to 400 mm contrary to more than 1,500 mm of the former.

The snow fall in winter time is rare in both parts and it is reported to freeze several times a year.

The difference of vegetation is recognized between the two parts reflecting the difference of these climates, especially of the rainfall.

The distribution of sparsely grown desert plants is general in the plain distributed in the southwestern to western part of the surveyed district. They consists of grasses of dry land, cactuses, yucca, agave and mesquite, all these being the low shrubs with prickles. On the other hand, in the mountains of the Sierra Madre Oriental, increasing amount of shrubs consisting mainly of conifers such as pine, oak, fir and rhododendron are found beside the grasses of dry land mentioned above. Among these mountainous regions, the northeastern slope of the mountain more than 2,600 meters high above sea level is often covered by the conifer wood, which is under the control the Forest Conservation Bureau. Thus the vegetation of the surveyed district is shown in the flora of xelophilous plant of dry land found in the plain in the western to southern part of the district to the flora of semi-humid mountainous sparse wood found in the mountainous region of the Sierra Madre Oriental.

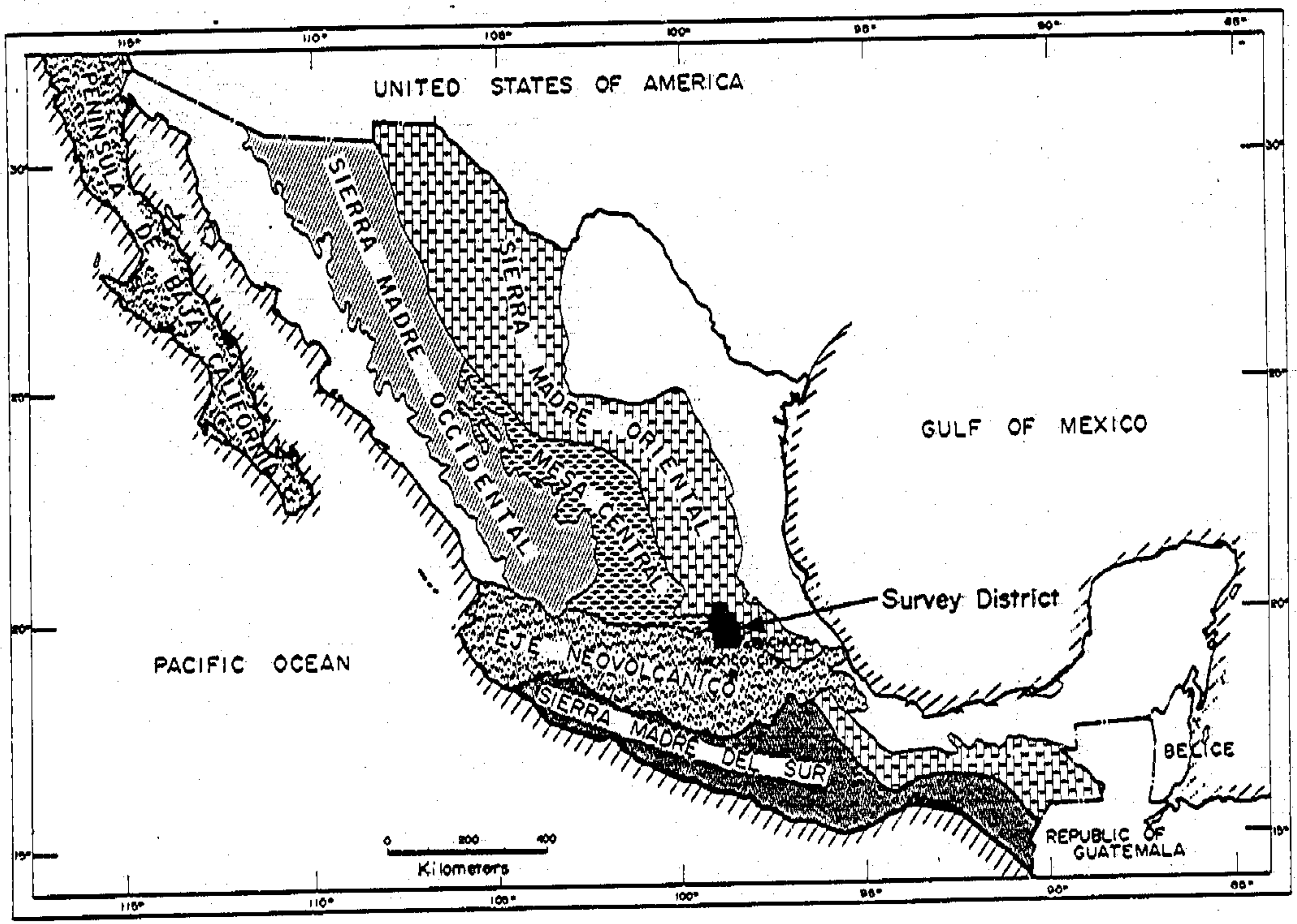


Fig. 1-2 Geomorphological provinces of Mexico (after G.P., Salas, 1975)

1-3-3 Mining

The State of Hidalgo is famous as one of the state in which the mine was exploited from the oldest time, especially it was reported that the Pachuca - Real del Monte mine which is located adjacent to the surveyed district on the southeast had been developed in 16th century by British people and that it had produced 38,000 tons of silver and 192 tons of gold (Geyne et al., 1963). At present, however, a small scale mining of the remained ore and prospecting are being carried out.

The ZIMAPAN area situated at the northwestern end of the surveyed district is one of the mining district having the history of development from old time. The area is scattered by the middle scale ore deposits of lead and zinc accompanied by gold and silver. Because it is on the way of development, it has a potential to be more developed in future. Beside these, several small-scale metal mines are currently being operated in the surveyed district. Further, mining and processing of marble are being carried out. Although the mining is one of the important industry in the district as in the above, the main industry is still agriculture.

1-4 Acknowledgments

The project started in fiscal 1979 was continued for four years and has been completed as scheduled. The writer gratefully acknowledes the generous assistance and support of the persons concerned in Mexico and in Japan.

Appreciation is expressed to the Japanese Embassy in Mexico, the representatives of the Japan International Cooperation Agency (JICA) as well as the Metal Mining Agency of Japan (MMAJ) in Mexico, Dr. Hideo Takeda, Mr. Akira Hirayama and Dr. Tetsuro Urabe who were staying in Mexico having been despatched from JICA as experts of their sustained interest and encouragement.

Especial thanks go to Prof. Yukitoshi Urashima of Kagoshima University, Prof. Naotake Okada of Yamagata University and Dr. Keisaku Tanaka of Geological Survey of Japan for their guidance and contribution to the project in Japan.

CHAPTER 2 OUTLINE OF THE SURVEY WORKS

2-1 Types and Methods of the Survey and Laboratory Examinations

All survey works and laboratory examinations carried out during the four years are compiled in Table 2-1 and 2-2.

Table 2-1 Method and Type of Survey Work

(I) Preparation of photogrammetric topographical map

Phase	Location name	Area (km^2)	Scale	Remark
I	Whole project district	7,500	1 : 25,000	25m contour line
II	DOS DE EL AGUILA	12.5	1 : 10,000	10m contour line
	EL ZAPOTE	62.5	1 : 10,000	"
	PECHUGA	38.0	1 : 10,000	"
	PROVIDENCIA and SAN CLEMENTE	34.0	1 : 10,000	"
	TOTAL	7,647		

(II) Photogeological interpretation

Phase	Location name	Area (km^2)	Scale	Remark
I	Whole survey district for photo-geological interpretation	5,250	1 :100,000	preliminary geological map

(III) Geological survey

Phase	Location name	Area (km^2)	Scale	Remark
I	Whole survey district for geological reconnaissance	3,750	1 :100,000	ground truce of photogeological map (regional geological reconnaissance)
II	A northern part of the survey district	750	1 : 25,000	Semi-detailed geological survey
	DOS DE EL AGUILA	12.5 } 147	1 : 10,000	Semi-detailed geological survey of mineralized zones
	EL ZAPOTE	62.5		
	PECHUGA	38.0		
	PROVIDENCIA	10.0		
	SAN CLEMENTE	24.0		
III	EL TEJOCOTE	32	1 : 10,000	Detailed geological survey of mineralized zones
	PROVIDENCIA	6	1 : 5,000	
	SAN CLEMENTE	14	1 : 5,000	
IV	PROVIDENCIA	0.48 } 0.56	1 : 1,000	Target investigation of mineralized zones
	SAN CLEMENTE	0.08		

(IV) Geochemical prospecting

Phase	Location name	Area (km^2)	No. of Sample	Sampling density (No./km^2)	Indicator	Sample material
II	A northern part of the survey district	627	416	0.7	Ag,Cu,Pb	Stream sediments
	DOS DE EL AGUILA	12.5	51	4.0	"	
	EL ZAPOTE	62.5	200	3.2	"	
	PECHUGA	38	210	5.5	"	
	PROVIDENCIA	10	69	6.9	"	
	(Stream sediment total)	(750)	(946)	(1.6)		
	SAN CLEMENTE	24	379	15.8	Au, Ag	Rock
III	EL TEJOCOTE	2.7	213	78.9	Ag,Cu,Pb	Soil
	PROVIDENCIA	2.7	230	85.2	Ag,Cu,Pb	Soil
	(Soil Total)	(5.4)	(443)	(82.0)		
	SAN CLEMENTE	0.64	302	471.9	Au, Ag	Rock (chip Sample)
IV	SAN CLEMENTE	0.08	725	9,062	Au, Ag	Rock (channel sample)

(V) Geophysical survey

Phase	Location name	Area (km^2)	Total line length	Line-spacing	No. of lines	Remark
III	EL TEJOCOTE	2.7	15 kms.	200m	10	
	PROVIDENCIA	2.7	15 kms.	200m	10	point interval : 100m

(VI) Diamond drilling

Phase	Location name	Drilling No.	Direction	Inclination	Length	Remark
IV	SAN CLEMENTE	MJM-1	N30°E	horizontal	300m	wireline, all coring
		MJM-2	N50°E	horizontal	300m	" "
		MJM-3	S35°E	horizontal	300m	" "
	PROVIDENCIA	MJM-4	-	vertical	300m	" "
		MJM-5	-	vertical	300m	" "

Table 2-2 Laboratory Examinations

Type of examination	Number of samples				Total
	Phase I	Phase II	Phase III	Phase IV	
Microscopy of rock thin section	177	148	55	22	402
Microscopy of ore polished section	23	23	27	41	114
Chemical analysis of ore sample	65	84	88	41	278
E.P.M.A. quantitative analysis	6	14	14	25	59
E.P.M.A. qualitative analysis	36	10	28	-	74
*Whole rock chemical analysis (rhyolitic rocks)	-	45	-	50	95
K-Ar age dating with whole rock chemical analysis	6	4	2	-	12
X-Ray powder diffractometry	11	15	11	-	37
Macrofossil determination	45	47	-	-	92
Nannofossil determination	10	244	-	-	254
Chemical analysis of geochemical soil samples	-	-	443	-	443
** Geochemical stream sediments samples	-	946	-	-	946
*** Geochemical rock samples	-	379	302	1,025	1,706
Trace metallic elements analysis of rock samples	-	-	-	8	8
Measurement of rock resistivity	-	-	34	-	34
Measurement of rock frequency effect	-	-	34	-	34

* Analyzed elements: SiO_2, TiO_2, Al_2O_3, Fe_2O_3, FeO, MnO, MgO, CaO, Na_2O, K_2O, $H_2O(+)$, $H_2O(-)$, P_2O_5

** Analyzed elements: Ag, Pb, Cu

*** Analyzed elements: Au, Ag

2-2 General Remarks of the Survey Works

2-2-1 Photogeology

Photogeological interpretation was conducted as a link of the regional geological survey of the first year having a purpose to make clear outline of geology and geological structure of the district.

The result of interpretation was compiled as the preliminary photogeological map, 1 : 100,000 in scale, and

The results of interpretation were corrected errors and modified by ground check of the regional geological reconnaissance carried out consecutively, and were compiled as a geological map, 1 : 100,000 in scale finally.

1) Topographic map and aerial photographs used

(1) Topographic map

Scale : 1/25,000, covering the whole district of 7,500 km^2, prepared in the first year.

(2) Aerial photographs

Scale : approximately 1/50,000, 601 sheets in total

(3) Published geological data

1. Plano Geologico del Estado de Hidalgo, 1/500,000 (CRM)
2. Geologic Map and Section of the Zimapán Mining District, State of Hidalgo, Mexico, 1/25,000 (Simons, F.S. and Mapes, V.E., 1957)
3. Geologic Map and Section of South-Central Hidalgo and Northeastern Mexico, Mexico, 1/200,000 (Segerstrom K., 1962)
4. Map and Section Showing the Relation of the Pachuca-Real del Monte Mining District to the Regional Geology, 1/200,000 (Geyne, A.R. et al., 1963)
5. Plano Geológico Local de Area de Encarnación Municipio de Zimapán, EDO. de HGO., 1/20,000 (Restvic Peres, L.V., 1973)

Table 2-3 Classification Standard of Geological Unit by the Photogeological Interpretation

Geological unit			Photographic		Drainage		Resis-tivity	Topography			Banding pattern of strat-ification	Lithofacies confirmed by field checking
			Tone	Texture	Pattern	Density		Form	Section			
									Valley	Ridge		
Tertiary-Quaternary System		Tcgs	white grey to grey	granular	dendritic	dense	low	flat			nil	gravel, sand, silt and ash
Tertiary-Quaternary System		Tba3	grey	smooth	dendritic	rough	high	flat			nil	basalt lava
Tertiary-Quaternary System		Trhy2 (West of Santuario)	dark grey	granular, partly rugged	dendritic	dense	low to moderate	steep			nil	rhyolite lava dome
Tertiary-Quaternary System		Trhy2	white grey to grey	granular, partly rugged	dendritic	rough	moderate	somewhat rounded			nil	rhyolite lava
Tertiary-Quaternary System		Tan3	grey to dark grey	coarse and rugged	dendritic	moderate	moderate	intermediate			nil	andesite
Tertiary-Quaternary System		Ttf2	white grey, grey and dark grey	granular to coarse	dendritic	moderate	low	somewhat rounded			distinct	tuff, lapilli tuff, tuff breccia, tuffaceous sandstone and conglomerate
Tertiary-Quaternary System		Tan2 Tan1	grey to dark grey	granular	dendritic	moderate to dense	moderate and high	somewhat rounded partly steep			nil	andesite lava and pyroclastic rock
Tertiary-Quaternary System		Tba2 Tba1	grey, partly white grey	fine to granular	dendritic	moderate	low and moderate	somewhat rounded partly steep			nil	basalt lava and pyroclastic rock
Tertiary-Quaternary System		Tcg	grey	granular	dendritic	moderate	low	rounded			indistinct	conglomerate
Jurassic-Cretaceous System	Mendez F.	Kms (Bca, del Encino area)	white to grey	fine to granular	parallel, partly dendritic	dense	low	somewhat rounded			indistinct, partly distinct	shale
Jurassic-Cretaceous System	Mendez F.	Kms (Zimpan area)	white grey to grey	granular	parallel and dendritic	moderate to dense	low	somewhat rounded or intermediate			indistinct	siltstone, sandstone and shale
Jurassic-Cretaceous System	Mendez F.	Kms (Northern part of Yonthe)	white grey to grey	fine to granular	parallel to dendritic	dense	low to moderate	intermediate			indistinct, partly distinct	shale intercalated with calcareous shale, siltstone and sandstone
Jurassic-Cretaceous System	El Doctor F.	Kds	light grey to grey	fine to granular	parallel	dense	low	steep, partly intermediate			indistinct	shale intercalated with calcareous shale, siltstone and sandstone
Jurassic-Cretaceous System	El Doctor F.	Kdf	grey and dark grey	granular	parallel to dendritic	moderate	moderate	intermediate, partly steep			distinct, partly indistinct	alternation of limestone marl, calcarenite, shale and flint
Jurassic-Cretaceous System	El Doctor F.	Kdl (Pozuelos)	white grey to grey	granular	parallel	rough to moderate	high to moderate	somewhat rounded			distinct, partly indistinct	massive limestone
Jurassic-Cretaceous System	El Doctor F.	Kdl (North-eastern part of area)	grey to dark grey	granular to coarse	parallel to dendritic	rough or moderate	high or moderate	rounded or gentle			indistinct, partly distinct	massive limestone
Jurassic-Cretaceous System	Las Trancas F.	Jts	white grey to grey	fine to granular	parallel partly trellis	dense	low to moderate	steep, partly intermediate			indistinct, partly distinct	shale intercalated with calcareous shale, siltstone, sandstone and andesitic tuff
Intru-sive rock		Tidi	white grey to grey	granular	dendritic	dense	low to moderate	steep			nil	quartz diorite, granodiorite and diorite

2) Classification Standards of Geological Units and the Results of Photogeological Interpretation

The elements for preliminary interpretation which correspond to each geological unit were determined by the correlation between photographic tone, texture, drainage pattern etc. and geological data of the previous works. These were applied to the whole district to classify the geological unit and to make interpretation on strike and dip of the formation, fault structure, various linear structures, and folding structure. These results of interpretation were laid down on topographical maps of 1/50,000. Taking the results of regional geological survey into consideration, the elements for interpretation were classified more in detail and correlated with geological units at the final interpretation.

The elements were classified into Cretaceous, Tertiary and Quaternary systems, and intrusive rocks, which were subdivided into geological formations and rock types as shown in Table 2-3.

2-2-2 Geological Survey

Geological survey in the first phase contained ground check on the main routes for the preliminary photogeological map, and observation and description of known ore deposits in the district. The survey results were compiled as a geological map, 1 : 100,000 in scale with data of photogeology. The survey works were conducted by five parties consisting of two geologists in each. In the second to final phases, small simple transits were also used to make correct positioning of old mines, ore showings and samples.

As a result, various kinds of geological map, 1 : 1,000 to 1 : 25,000 in scale were prepared.

2-2-3 Geochemical Prospecting

Geochemical prospecting of the second phase was composed of a semi-detailed survey in an extent of 750 km^2 of the northern part of the district and detailed surveys of four areas included in the above with stream sediments, and a detailed survey with rock in the potash rhyolite mass of SAN CLEMENTE area. Stream sediments samples were collected at crossing of creeks with an interval about 500 meters in the semi-detailed survey and about 300 meters in the detailed surveys. Stream sediments were passed through a sieve of 80 mesh to obtain each sample. Ag, Cu and Pb elements were analyzed chemically as the indicators.

As a result of the survey, large-scale A-class anomalies of Ag and Pb in the EL TEJOCOTE and the PROVIDENCIA areas, and B-class anomalies of Cu, Ag and Pb in the SAN JOSE DEL ORO and LAS PIEDRAS areas were detected respectively.

In the SAN CLEMENTE area, sampling points were localized with an interval of about 200 meters each along creeks in the San Clemente mountain mass which occupied an extent of about 2.5 km by 5 km. 739 pcs. of rock samples were obtained in total by picking almost same amount of rock chips from each of several outcrops surrounding a sampling position.

Gold and silver were of indicator elements. As a result of the geochemical prospecting, three geochemically anomalous zones of Au and Ag such as in and around SAN SEVERIANO mining area, 500 meters to the south of the SAN SEVERIANO mining area and the eastern side of former were detected.

Geochemical prospecting in the third phase was conducted in parallel with the geological survey in the SAN CLEMENTE area, and geophysical survey in both areas of the EL TEJOCOTE and the PROVIDENCIA beside geological survey. In the SAN CLEMENTE area, rock samples were collected 302 pieces in total with 50 meters grid spacing. Two elements of gold and silver were determined as the indicators. In both areas of the PROVIDENCIA and the EL TEJOCOTE, soil samples were taken with an intervals of about 100 meters along the IP electric survey lines (200 meters line-spacing). Three elements of copper, silver and lead were determined as the indicators taking the result of geochemical prospecting in the previous year, and considering the type of meneralization observed in those areas.

As the results of surveys, the outlines of silver-lead minzeralized zone in the central part of the PROVIDENCIA area and gold-silver mineralized zone of the SAN SEVERIANO Mining area, SAN CLEMENTE were deleneated, and those results have greatly contributed to the planning of the next step exploration.

Geochemical prospecting of the fourth phase was conducted to the western mineralized zone (200 m X 400 m) of the SAN SEVERIANO Mining area with rock channel sampling continued along trench lines. The trench lines were prepared with 50 meters grid line-spacing having an extension of 3,500 meters in total. Each rock channel sample covered 5 meters portion along the trench. Number of samples reached seven hundred and twenty five in total. Gold and silver were indicator elements as same as the third phase. All the assay values of samples were statistically treated by computers to obtain histograms, cumulative frequency distributions, standard deviations, etc. After that, geochemical classification parameters such as background, threshold values and correlation coaficients were studied to deleneate geochemical anomalies.

Table 2-4 shows the details of geochemical prospecting works in this project.

Table 2-4 Geochemical Prospecting in the Project District (Phase Ⅱ—Phase Ⅳ)

	Survey area	Area (㎢)	Number of sample			Sampling density (per ㎢)	Indicator elements	Remarks
			Stream sediments	Soil	Rock			
Phase Ⅱ	A northern part of the district	627	416			0.67	Ag, Cu, Pb	random sampling
	DOS DE EL AGUILA	12.5	51			4.0	〃	〃
	EL ZAPOTE	62.5	200			3.2	〃	〃
	PECHUGA	38.0	210			5.5	〃	〃
	PROVIDENCIA	10.0	69			6.9	〃	〃
	SAN CLEMENTE	24.0			379	15.8	Au, Ag	〃
Phase Ⅲ	EL TEJOCOTE	2.7		213		78.9	Ag, Cu, Pb	line-spacing 200m point interval 100m
	PROVIDENCIA	2.7		230		85.2	〃	〃
	SAN CLEMENTE	0.64			302	471.9	Au, Ag	50m grid sampling
Phase Ⅳ	SAN CLEMENTE	0.08			725	9,062	Au, Ag	channel line-sampling on trenches of 50m grid line-spacing
Total		780.12	946	443	1,406	—		

2-2-4 Geophysical Survey

The IP electric survey was conducted, as the geophysical survey in the third year, in the two areas including El TEJOCOTE and PROVIDENCIA to obtain geophysical informations on subsurface structure, mineralized zone and ore deposit for 15 line kilometers in each area (30 kilometers in total).

Although the IP anomalous zones detected in the two areas seem to be caused by the mineralized zone of copper, lead and silver, the values of IP anomaly have not been so great. As the results, following conclusions are derived.

EL TEJOCOTE Area

1) Chargeability measured in this area has the range of 0.67 - 3.83 milli-sec. Those values are very small for anomalous values of chargeability, but the values between 0.67 and 2.50 milli-sec. were considered to be the background generally endowed with the rocks in the survey area, and the value higher than 2.50 milli-sec. were taken to be anomaly.

2) The values of apparent resistivity measured in the area were distributed in the wide range between 200 and 3700 Ω-m. The area is widely underlain by limestones, and the range of measured values described above is considered to be a little small for apparent resistivity of the limestone.

3) Most of anomalous zones of chargeability in this area situate in high apparent resistivity zone. Namely, they form high chargeability and high apparent resistivity type anomaly, but the anomalous value of chargeability is only about two times as large as background value. From this fact, it cannot be inferred that those anomalies in this area are caused by existence of sulfide ore mineralized zones.

4) It cannot be concluded that those anomalous zones have possibility for ore deposit.

PROVIDENCIA Area

1) Chargeability in this area has the range between 1.90 and 9.00 milli-sec., this range is about two point five times as large as that of EL TEJOCOTE area. It was considered that lower values than 3.5 milli-sec. were background value and higher than 3.5 were taken to be anomalous value.

2) Apparent resistivity has the range of 170 - 3400 Ω-m. In this area, shale, siltstone, sandstone and marl are distributed at the ends of all survey lines and the zones of those rocks coincide with low apparent resistivity zone. Limestone is distributed in the central zone in this area between those rocks, and the apparent resistivity of this zone is relatively high.

3) In this area, a tendency can be recognized that chargeability and apparent resistivity become greater as the increase of depth below ground surface and it is supposed by this fact that there may exist an sulfide ore zone in the deep part, from which an influence of mineralization comes up to the near ground surface.

4) Anomalies A and C have high chargeability and low apparent resistivity, and chargeability and apparent resistivity of B and E anomalies are high.

5) A and C anomalies are distributed in the zone of shale - marl mentioned above, and B and E anomalous zones coincide with the mineralized zone which is recognizable on the ground surface. In comparison with the result of geochemical analysis, B anomaly has relation to the anomalous zone of silver and lead, and E to the anomaly of lead.

6) B anomaly has a large extent and is inferred to have strong possibility of being ore deposit. Thus, the results of IP survey in the third phase had greatly contributed to the planning of the next step exploration.

2-2-5 Diamond Drilling

After a comprehensive evaluation of the survey results until the third phase, diamond drilling were carried out in the two areas of the PROVIDENCIA and the SAN CLEMENTE which seemed to be most promising within the survey district.

The drilling in the PROVIDENCIA area was purposed to examine the mineralized sulfide-zone presumed in a depth taking the results of surveys such as geological, geochemical and geophysical works into consideration. Two vertical holes with 300 meters depth of each hole were drilled.

The drilling in the western mineralized zone of the SAN CLEMENTE area was carried out with the purpose of obtaining informations of subsurface gold mineralization related to the surface geochemical anomalies.

Three horizontal holes with 300 meter length of each hole were drilled. In both areas of the PROVIDENCIA and SAN CLEMENTE, 1,500 meters were drilled with 5 holes in total.

The drilling operation was conducted by the El Consejo de Recursos Minerales under the technical cooperation of two Japanese drilling engineers. The drilling machines in these operations were of two L-38 of Long-Years and one of JK-300 type.

The drilling operation were started on July 1982 and completed on January 1983 with a delay of two months than the program. The reason of delay were mainly of drill machine's trouble caused by superannuation and other reasons excepting technical matter.

CHAPTER 3 GENERAL GEOLOGY

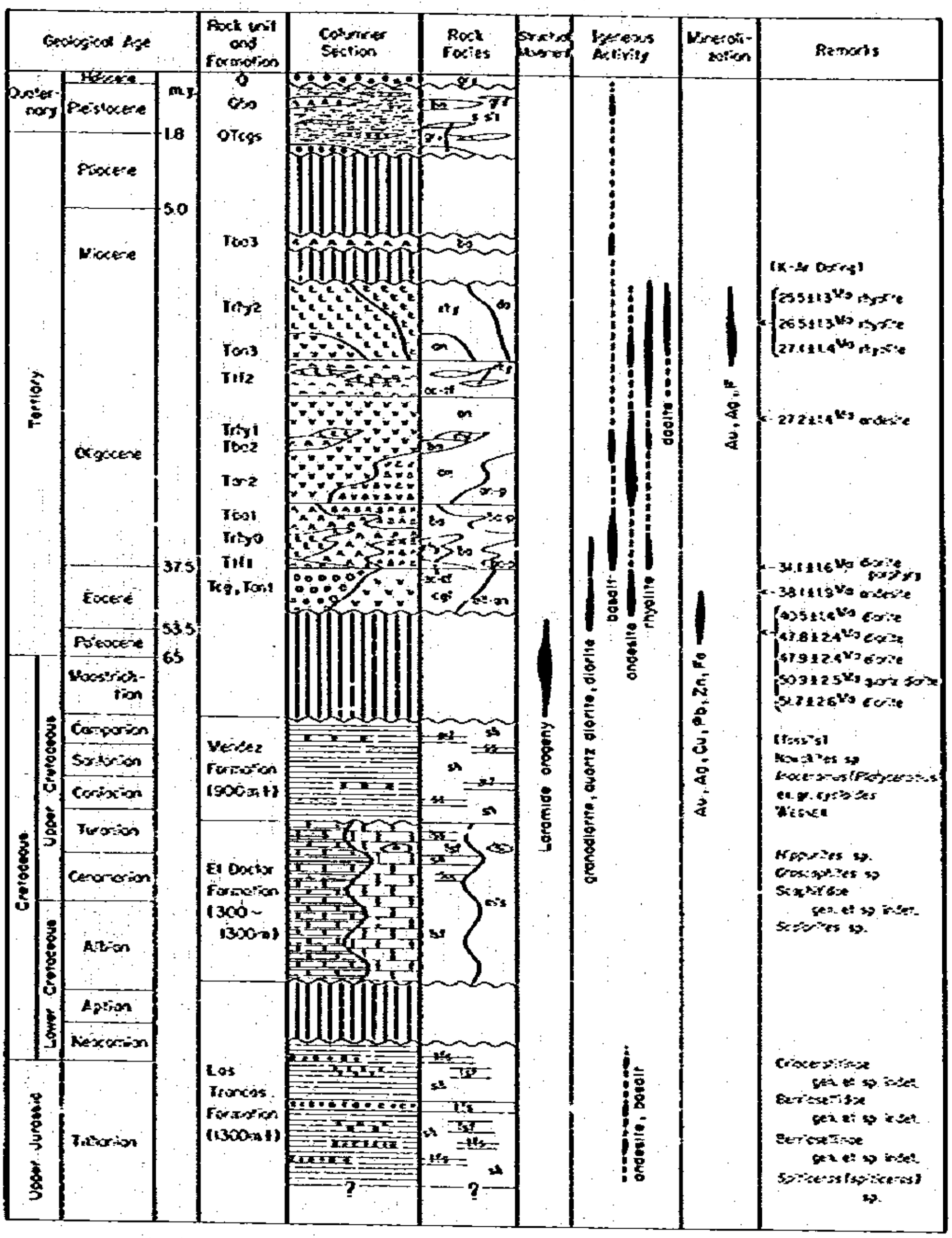
3-1 Outline of Geology

Geology of the surveyed district consists of pre-Tertiary sedimentary rocks dominantly distributed in the region of Sierra Madre Oriental from the northern part to the eastern half of the district, the Tertiary effusive rocks intermittently distributed in the Younger Volcanic zone from the southern part to the western part forming the mountain masses, Tertiary intrusive rocks scattered in the pre-Tertiary formations in the northern part, and the Quaternary sediments filling the topographically low land from the central part to the southern part (Fig. 3-1, 3-2 and PL. 1).

The Sierra Madre Oriental zone corresponds to the southeastern extension of the Rocky Mountain Range which is positioned as the forefront of the Alpine Orogenic Belt extending from the northern part to the central part of the North American Continent. On the other hand, the Younger Volcanic zone is distributed in the direction of E-W cutting the Sierra Madre Oriental zone and the main geologic structures parallel to the zone.

There are evidences that the Younger Volcanic zone was under water-connecting the Pacific with Gulf of Mexico at the time of Cretaceous submergence, and at the same time, it corresponds to the part of extension of the Transform fault extending from the bottom of the Pacific Ocean. Thus it is considered that the zone is a great tectonic zone since it forms a field of intense volcanic activity continued to present.

Overfold, intraformational folding, minor folding and intrafolial fold considered to be the effect of the Laramide Orogeny which took place at the beginning of Tertiary are markedly observed in the pre-Tertiary sedimentary rocks. Whereas, in the Tertiary effusive rocks, only some minor faults and minor fold structure are observed.



Abbreviations

grv	:	gravel	cgl	:	conglomerate
s	:	sand	alt	:	altered
slt	:	silt	ml	:	marl
ba	:	basalt	sh	:	shale
rhy	:	rhyolite	ss	:	sandstone
da	:	dacite	lsc	:	clastic limestone, limestone conglomerate
an	:	andesite	lss	:	calcarenite
p	:	pyroclastic rock	lsf	:	thin to medium-bedded limestone with black flint
tf	:	tuff	m/s	:	massive limestone
ac-tf	:	acidic tuff, tuff breccia	tfs	:	tuffaceous sandstone, conglomerate, tuff

Fig.3-1 Generalized Stratigraphic Column of the Survey District

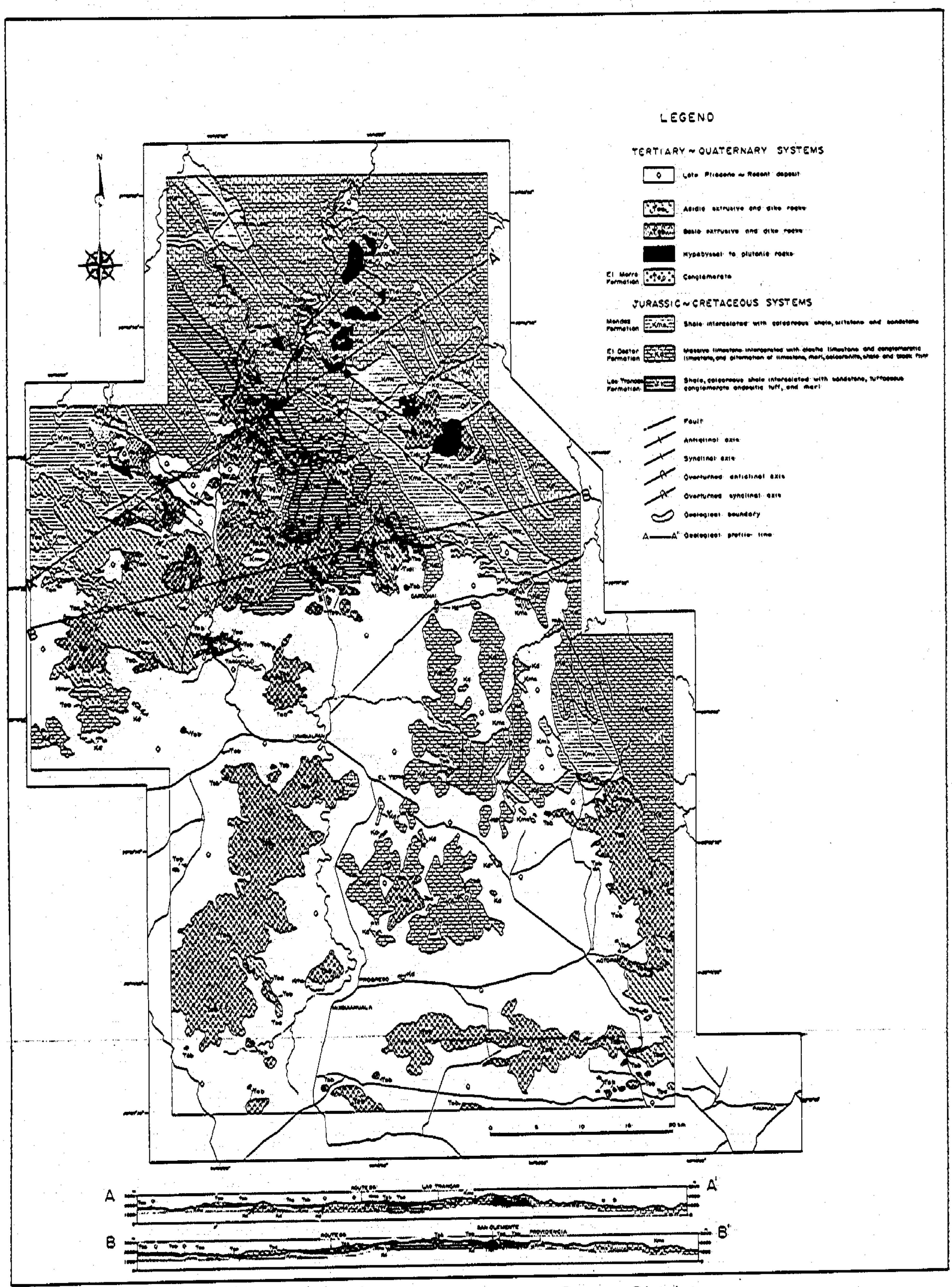


Fig.3-2 Geological Map of the Survey District

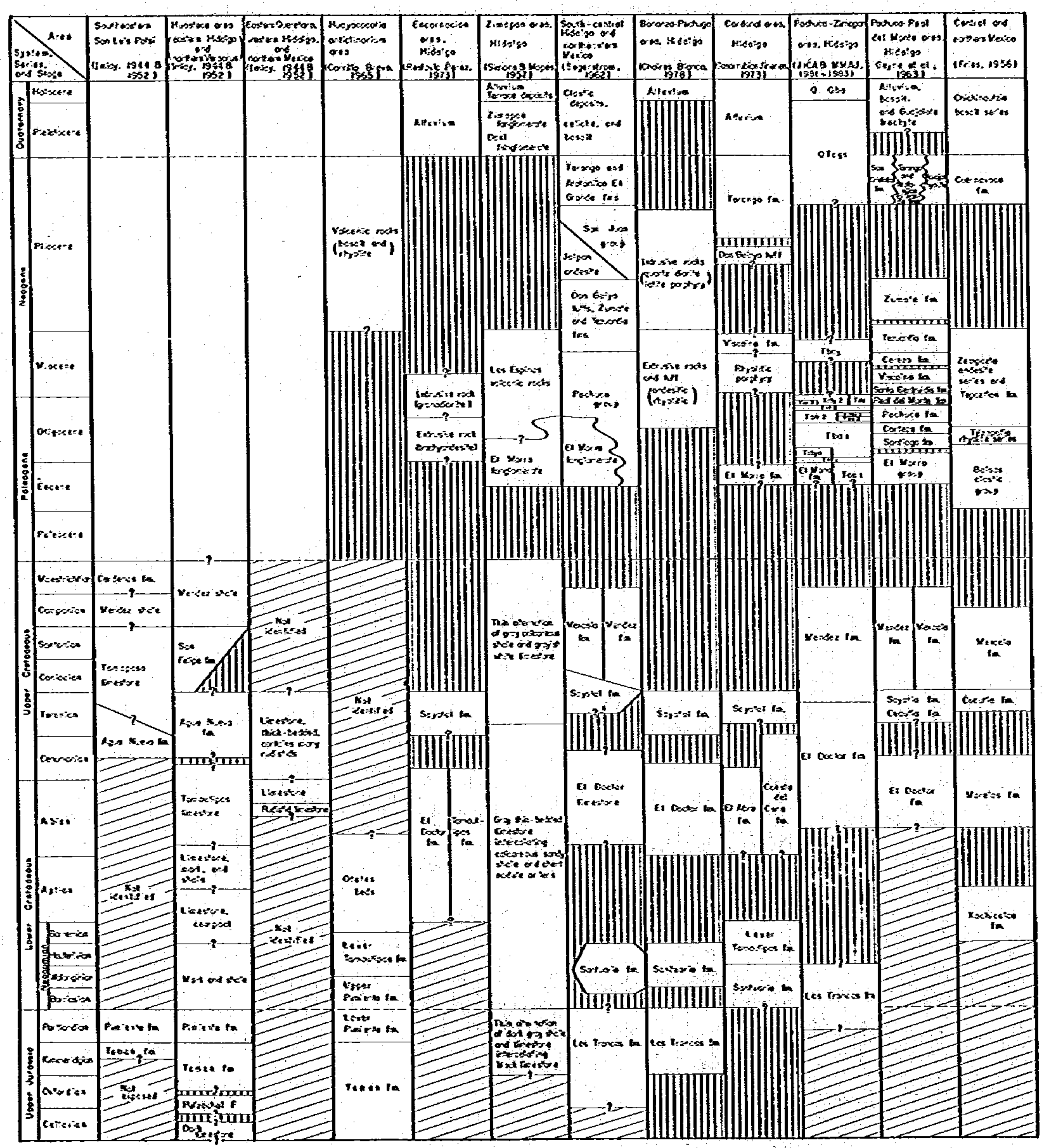


Fig. 3-3 Stratigraphic Correlation of Geological Units in the Sierra Madre Oriental

3-2 Pre-Tertiary System

The pre-Tertiary sedimentary rocks are divided into the Las Trancas Formation, the El Doctor Formation, and the Mendez Formation in ascending order. The Las Trancas Formation is the oldest formation in the surveyed district and distributed in a zone along the axis of a large overfold anticlinal structure. It is divided lithologically into the three members such as Jts (alternating beds of shale, calcareous shale, sandstone and marl), Jtc (alternating beds of tuffaceous conglomerate, tuffaceous sandstone and andesitic tuff) and Jtl (pelitic limestone and flint bearing limestone), among which the Jts Member forms the substantial part of the formation, and the Jtc and Jtl Members are the intercalatory layers in the Jts Member.

It was made clear by the combination of macrofossils that the formation was deposited from Tithonian of the latest Jurassic to Neocomian of the earliest Cretaceous (Apx. 1, 2). The formation is correlated to the Las Trancas Formation and the Santuario Formation of Segerstrom (1962) (Fig. 3-3). The thickness of the formation is estimated to be more than 1,300 meters.

The El Doctor Formation is widely distributed from the northern part to the central and the eastern part of the district. It is divided into the Massive Limestone Member (Kdl) and the Flint Bearing Medium-Bedded Limestone Member (Kdf) which are in the relation of contemporaneous heterotopic facies each other. The former is intercalated with the rock facies (Kdc) such as intramicrite, calcirudite and calcarenite, and the latter with those (Kds) such as shale and marl.

The Kdl Member shows an extensive distribution in a form of bank in the nucleus part of the Sierra Madre Oriental zone and the geologic structure is relatively stable, while the Kdf Member shows the complex geologic structure in a marked contrast to the former, being distributed in a form of zone on the western side of the former.

Mineralization is observed in the Kdf Member in the PROVIDENCIA area, and the irregularly massive to vein type oxide ore bodies containing silver, lead and zinc are found.

Although the formation directly rests on the lower Las Trancas Formation seemingly conformably, the age of the formation estimated from the fossils is from middle Albian to upper Turonian (Apx. 1-4), showing a time gap of sedimentation with that of the Las Trancas Formation. The formation is correlated to the El Doctor Formation of Segerstrom (1962). The thickness of the formation is shown to be from 300 meters to more than 800 meters in the Kdl Member and from 500 meters to 1,300 meters in the Kdf Member.

The Mendez Formation occupies the uppermost part of the Cretaceous system in the surveyed district and is widely distributed from the northeastern part to the eastern part of the surveyed district, showing a small distribution in the western part.

The rock facies consists mainly of thick beds of phyllitic shale and alternating beds of medium-bedded massive calcareous shale and marl, which is frequently intercalated with sandstone and siltstone in the middle to the upper part of the formation.

The time of sedimentation of the formation is estimated, from the fossils, to be from late Turonian to Campanian (Apx. 1-4). The formation conformably overlies the underlying El Doctor Formation in general, but it is in the relation of angular-unconformity in the northern part of the surveyed district. The formation is correlated to the Soytal Formation and the Mendez Formation of Segerstrom (1962). The thickness was calculated to be more than 900 meters.

3-3 Tertiary System

The Tertiary rocks in the district is mostly composed of volcanic rocks excepting the El Morro Formation. They are roughly divided into basic volcanic rocks (andesite to basalt) and acidic volcanic rocks (dacite to rhyolite) and further subdivided by rock facies and rock types, their K-Ar ages (Fig. 3-4 and Table 3-1) and succession of their effusion observed in the field. The description will be made on the main rocks in the following.

The El Morro Formation shows an isolated distribution in the northwestern part of the district. The formation consists of poorly sorted conglomerate containing abundant angular to subangular pebbles mainly of the underlying Cretaceous sedimentary rocks. The time of sedimentation is estimated to have been late Eocene to Early Oligocene.

It seems that the formation is a continental sediment deposited in the depression locally formed in the inland part, because its distribution is localized, sorting has not been observed and because it has a relationship of angular unconformity with the underlying Cretaceous and Jurassic formations.

Among the basic volcanic rocks, olivine-pyroxene basalt and quartz basalt are widely distributed which belong to Tba1 and two pyroxene basalt to belongs to Tba3. The former is distributed in the northwestern part and the central part, and at the southern end of the surveyed district directly overlying the El Morro conglomerate bed and pre-Tertiary rocks with angular unconformity. They are generally subject to alteration mainly of argillization. The time of activity is estimated to have been early Oligocene. On the other hand, the latter is distributed in the northwestern part of the surveyed district forming a gentle plateau. Although it is difficult to estimate the time of activity because of its isolated distribution, it is likely that the rock is the youngest among the Tertiary volcanic rocks, because it is an unaltered rock and because it forms a flat plateau and has not been subject to notable erosion.

Among the acidic volcanic rocks, potash rhyolites which belong to Trhy2 are large in scale and the most important. The rocks consist mainly of massive and compact rhyolite, rhyolite lava with distinct flow structure and rhyolitic pyroclastic rocks, and partly occur as dykes.

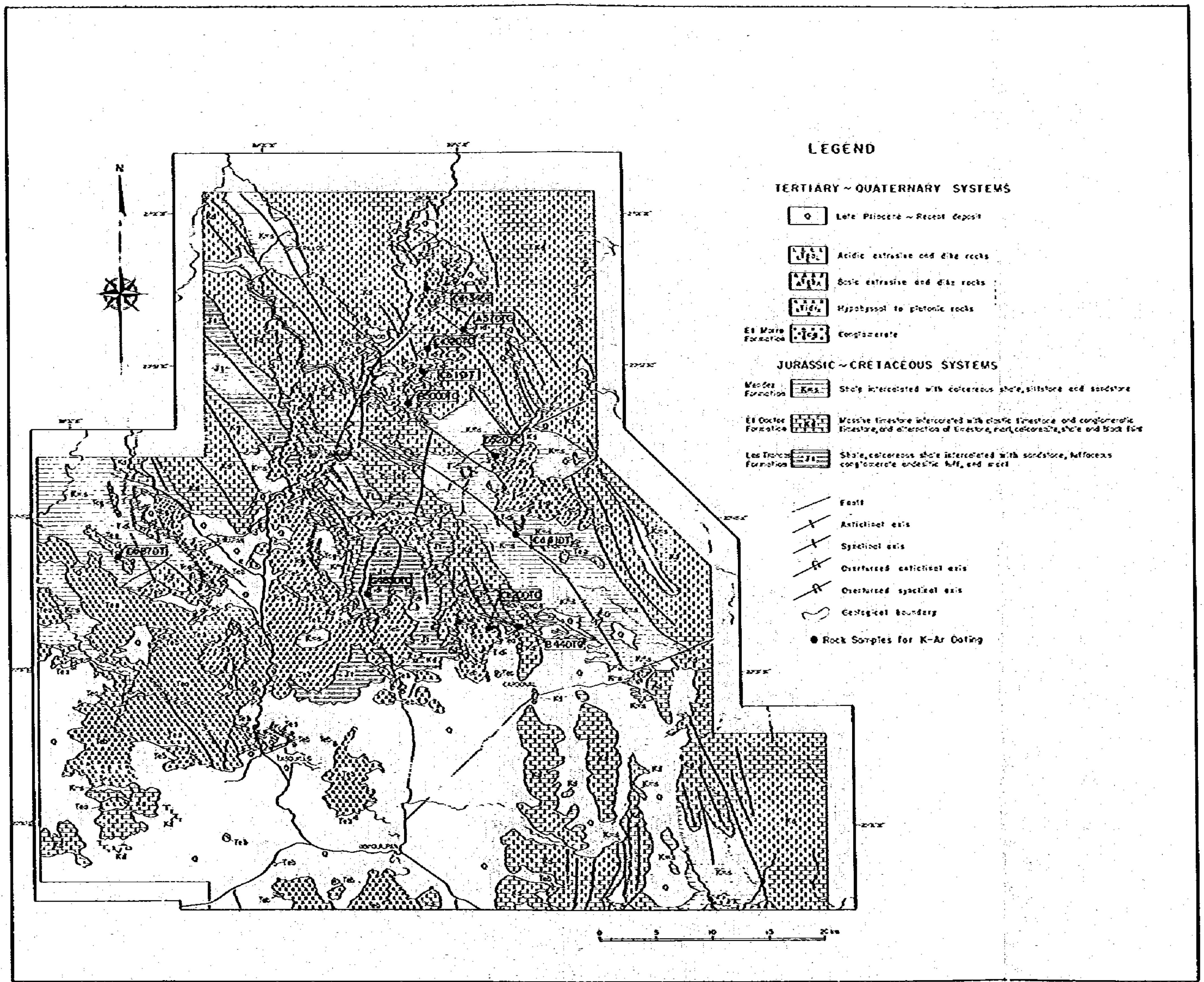


Fig.3-4 Location Map of Rock Samples for K-Ar Dating of Igneous Rocks

Table3-1 Whole-rock κ-Ar Datings of Igneous Rocks

No.	Sample No.	Coordinates E	Coordinates N	Rock name	Strati-graphic unit	κ (%)	$SCC^{40}Ar^R/g\times10^{-5}$	$^{40}Ar^R$ (%)	Age (Ma)
1	Ca41DT	487525	2292775	Altered biotite-hornblende andesite	Tian	3.40 3.39	0.506 0.512	74.8 78.7	38.1±1.9
2	Ba70D	Out of the survey area		Andesite	Tan2	1.47 1.45	0.152 0.159	64.3 61.8	27.2±1.4
3	Cb1DT	478800	2307650	Quartz diorite	Tidi	2.29 2.29	0.458 0.460	79.5 80.2	50.9±2.5
4	Cb20DTC	485075	2284300	Hornblende-biotite rhyolite	Trhy2	7.02 7.00	0.731 0.724	90.2 92.6	26.5±1.3
5	Db87DT	452250	2291025	Biotite rhyolite	Trhy2	3.57 3.56	0.831 0.375	79.5 80.1	27.1±1.4
6	Cd134DT	479700	2315525	Biotite-augite diorite	Tidi	1.76 1.75	0.269 0.290	74.8 74.2	40.5±2.0
7	B500DTC	478210	2304805	Quartz diorite	Tidi	2.96 2.99	0.556 0.567	81.8 79.3	47.8±2.4
8	C102DTC	479975	2309845	Quartz diorite	Tidi	2.53 2.54	0.470 0.487	76.9 80.5	47.9±2.4
9	D52DTC	485725	2299916	Quartz monzonite	Tigd	3.69 3.72	0.332 0.340	34.3 63.4	23.2±1.2
10	G483DTC	474472	2287728	Diorite porphyry	Tidp	2.01 2.02	0.249 0.243	48.3 54.2	31.1±1.6
11	A57DTC	483500	2310810	Quartz diorite	Tidi	2.06 2.06 2.09	0.413 0.426	87.8 84.6	51.7±2.6
12	B44DTC	488385	2284625	Rhyolite	Tirh	2.74 2.75 2.77	0.272 0.279	82.7 80.9	25.5±1.3

$\lambda\varepsilon=0.581\times10^{-10}yr^{-1}$, $\lambda\beta=4.962\times10^{-10}yr^{-1}$, $^{40}\kappa/\kappa=1.167\times10^{-4}$,
^{40}ArR; radiogenic argon 40. All samples were analyzed in duplicate.

Compact rhyolite is distributed on the southwestern slope of the San Clemente mountain mass, rhyolite lava and the pyroclastic rocks on the northeastern slope. The dykes are found in a scattered pattern near the San Clemente mountain mass and also found in the PROVIDENCIA area. The K-Ar ages of the rocks showed 27.1 ± 1.4 Ma, 26.5 ± 1.3 Ma and 25.5 ± 1.3 Ma (Table 3-1). These correspond to late Oligocene. The rocks have a close relation with the mineralization such as of gold and silver in the SAN CLEMENTE area and of lead and zinc in the PROVIDENCIA area, and the investigation of these was one of the main themes of the survey.

3-4 Intrusive Rocks

The intrusive rocks include Diorites (Tidi), Diorite porphyries (Tidp), Perthite granites (Tigd), Basalt (Tiba) and Andesite (Tian). Among these, Diorites (Tidi) are the most important in connection with the mineralization.

Diorites (Tidi) are distributed in the northern part of the surveyed district in a form of irregular stock arranged approximately in the direction of NNE-SSW. This trend is concordant with the strike of the main faults observed in the district.

The rocks show generally dark grey to grey color and holocrystalline granular texture and displays various facies such as hornblende dioritic, biotite-hornblende-quartz dioritic and granodioritic.

The K-Ar ages of the rocks shows 40 - 50 Ma (Table 3-1), indicating the time of intrusion to be early to late Eocene.

The rocks are closely related to the contact metasomatic to hydrothermal mineralization in the district, and the ore deposits such as El Zapote, Encarnación and Dos El Aguila are found in the surrounding area of the rock mass.

Diorite porphyries (Tidp) are found in the vicinities of the Pechuga mine, the Bonanza village and at San Clemente.

The rocks are generally greenish grey to pale greyish brown diorite porphry to granodiorite porphyry. Under the microscope, coarse crystals of euhedral plagioclase are characteristically observed. The rocks have been highly altered, in which phenocrystic plagioclase has been chloritized and sericitized, and biotite has been chloritized. The ages by the K-Ar method shows 31.1 ± 1.6 Ma, indicating Oligocene.

It is considered that the Pechuga mineralized zone is closely related to the intrusion of these rocks.

Perthite granites (Tigd) show a scattering distribution at several places in the northern part of the district. The rock varies in type from perthite granite to quartz monzonite, granodiorite and quartz diortie, in which perthite is contained characteristically in general.

The result of the whole rock analysis of perthite granite was calculated based on the C.I.P.W. Norm (Table 3-2) and it was plotted on the Quartz-Orthoclase- (Albite + Anorthite) diagram. The result shows that the rock corresponds to quartz monzonosyenite (Fig. 3-5).

Although the rocks have an effect of contact metamorphism on the surrounding Cretaceous rocks, no mineralization can be observed.

Basalts (Tiba) and Andesites (Tian) are found as small dykes mainly in the Cretaceous sedimentary rocks in the northern part of the district.

3-5 Quaternary System

The Quaternary system shows a wide distribution from the central part to the southern part of the surveyed district. It consists of alternating beds of poorly consolidated gravel, sand, silt and volcanic ash (QTcg), and basalt as well as sand, gravel and clay.

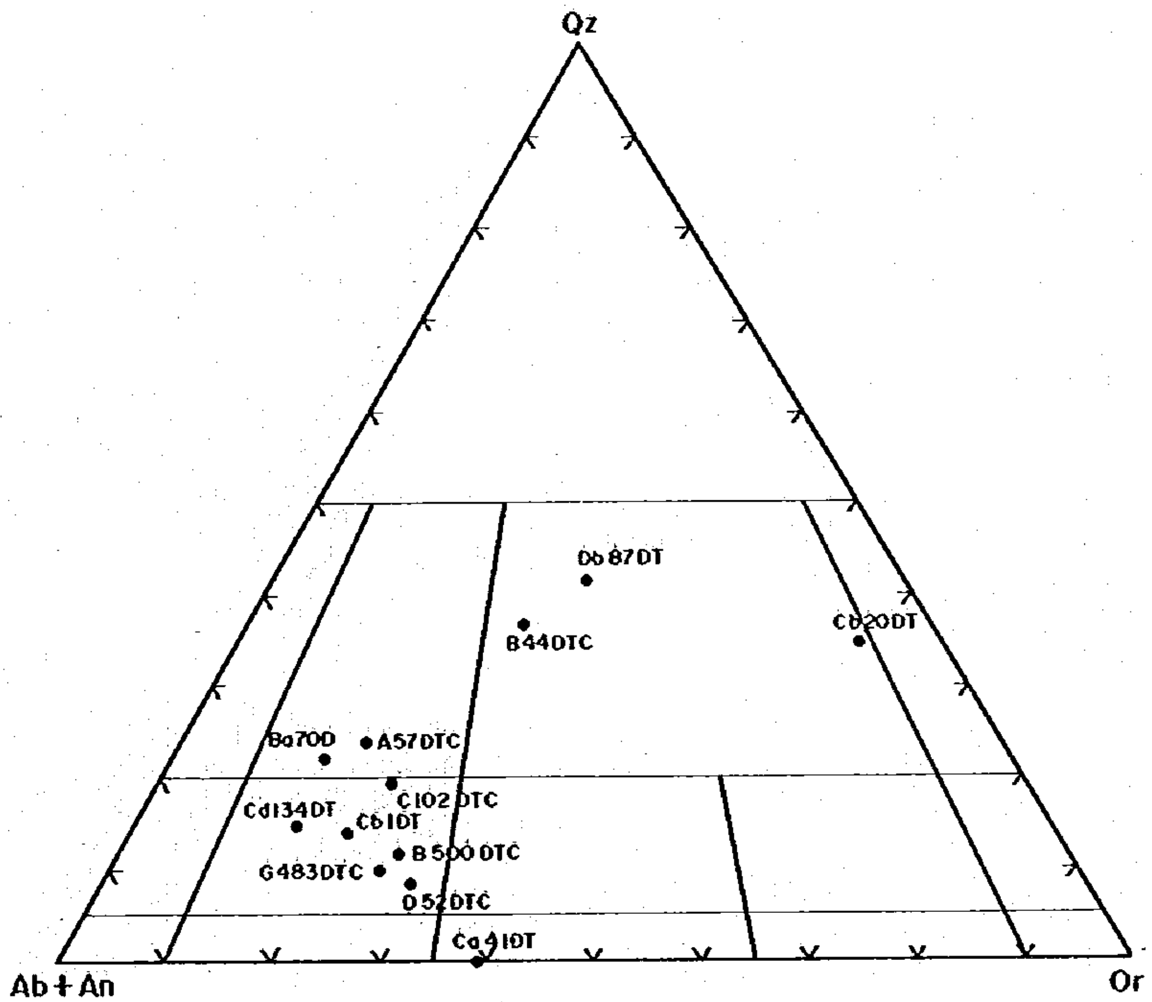


Fig.3-5 Normative Quartz-Orthoclase-(Albite+Anorthite) Triangular Diagram of Some Igneous Rocks.

Table 3-2 Chemical Composition and C.I.P.W. Norm of Igneous Rocks

Sample No.			Ca41DT	Ba70D	Cb1DT	Cb20DTC	Db87DT	Cd134DT	B500DTC	C102DTC	D52DTC	G483DTC	A57DTC	B44DTC
Coordinates		E	487525	Out of Out of the survey area area	478800	485075	452250	479700	478210	479975	485725	474472	483500	488385
		N.	2292775		2307650	2284300	2291025	2315525	2304805	2309845	2299916	2287728	2310810	2284625
Rock name			Andesite	Andesite	Quartz diorite	Rhyolite	Rhyolite	Quartz diorite	Quartz diorite	Quartz diorite	Quartz monzonite	Diorite porphyry	Quartz diorite	Rhyolite
Stratigraphic unit			Tian	Tan2	Tidi	Trhy2	Trhy2	Tidi	Tidi	Tidi	Tigd	Tidp	Tidi	Tirh
Chemical composition	SiO_2		51.81	60.24	59.11	72.31	75.40	56.95	60.41	61.61	61.38	58.34	62.4	73.8
	TiO_2		1.25	0.82	1.00	0.28	0.10	1.34	0.83	0.83	1.19	0.66	0.76	0.25
	Al_2O_3		15.85	18.66	17.20	13.77	13.22	17.82	17.57	16.34	16.73	19.94	16.4	13.1
	Fe_2O_3		0.49	2.32	3.39	2.06	0.60	3.80	3.41	2.83	0.97	1.54	2.75	1.38
	FeO		5.42	1.58	2.80	0.33	0.58	3.59	2.03	2.73	4.58	2.35	2.50	0.49
	MnO		0.16	0.08	0.14	0.02	0.02	0.15	0.12	0.13	0.11	0.05	0.09	0.07
	MgO		4.97	2.15	2.58	0.15	0.15	3.36	2.00	2.44	1.75	2.13	1.76	0.30
	CaO		8.84	4.34	5.99	0.10	0.57	6.61	4.84	5.00	3.48	4.96	4.80	1.52
	Na_2O		3.14	3.85	3.83	0.75	2.59	3.25	4.14	3.48	4.76	4.93	3.50	3.47
	K_2O		4.10	1.95	2.78	9.06	4.49	2.02	3.54	2.99	4.09	1.94	2.46	4.08
	$H_2O(+)$		3.02	3.17	0.60	1.07	1.45	0.65	0.65	0.73	0.50	2.08	0.72	0.49
	$H_2O(-)$		0.19	1.10	0.11	0.22	0.82	0.10	0.48	0.51	0.26	0.56	0.51	0.60
	P_2O_5		0.49	0.18	0.45	0.04	0.02	0.31	0.32	0.39	0.32	0.25	0.39	0.13
	Total		99.73	100.50	99.98	100.16	100.01	99.95	100.34	100.01	100.12	99.73	99.04	99.68

weight in percent

		Ca41DT	Ba70D	Cb1DT	Cb20DTC	Db87DT	Cd134DT	B500DTC	C102DTC	D52DTC	G483DTC	A57DTC	B44DTC
C.I.P.W. normative calculations	apatite	1.13	0.41	1.04	0.09	0.05	0.71	0.73	0.90	0.74	0.58	0.91	0.30
	orthoclase	24.30	11.47	16.43	53.46	26.53	11.94	20.85	17.67	24.14	11.50	14.68	24.19
	albite	20.86	32.41	32.41	6.34	21.91	27.51	34.91	29.44	40.23	41.83	29.90	29.40
	nepheline	3.13	0	0	0	0	0	0	0	0	0	0	0
	anorthite	17.09	20.26	21.54	0.24	2.70	28.09	18.84	20.13	12.19	23.05	21.50	6.72
	corundum	0	2.74	0	2.64	3.11	0	0	0	0	1.31	0.18	0.52
	ilmenite	2.38	1.55	1.90	0.53	0.19	2.55	1.57	1.58	2.26	1.26	1.46	0.48
	magnetite	0.71	2.96	4.92	0.32	0.87	5.51	4.51	4.10	1.40	2.24	4.03	1.08
	diopside	19.32	0	4.17	0	0	2.15	2.35	1.71	2.49	0	0	0
	hematite	0	0.33	0	1.84	0	0	0.29	0	0	0	0	0.64
	hypersthene	0	5.33	5.41	0.37	0.81	8.87	3.78	6.81	8.94	7.37	5.67	0.75
	olivine	7.86	0	0	0	0	0	0	0	0	0	0	0
	quartz	0	18.29	11.48	32.94	41.56	11.91	10.94	16.43	6.85	8.23	20.45	34.78
	Total	96.77	95.75	99.29	98.72	97.74	99.25	98.86	98.77	99.24	97.37	98.76	98.91

3-6 Geological Structure (ref. Fig. 3-6)

The most characteristic structural-features observed in the survey district are folds and faults in the pre-Tertiary sedimentary rocks.

Occurrence of folded structure are more or less controlled by lithofacies of strata. However, generally speaking, folds are severe in the district, and those of various sizes, large and small scales, are often observed.

Among them, many overturned folds of large scale are the most characteristic ones in the survey district.

Two systems of faults such as strike faults of NW-SE system and Transverse faults of NNE-SSW system are observed. These faults are large in scale, but small in number.

As compared with these remarkable geologic structures developed in the pre-Tertiary sedimentary rocks, no notable folds and faults can be observed in the Tertiary system. The Tertiary intrusive rocks, however, show the distribution trending in two directions and it is possible that it reflects the faults or the structure of the basement. The details are as follows.

[Fold structure]

The largest one is a couple of overfold anticline and syncline observed in the north-central part of the district. The axis of the overfold anticlinal structure extends in the direction of NW-SE from the northwestern part to the central part, which slightly turns its trend to N-S toward the south from there, showing the axial plane dipping 40° to 70° southwestward. The fold axis extends toward the southeast passing the western side not far from the Apesco and Las Trancas villages in the northwestern part of the district and further runs southward through the Taxhai village in the central part. The Las Trancas Formation, the lowermost one in the district, is distributed along the fold axis, and the Cretaceous El Doctor Formation (Kdf) is arranged on both side of it, in which an apparent monoclinal structure is shown because of westward dipping of the axial plane.

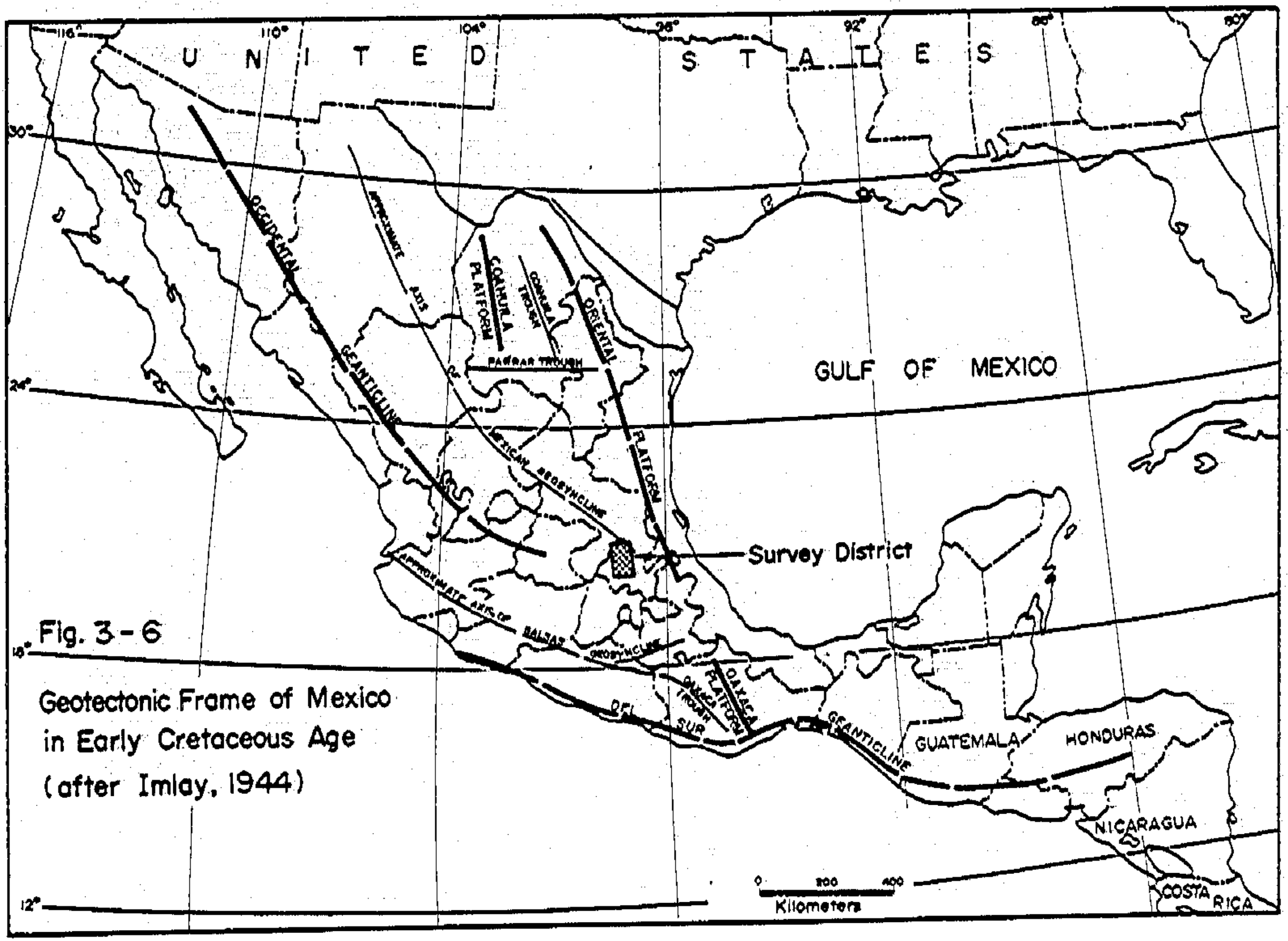


Fig. 3-6

Geotectonic Frame of Mexico in Early Cretaceous Age (after Imlay, 1944)

On the other hand, an overfold synclinal structure which forms a counterpart to the above anticline occurs on the eastern side. The structure has its synclinal axis in the area of distribution of the Mendez Formation, the uppermost formation among the Cretaceous sedimentary rocks. The synclinal axis, which has a westward dipping axial plane, extends southeastward from a point about three kilometers to the east-northeast of the Las Trancas village passing through the vicinities of the villages such as Pajeadi, Nicolas Flores, El Bocua and Tedra, and further runs toward the south. The eastern side of the overfold synclinal structure is cut by a fault, and the Mendez Formation is in fault contact with the underlying El Doctor Formation (Kdl member). In the western wings, formations are upturned.

In the Mendez Formation which is distributed from Mezquite village in the northern part of the district to the east of Las Piedras village in the southwest, other overturned synclinal structure is observed. The synclinal axis of the structure is in the direction of NW, and the axial plane inclines to the southwest with a gentle angle from 20 to 40 degrees. In the area, the structure shows that the Mendez Formation is wrapped in the lower Kdf and Kdl Members of the El Doctor Formation, and suggesting a possibility of the existence of thrust fault.

Beside these major fold structures, numerous fold structures are observed in the district. Namely, a repetition of anticline and syncline with the folding axis of NW-SE system is observed from the southwest of the Las Trancas village to the northeast of the Guadalupe village. A part of the fold continues to a point about two kilometers to the west of the Bonanza village, where the fold axis is curved in the direction of NNW-SSE, which makes the geologic structure of the surrounding area more complicated.

On the north-northwest of the Santuario village, the overfold structure having the axis of NNW-SSE system and the synclinal structure on the western side, make the distribution of the El Doctor Formation to stretch out toward the southwest.

A small-scale repetition of anticline and syncline having the axis of NW-SE system is observed in the Mendez Formation on the southwestern side of the Itatlaxco village in the northeastern part of the surveyed district.

In respect with other minor fold structures, abundant steeply-dipping intrafolial folds can be observed in the Las Trancas Formation (Jts), the Black Flint Bearing Medium-Bedded Limestone Member (Kdf) and the Mendez Formation. In the Massive Limestone Member (Kdl) distributed in the northern part of the area, however, only the gentle anticlinal and synclinal structures showing the dip of strata of about 20° are observed.

Thus the difference of fold structure due to rock facies and rock types seems to represent that of competency against the tectonic movement of each stratum, and especially the incompetent pelitic bed more tends to show a remarkable fold structure.

The axis of fold structures mentioned above have the trend of NW-SE system in the northernmost part of the surveyed district, while on the southern side of a line joining the Guadalupe village and the Nicolas Flores village, the fold axis tends to turn its direction to NNW-SSE and further to N-S.

[Fault structure]

Two systems of faults such as those of NW-SE system and those of NNE-SSW system oblique to the former are found in the surveyed area. There are two faults belonging to the NW-SE system. The one is that which divides the Massive Limestone Member (Kdl) from the Mendez Formation. It is a large-scale one to extend to the outside of the surveyed area, and is estimated to have a great throw. The other is that of NW-SE system which runs on the northeast of the Las Piedras village, cutting the northeastern extension of the Black Flint Bearing Medium Bedded Limestone Member (Kdf).

Two faults belong to NNE-SSW system. The one extends from the east of the Durango village in the northernmost part of the surveyed district south-southwestward to the Las Trancas village, and the other extends toward the south-southwest from the Las Piedras village. Both of these are the transverse fault cutting the pre-Tertiary sedimentary rocks. The faults of N-S system are found as small faults stemmed from the faults of NNE-SSW system in the vicinity of the Dos de El Aguila mine and on the south of it.

[Arrangement of Tertiary intrusive rocks]

Intruded positions of the Tertiary Diorite (Tidi), Diorite porphyry (Tidp) and Perthite granite (Tigd) are roughly lined on the two directions, namely, NNE-SSW and NW-SE. Concretely speaking a line of NNE-SSW direction is traceable from the southeast of Agua Fria Chica village in the north of the survey district, then, to the vicinities of the Encarnación and El Zapote mines, small rock bodies in the north-northwest of Taxhai village, NNE of Bonanza village and to the vicinity of the Pechuga mine. These intrusives of stockform, large and small, are straight-lined in the direction of NNE-SSW. Another line is in the direction of NW-SE, and is also traceable from the vicinity of Colorado village in the northwest of the survey district, passing through the El Zapote mine, northeast of Nicolas Flores village and to the northeastern part of El Bocua village in the direction of southeast. These two lines roughly coincide with the trends of faults in the district, and are considered to reflect the geological structure of the basemental rocks which exist below.

3-7 Geological History

The survey district is located at the southern end of the Mexican miogeosyncline which started to form from the late Jurassic period in relation to the Nevadan orogeny of the western part of American Continent. In the district, the marine sediments belonging from the Tithonian stage of the uppermost Jurassic to Campanian stage of the upper Cretaceous, are predominated. These strata had been deposited in parallel with the development of geosyncline above mentioned.

The lowermost strata distributed in the area is the Las Trancas Formation, which is correlated to Tithonian of the uppermost Jurassic to Campanian of the Upper Cretaceous.

The formation is chiefly composed of alternations of homogeneous phyllitic shale and sandy shale, however, thin layers of andesitic tuff, tuffaceous sandstone and tuffaceous conglomerate are often intercalated. Consequently these lithologic features indicate that the sedimentary environment at that time was in shallow sea, repeating small-scaled volcanic activity, transgression and regression. Since the distribution of marine strata which belong to the age from Aptian to early Albian is not observed, the district is thought to have been in regressional environment during that period. After that, transgression began from middle Aptian, and the sedimentation of marine deposit predominated until late Turonian.

In the northern to the northeastern part of the area, the El Doctor Formation which is correlated to the middle Albian to the upper Turonian consists of the Kdl Member of thick-bedded limestone, whereas, in the northwestern to the central part, the formation consists of the Kdf Member composed of medium-bedded limestone often intercalated characteristically with thin layers of black flint and calcareous shale, and both of them are in the relation of contemporaneous heterotopic facies. Therefore, it seems that there was a notable difference of sedimentary environment between the northern to the northeastern part and the northwestern to the central part.

Taking the trend of the distribution of the underlying formation and the extent of distribution into account, it is considered that the difference was formed under the control of structure of the basement at that time.

Then followed the deposition of the Mendez Formation which is correlated to the upper Turonian to the Campanian.

According as the sedimentary basin was filled up with the sediments, frequency of transgression and regression increased and abundant terrestrial clastics were supplied, having resulted in to be predominant with pelitic and arenaceous deposits. Therefore, the relation between the formation and the El Doctor Formation is partly conformable and partly unconformable.

The Laramide orogeny which took place from late Cretaceous to early Eocene of Tertiary caused an intense compressive force to the sediments in the geosyncline of the area to be folded and to be uprised above the sea level. The folded structures observed in the pelitic strata of the Las Trancas Formation, Kdf Member of the El Doctor Formation and the Mendez Formation, are thought to have been developed by the compressive force went through those strata against the Kdl Member of the El Doctor Formation as a fixed wall.

After the end of the Laramide orogeny, the igneous activity of the district initiated with the intrusion of Diorites, Diorite porphyrises and Perthite granites, and these were arranged in the directions of NW-SE system and NNE-SSW system controlled by the structure of basement.

Pyrometasomatic - hydrothermal ore deposits in the district have been developed under the intimate relation to the intrusion of those igneous rocks. Age of intrusion of the Dioritic rocks is in between 40.5 ± 1.4 Ma and 50.9 ± 2.5 Ma and is Eocene, Tertiary in age.

In a period between late Eocene and early Oligocene, conglomerate bed of the El Morro Formation has been locally deposited with an unconformity upon the Cretaceous strata below. From this period, igneous activities in the district were gradually getting brisk and the altered andestic rocks (Tan 1) in the east of the district were erupted in late Eocene. After that, igneous activities represented by the basalt, andesite, rhyorite and dacite took place. The time of these igneous activity shown by the result of K-Ar dating is 31.1 ± 1.6 Ma to 26.5 ± 1.3 Ma, showing a characteristic that these are mostly concentrated to Oligocene. The important one among these is the activity of rhyolitic rocks (Trhy-2) which constitute the San Clemente mountain mass. In association with this activity, the mineralization of gold, silver, copper, lead and zinc is observed, which is one of the principal themes of the survey. From the end of Tertiary to Quaternary, inland lake deposits in the structural basin at the south of survey district were deposited.

CHAPTER 4 ORE DEPOSIT

4-1 Outline of Mineralized Zone

From the view of metallogenic province, the survey district belongs to the Sierra Madre Oriental province and the Younger Volcanic province.

The mineralized zone in the Sierra Madre Oriental province is related intimately to the Tertiary intrusive rocks of dioritic nature and occur in the Cretaceous sedimentary rocks.

As mineralized zone belonging to the Younger Volcanic province, gold ore deposits in rhyolitic rocks in the southern center of the district are known.

The ore deposits and showings in the survey district are grouped in several mineralized zones as follows owing to their geographical position, kind of host rock, kind of main ore minerals (ref. Fig. 4-1, Table 4-1).

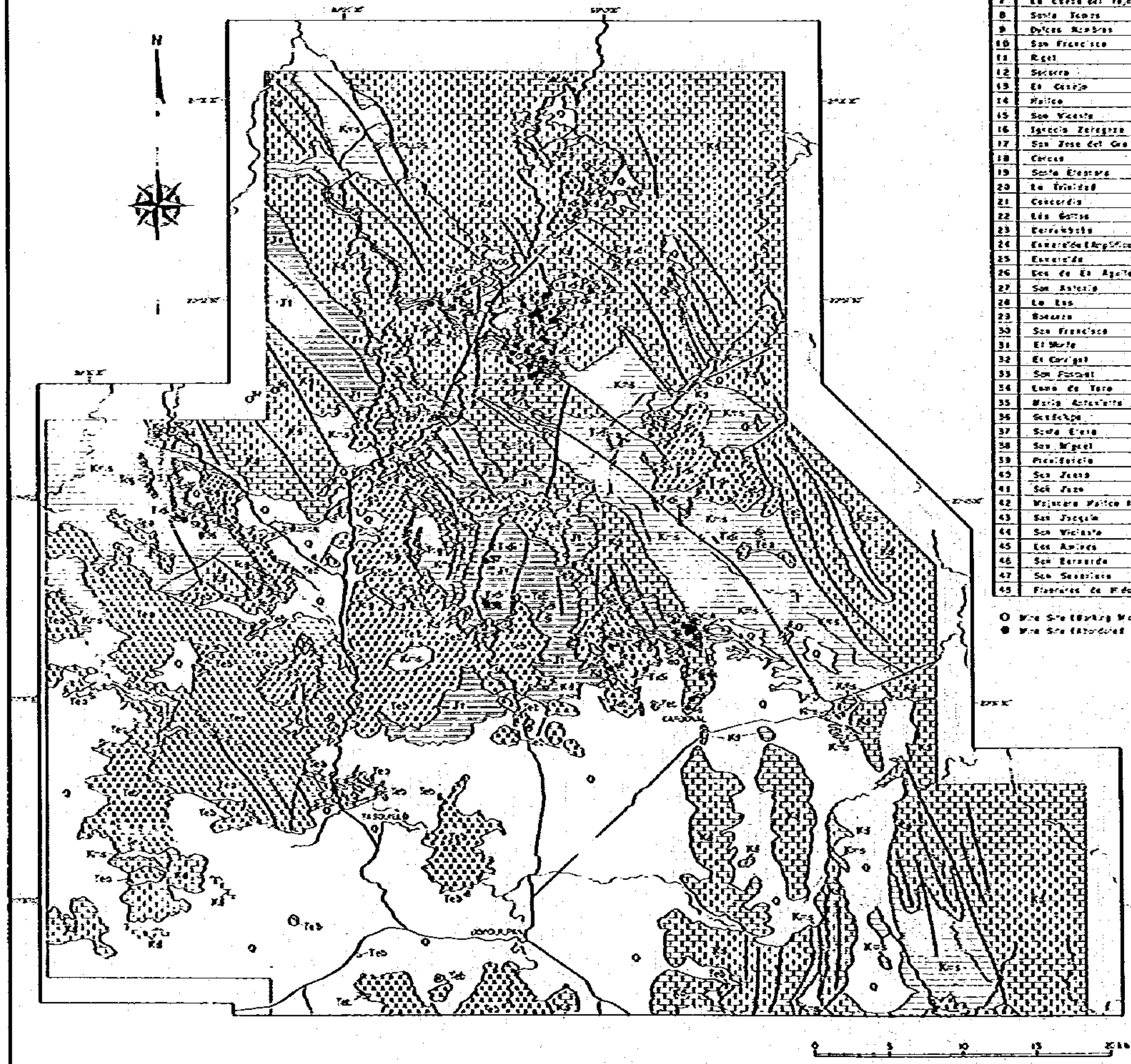
Mineralized zone observed in this district are divided into following three types by their metallogenic natures:

(1) Contact metasomatic type Fe-Cu-(Pb-Zn-Ag-Au) (represented by EL TEJOCOTE, ENCARNACIÓN, EL ZAPOTE, DOS DE EL AGUILA, LA LUZ and ZIMAPAN mineralized zones) which originates in contact zone between diorite stocks and calcareous rocks in the northern part of the district.

(2) Hydrothermal type Pb-Ag-(Zn-Au-Cu) (as represented by PECHUCA, PROVIDENCIA and EL TEJOCOTE mineralized zones) that occurs in the form of irregular massive-manto-vein in calcareous rocks near the diorite porphyry (Tidp) and diorite (Tidi).

(3) Hydrothermal type gold deposit (as represented by the SAN SEVERIANO mine in the SAN CLEMENTE) as observed in the compact rhyolite which formes the San Clemente mountain mass in the southern part of the district.

Ore deposits of the type (1) take various shapes such as vein, chimney, manto, pocket and lens. The ore minerals observed in the zone are mainly of magnetite, pyrite, chalcopyrite, pyrrhotite, sphalerite and galena as primary



List of Mines

No	Name of Mine	Produced metal	Mineralized zone
1	Las Delicias	Fe,Cu	El Tepozán ∫ Encarnación
2	Santo Domingo	ditto	
3	El Cambio	Fe,(Cu)	
4	"Piedra Rosa"	ditto	
5	Corral Viejo	ditto	
6	Agua Baja	ditto	
7	La Cueva del Tejon	ditto	
8	Santa Teresa	ditto	
9	Dulces Nombres	ditto	
10	San Francisco	ditto	
11	Rigel	ditto	
12	Socorro	ditto	
13	El Conejo	Fe,Cu	El Zapote
14	Maitco	ditto	
15	San Vicente	ditto	
16	Ignacio Zaragoza	Fe,Cu,Pb,Ag,Zn	
17	San Jose del Oro	Fe,Cu,Pb,Ag,Zn	
18	Cercas	ditto	
19	Santa Eleonora	ditto	
20	La Trinidad	ditto	
21	Concordia	ditto	
22	Los Gallos	ditto	
23	[illegible]	ditto	
24	Esmeralda (Magnificat)	Fe,Ag,Pb,Zn	Ojo de El Aguila
25	Esmeralda	Ag,Zn,Pb,Zn	
26	Ojo de El Aguila	ditto	
27	San Antonio	Ag,Pb,Zn	La Luz
28	La Luz	ditto	
29	Rosario	ditto	
30	San Francisco	Ag,Pb,Zn	Zimapán
31	El Monte	ditto	
32	El Carrizal	ditto	
33	San Pascual	ditto	
34	Loma de Toro	ditto	
35	Maria Antonieta	ditto	
36	Guadalupe	ditto	
37	Santa Elena	Ag,Pb,Zn	Bonanza
38	San Miguel	Ag,Pb,Zn	
39	Providencia	Ag,Pb,Zn	Providencia ~ Vasca
40	San Juan	ditto	
41	San Jose	ditto	
42	Mejicana Maitco 10	ditto	
43	San Joaquin	ditto	
44	San Vicente	ditto	
45	Los Aguilas	ditto	
46	San Bernardo	ditto	
47	San Sebastian	Au,Ag	San Clemente
48	Fluoritas de Hidalgo	F	

○ Mine Site (Working Mine)
● Mine Site (Abandoned Mine)

LEGEND

TERTIARY ~ QUATERNARY SYSTEMS

Q — Late Pliocene ~ Recent deposit

Acidic extrusive and dike rocks

Basic extrusive and dike rocks

Hypabyssal to plutonic rocks

El Morro Formation — Conglomerate

JURASSIC ~ CRETACEOUS SYSTEMS

Mendez Formation (Kms) — Shale intercalated with calcareous shale, siltstone and sandstone

El Doctor Formation (Kd) — Massive limestone intercalated with clastic limestone and conglomeratic limestone, and alternation of limestone, marl, calcareous shale, shale and black flint

Las Trancas Formation (Jt) — Shale, calcareous shale intercalated with sandstone, tuffaceous conglomerate andesitic tuff, and marl

Fault

Anticlinal axis

Synclinal axis

Overturned anticlinal axis

Overturned synclinal axis

Geological boundary

Fig.4-1 Location Map of Mines and Ore Showings in the Survey District

Table 4-1 List of Mineralized Zone

Mineralized zone	No.	Name of mine	Type of ore deposit	Produced metal	Operation	Mine works
EL TEJOCOTE	1	Las Delicias	Pyrometasomatic: massive	Fe, Cu	Active	1 adit
	2	Santo Domingo	ditto	Cu, Pb, Zn	Inactive	adit and pit
ENCARNACION	3	El Cambio	ditto	Fe, (Cu)	ditto	pits
	4	Piedra Iman	ditto	ditto	ditto	?
	5	Corral Viejo	ditto	ditto	ditto	pits
	6	Aguila Roja	ditto	ditto	Active	1 adit
	7	La Cueba del Tejon	ditto	ditto	Inactive	pits
	8	Santo Tomas	ditto	ditto	ditto	ditto
	9	Dulces Nombres	ditto	ditto	ditto	ditto
	10	San Francisco	ditto	ditto	ditto	ditto
	11	Rigel	ditto	ditto	ditto	ditto
	12	Socorro	ditto	ditto	ditto	ditto
EL ZAPOTE	13	El conejo	ditto	Fe, Cu	ditto	1 adit, 1 shaft
	14	Huilco	ditto	ditto	ditto	1 adit
	15	San Vicente	ditto	ditto	ditto	1 adit
	16	Ignacio Zaragoza	ditto	Fe, Cu, (Au, Ag, Zn)	Active	2 adits
	17	San Jose del Oro	ditto	Fe, Cu, (Au, Ag)	Inactive	2 adits, 2 shafts
	18	Corcus	ditto	ditto	Active	2 adits
	19	Santa Eleanora	ditto	ditto	ditto	1 adit
	20	La Trinidad	ditto	ditto	ditto	2 adits
	21	Concordia	ditto	ditto	Inactive	3 adits
	22	Los Gallos	ditto	ditto	ditto	4 adits
	23	Derrumbada	ditto	ditto	ditto	1 adit, 1 shaft
DOS DE EL AGUILA	24	Esmeralda (Amplification)	ditto	Fe, (Au, Pb, Zn)	Active?	pits
	25	Esmeralda	ditto	Ag, (Cu, Pb, Zn)	Active	2 adits, 1 shaft
	26	Dos de El Aguila	ditto	ditto	ditto	2 adits, 1 shaft
LA LUZ	27	San Antonio	Hydrothermal-replacing: mant	Ag, Pb, Zn, (Au)	Inactive	1 adit
	28	La Luz	ditto	ditto	Active	1 adit
	29	Bonanza	ditto	ditto	Inactive	1 adit
ZIMAPAN	30	San Francisco	Pyrometasomatic, Hydrothermal: manto, chimney	Ag, Pb, Zn	Active	adits?
	31	El Monte	ditto	ditto	ditto	adits?
	32	El Carrizal	ditto	ditto	ditto	adits
	33	San Pascual	ditto	ditto	ditto	ditto
	34	Lomo de Toro	ditto	ditto	ditto	ditto
	35	Maria Antonietta	Hydrothermal: vein	ditto	Inactive	adit
	36	Guadalupe	ditto	ditto	ditto	pits
PECHUGA	37	Santa Elena	Hydrothermal: vein	Ag, Pb, Zn	ditto	>5 adits, >4 shafts
	38	San Miguel	Pyrometasomatic to hydrothermal: massive	Ag, Pb, Zn	ditto	2 adits, 2 pits
PROVIDENCIA ~ YONTH	39	Providencia	Hydrothermal: vein, mant	Pb, Zn, (Ag)	ditto	>6 adits, >6 pits
	40	San Juana	ditto	ditto	ditto	4 adits, 3 pits
	41	San Juan	ditto	(Pb, Zn)	ditto	1 adit
	42	Mojonera of Huilco 10	ditto	ditto	ditto	4 adits, 8 pits
	43	San Joaquin	Hydrothermal: chimney	ditto	ditto	adits
	44	San Vicente	ditto	ditto	ditto	shafts, adits
	45	Las Aminas	ditto	ditto	ditto	adits, pits
	46	San Bernardo	ditto	ditto	ditto	adits, pits
SAN CLEMENTE	47	San Severiano	Hydrothermal: dis-semination	Au, Pb, Zn, (Ag)	ditto	many pits & adits
	48	Fluoruros de Hidalgo	Hydrothermal-replacing: massive? vein?	F	ditto	pits

minerals and hematite, goethite, malachite and various oxides as secondary minerals. As gangue minerals, garnet, wollastonite, epidote and calcite are generally included.

Ore deposits of the type (2) are mainly composed of oxides ore such as goethite, hematite, limonite and jarosite. But under the microscope, cerussite and smithsonite are often observed.

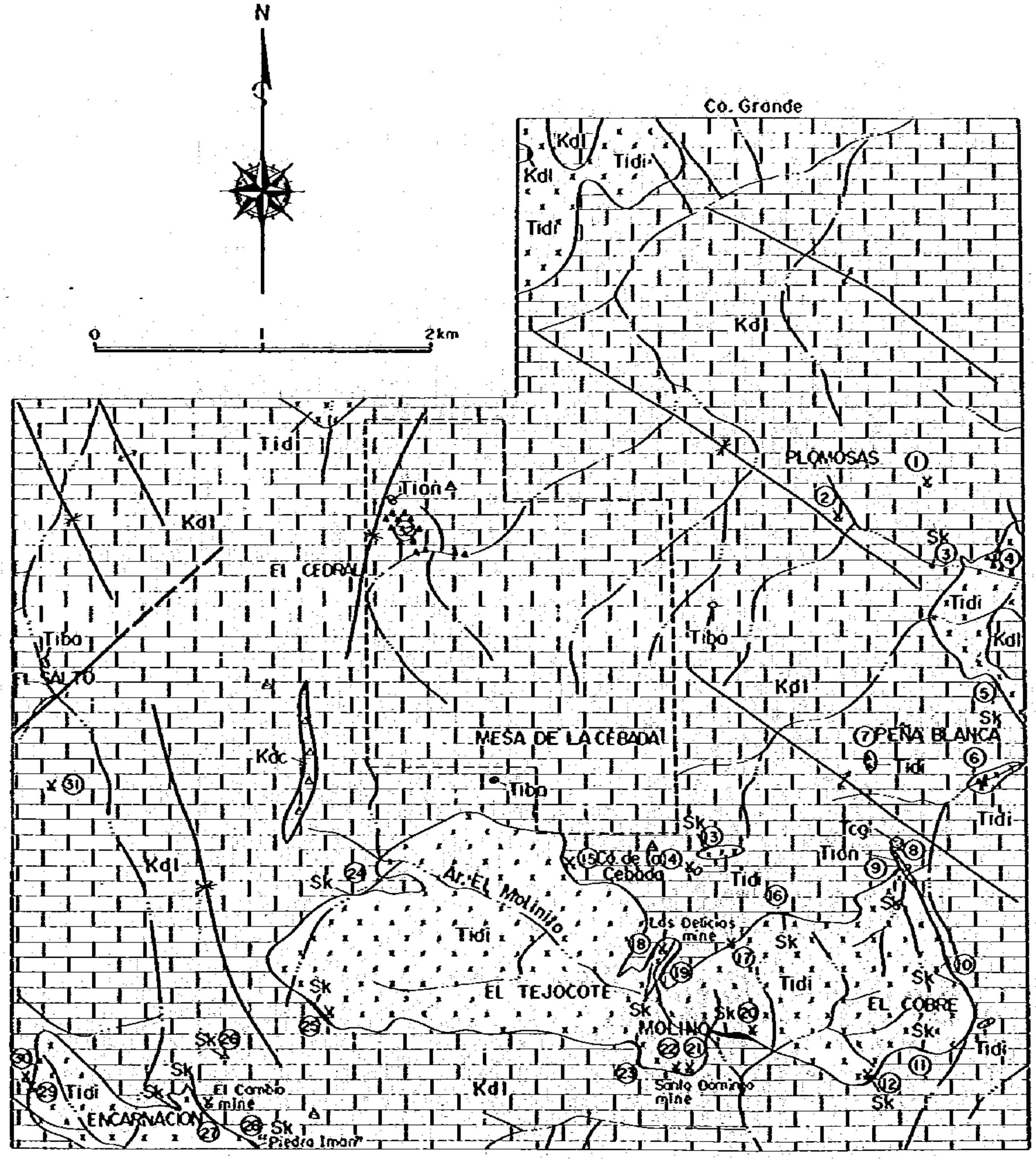
The gold mineralization in the compact rhyolite of the type (3) is thought to be of irregular network to dissemination of electrum and sulfosalts grains associated with no remarkable hydrothermal - alteration such as silicification, carbonitization, etc. in the country rock.

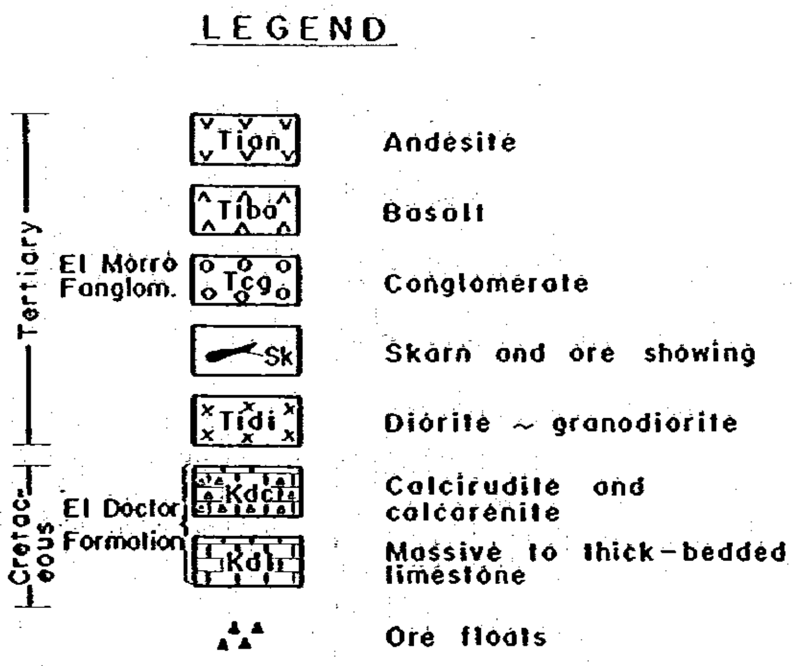
4-2 EL TEJOCOTE Mineralized Zone (Ref. Fig. 4-2, Table 4-2)

EL TEJOCOTE Area is in the northeastern neighbourhood of Enacarnación village situated in the northern part of the project district. Geology of the EL TEJOCOTE area including the whole neighborhood of Encarnación is characterized by the predominant distribution of the thick-bedded to massive limestone (Kdl Member) of the El Doctor Formation, and quartz diorite intruded into limestone in the form of stock in various sizes.

The ore deposits scattered in this area are generally divided into two types such as copper and iron ore deposit of contact metasomatic type emplaced in the skarn zone between limestone and quartz diorite, and silver, lead and zinc deposit of hydrothermal type emplaced in limestone in the outer surrounding part of the former.

The contact metasomatic deposit represented by such ore deposits as Las Delicias, Santo Domingo, El Cambio and Piedra Iman, is furthermore divided into three types, that is, (1) the irregular massive to lenticular and vein types consisting mainly of magnetite accompanied by some amounts of iron sulfide and chalcopyrite emplaced in garnet-epidote (rarely wollastonite) skarn, (2) the lenticular type with dissemination of magnetite, pyrrhotite, pyrite and chalcopyrite in skarn zone, and (3) the type which contains galena and





No.	Name of mine	Metals	No.	Name of mine	Metals
①	Prospect	Pb < Zn	⑰	Prospect	(Cu)
②	Prospect	Pb ≪ Zn	⑱	Los Delicios	Fe ≫ Cu
③	Outcrop	(Trace)	⑲	Outcrops	Fe ≫ Cu
④	(Floats)	Fe ⋙ Cu	⑳	Prospect	(Trace)
⑤	Outcrop	Fe ≫ Cu	㉑	Santo Domingo	Cu
⑥	(Floats)	(Trace)	㉒	Santo Domingo	Cu-Pb-Zn
⑦	(Floats)	(Trace)	㉓	Outcrop	(Trace)
⑧	Outcrop	(Trace)	㉔	Outcrop	(Trace)
⑨	Outcrop	Fe	㉕	Prospects	(Cu)
⑩	Outcrop	Fe	㉖	Outcrop	(Trace)
⑪	Outcrop	Fe	㉗	El Cambio	Fe ≫ Cu
⑫	Prospect	Fe ⋙ Cu	㉘	"Piedra Iman"	Fe ⋙ Cu
⑬	Outcrops	Fe	㉙	Prospect	(Pb-Zn)
⑭	Nameless mine	Fe ≫ Cu	㉚	Nameless mine	(Cu)
⑮	Prospect	Fe ≫ Cu	㉛	Prospect	(Ba)
⑯	Outcrop	Fe	㉜	(Floats)	Fe

Fig. 4-2 Location Map of the Mines, Prospects and Ore Showings in the EL TEJOCOTE Area.

Table 4-2 Mines, Prospects and Ore Showings in the EL TEJOCOTE Area

Index ☆.※	Name of Mine	Type of Mineralization	Scale of Orebody (m)	Ore Minerals	Gangue Minerals	Workings
①	Prospect	Ht vein	1.2(w), +10(l)	lm,jr	ca,qz?	2 shafts
②	Prospect	Ht veinlets	0.3(w), +3 (l)	lm,jr	ca	2 pits
③	Outcrop	Ht veinlets(manto)	3.0(w), 15(l)	lm,jr	ca	—
④	(Floats)	Pm	?	mg, py	ga,ep	—
⑤	Outcrop	Pm	+1.0(w), 10(l)	mg,ml	ga,ca	—
⑥	(Floats)	Ht(?)	?	lm,jr	ca	—
⑦	(Floats)	Ht(?)	?	lm	—	—
⑧	Outcrop	Ht network	1.0(w), 2(l)	lm,jr	ca	—
⑨	Outcrop	Pm	1.5(w)	mg	ca,ga	—
⑩	(Floats)	Pm	?	mg	—	—
⑪	Outcrop	Pm	+3 (w), 10(l)	mg	ca	—
⑫	Prospect	Pm and Ht vein	0.3(w), +2(l)	lm,mg,ml	ca,ga	1 pit
⑬	Outcrop	Pm	+1 (w), 20(l)	mg,lm	ep,ga,ca	—
⑭	Nameless working	Pm	10(w), 18(l)	mg,ml	ga,ep,ca	3 pits
⑮	Nameless working	Pm	2.5(w)	mg	ga,ca	1 tunnel
⑯	Outcrop	Pm	2.0(w)	lm,ml	—	—
⑰	Prospect	Pm	1.5(w)	mg,cp,py,po,ml	ga,ca	2 pits
⑱	Las Delicias	Pm	16(w), 40(l)	mg,cp,py,po,ml	ga,ep,ca	2 pits,1 tunnel
⑲	Outcrops	Pm	+16(w), 90(l)	lm	ga,ep,ca	—
⑳	Prospect	Pm	12(w), 20(l)	ml,lm	ga,ep,ca	1 shaft-tunnel
㉑	Santo Domingo 1	Pm	2.5(w)	lm	ga,ep,wo	1 shaft,1pit
㉒	Santo Domingo 2	Ht vein	1.0(w)	lm	ca	1 shaft-tunnel
㉓	Outcrop	Pm	1.0(w)	py,lm	ep,ca	—
㉔	Outcrop	Pm	+1.0(w)	lm	ca	—
㉕	Prospect	Pm	1.5(w)	py,lm	ga,ep,ca	1 shaft,1 tunnel
㉖	Outcrop	Ht vein	0.4~0.8(w)	ml,lm	ca	—
㉗	El Cambio	Pm	15(w), 40(l)	mg,cp,py,ml	ga,ep,ca	3 tunnels
㉘	"Piedra Iman"	Pm	5(w), 30(l)	mg,ml	ga,ep,ca	—
㉙	Nameless working	Ht ~ Pm	1.5(w)	mg,lm	ga,qz,ca	open pit
㉚	Nameless working	Ht cavity-filling	5(w), 8(l)	lm,jr	ca	1 tunnel
㉛	Prospect	Ht vein	3~4(w)	mg	—	1 pit
㉜	(Floats)	Pm	?	ba	ca,qz	—

Abbreviations: Ht, Hydrothermal; Pm, Pyrometasomatic; w, width, l; length; mg, magnetite; cp; chalcopyrite; py, pyrite; po; pyrrhotite; ml, malachite; lm, limonite; Jr, jarosite; ba, barite; ga, garnet; ep, epidote; ca, calcite; qz, quartz.

☆ Index number corresponds number of mines on the Fig. 4-2

Table 4-3 Metal Contents of Ore Samples from the EL TEJOCOTE Area

Ser. №	Sample №	☆Index № and Name of Mine	Au g/t	Ag g/t	Cu %	Pb %	Zn %	T.Fe %
1	A14M	① Prospect	—	65	—	1.8	3.73	—
2	A13M	② Prospect	—	23	—	0.74	3.92	—
3	A21M	④ Outcrop	—	9	0.06	0.01	0.03	—
4	A25M	③ (Floats)	—	44	0.68	0.01	0.26	—
5	A55M	⑤ Outcrop	—	—	1.3	—	—	—
6	A 6M	⑥ (Floats)	—	—	0.07	0.01	0.09	—
7	A31M	⑧ Outcrop	—	12	—	0.17	0.64	—
8	A10M	⑫ Prospect	—	—	0.14	0.01	—	—
9	C12MR	⑬ Outcrop	0.02	2	0.042	0.002	0.11	—
10	A58M	⑭ Nameless mine	—	—	3.3	—	—	38
11	A15M	⑮ Prospect	—	16	1.4	—	—	—
12	C103MR	⑱ Las Delicias	0.19	30	2.02	0.004	0.24	—
13	A19M	⑱ Las Delicias	0.26	20	1.4	—	—	44
14	A20M	⑱ Las Delicias	—	13	1.8	—	—	—
15	A40M	㉑ Santo Domingo 1	2.0	66	1.8	0.02	0.04	—
16	A39M	㉒ Santo Domingo 2	—	11	1.4	1.3	1.57	—
17	A38M	㉓ Outcrop	—	20	0.02	0.03	0.34	—
18	eA20M	㉔ Outcrop	—	0.5	0.029	0.003	—	—
19	A35M	㉕ Prospect	—	9	0.38	0.01	0.04	—
20	eA7M	㉖ Outcrop	—	0.7	0.016	0.003	—	—
21	eA3M	㉗ El Cambio	—	45.4	0.192	0.003	—	—
22	eA6M	㉗ El Cambio	—	9.3	0.192	0.004	—	—
23	A62M	㉗ El Cambio	1.6	66	2.3	0.02	0.12	29
24	A63M	㉘ "Piedra Iman"	—	—	0.42	—	—	62
25	A43M	㉙ Nameless mine	—	50	0.01	0.44	—	—
26	A45M	㉛ Nameless mine	0.11	2	0.25	0.01	0.18	—
27	eA9M	㉜ (Floats)	—	0.7	0.003	0.011	—	—
28	eA12MR	㉜ (Floats)	—	7	0.01	0.02	0.15	62

(—: not analyzed)

☆ Index number corresponds number of mine on the Fig 4-2 sphalerite in addition to those of the former type. These deposits are subjected to oxidation on the surface. The size of skarn varies from several meters to about 20 meters in width, and the extension reaches up to several hundred meters.

These skarn zones are intermittently arranged along the contact between intrusive rock and limestone. Therefore, the size of mineralized zone emplaced in the skarn is about 15 meters width in maximum and up to several tens meters in extension.

In terms the grade of ore, those of which composed mainly of magnetite show iron content of 44 to 66 percent of total iron, and iron sulfide dissemination-type skarn or those composed of limonite, jarosite and malachite, show the values such as Cu 1 - 2%, Au 0.2 - 0.3 g/t and Ag 20 - 30 g/t containing subordinate amount of lead and zinc.

As an unusual example (Nuevo Encino Prieto mine), such values were shown as Au 6.7 g/t, Ag 130 g/t, Pb 8.5%, and Zn 5.78%. Beside these, there found the ore rich in zinc as the result of secondary enrichment.

On the other hand, the hydrothermal type deposits have been emplaced in limestone at a distance from the intrusive rocks, being mainly distributed in the surrounding area of Plomosas, to the southeast of Peña Blanca and to the west-northwest of Encarnación. These show the shapes such as irregular veins or gently dipping mantos having filled the fissures and cavities in limestone. The veins are accompanied by weak to moderate silicification in the hanging and foot walls, having the thickness of one to three meters and lateral extension of about 15 meters. Since the deposit has been completely oxidized, ore minerals consist mainly of limonite and jarosite and sometimes are accompanied by small amount of malachite and magnetite. The ore grades are generally Ag 20 - 65 g/t, Pb n%, Zn n - n x 10% and Cu 0.n%.

Fig. 4-2, Table 4-2, 4-3 show the outline of each ore deposit in this area.

The results of geological, geophysical surveys and geochemical porspecting of the project reveal that ore deposits observed in this area, are rather small on a scale and also not so high grade.

Taking the results of the exploration works into consideration, this area cannot be ranked as a promising area.

4-3 EL ZAPOTE Mineralized Zone

The EL ZAPOTE Area is located to the south of the EL TETOCOTE area in the northern part of the project district (Fig. 4-3).

The villages of Puerto de Vigas and San Jose del Ore are situated in the northwestern part of the area, Las Milpas in central-northern end, Itatlaxo and Santo Domingo near the northeastern corner, Las Piedras in the north-central part, Pajeadi in the southern end. Nicolas Flores is located to the southeast of the area.

The major ore deposits, observed in this mining area, are respresented by the contact metasomatic type, mainly productive of iron and copper associated with lead, zinc, gold and silver in minor, and occur near the boundary of sedimentary and dioritic intrusive rocks. The skarnized zones, 30 to 150 meters wide, are well-developed in the periphery of the dioritic intrusive rock in the central mining area. Some roof-pendants of skarnized sedimentary rock, probably originated from the Mendez Formation, are observed in the central part of the intrusive mass. Both the El Doctor and the Mendez Formations are skarnized and they show preferably stronger skarnization in more muddy parts (Fig. 4-4).

Fairly wider skarn zones are well developed in the area, where the Black Flint-Bearing Medium-Bedded Limestone Member of the El Doctor Formation and the Mendez Formation are widely observed. Some skarn zones, considered to be originated from dioritic rock, are rarely observed along the road, eastwards from the Trinidad mine, where a lot of relics of dioritic rock texture, that is, pebbles less than 10 centimeters in diameter or breccia are observed in

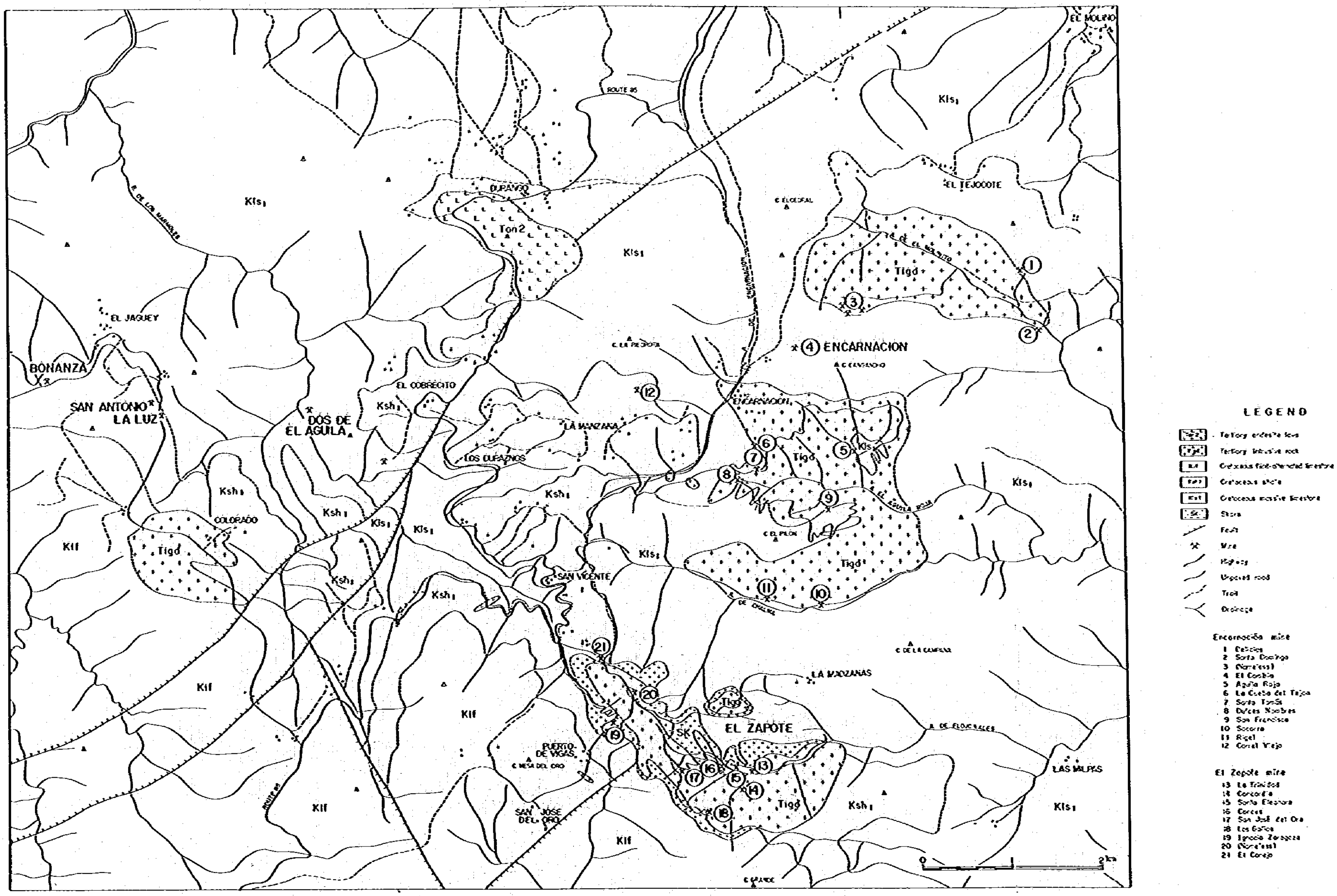


Fig. 4-3 Location Map of Metal Mines in the Encarnación-El Zapote Area

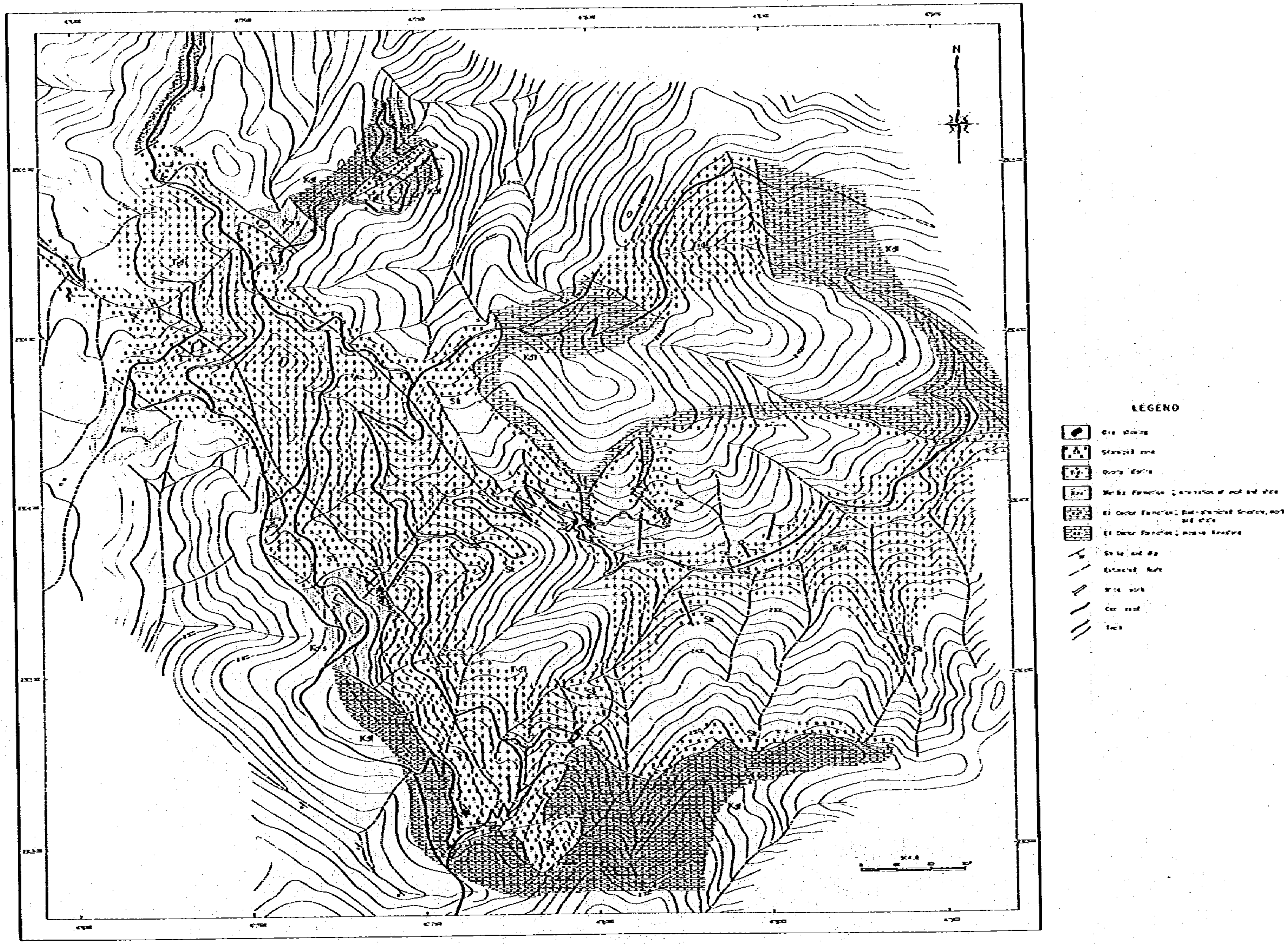


Fig. 4-4 Geological Sketch of the EL ZAPOTE Mining Area

garnet skarn at the boundary of the dioritic intrusive rock and massive limestone bed.

Ore body is formed in skarn zone and is concentrated by magnetite, chalcopyrite and bornite in an irregular or lenticular form. It is small in scale in general. The general dimensions of an ore body in the Corcus, Santa Eleanora and Trinidad mines, where the ore bodies have been fairly scrutinized, is estimated to be 5 to 10 meters thick and some 100 meters long on strike and 70 to 130 meters long on dip.

Type of the ore is classified in two groups; one is dominated by magnetite, associated with disseminations of chalcopyrite and other sulfide minerals; the other is almost composed of sulfide minerals. The former has been more productive mainly in the area and the latter has been coproductive in the Ignacio Zaragoza, San Jose del Oro, Trinidad and Los Gallos mines. The ores are oxidized by weathering near the ground surface.

Primary ore minerals are composed of magnetite, pyrrhotite, pyrite, chalcopyrite, bornite, sphalerite, and native gold, etc. Secondary sulfide minerals are covellite and chalcocite. Oxidized minerals are composed of hematite, goethite, hisingerite-like mineral, malachite, chrysocolla and azurite, etc.

Results of chemical analyses of ore samples in this mineralized zone range in the grade of 0.02 - 43.4 g/t of Au, 0.02 - 313.9 g/t of Ag, 0.26 - 23.7% of Cu, 0.00 - 3.18% of Pb and 0.04 - 5.20% of Zn.

Some samples from the San Jose del Oro and Los Gallos mines contain abundant gold, ranging from 13.8 to 43.4 g/t. Some samples from the Ignacio Zaragosa, Trinidad and Los Gallos contain some amount of silver, ranging from 167 to 313 g/t. The average copper grade of common copper ore, produced in the area, is considered to range from 1.5 to 8.6 percent copper among some fluctuations of figures in the table. It shows generally low grades in lead and zinc. The average grades of the ore, mainly composed of magnetite and produced in the mining area, are estimated to range 55 to 60 percent total iron and 1.5 to 8.6 percent copper.

Central part of the EL ZAPOTE Mining area is explored in detail by private companies and also there are active mines such as Santa Eleanora, Corcus, Trinidad and Ignacio Zaragoza.

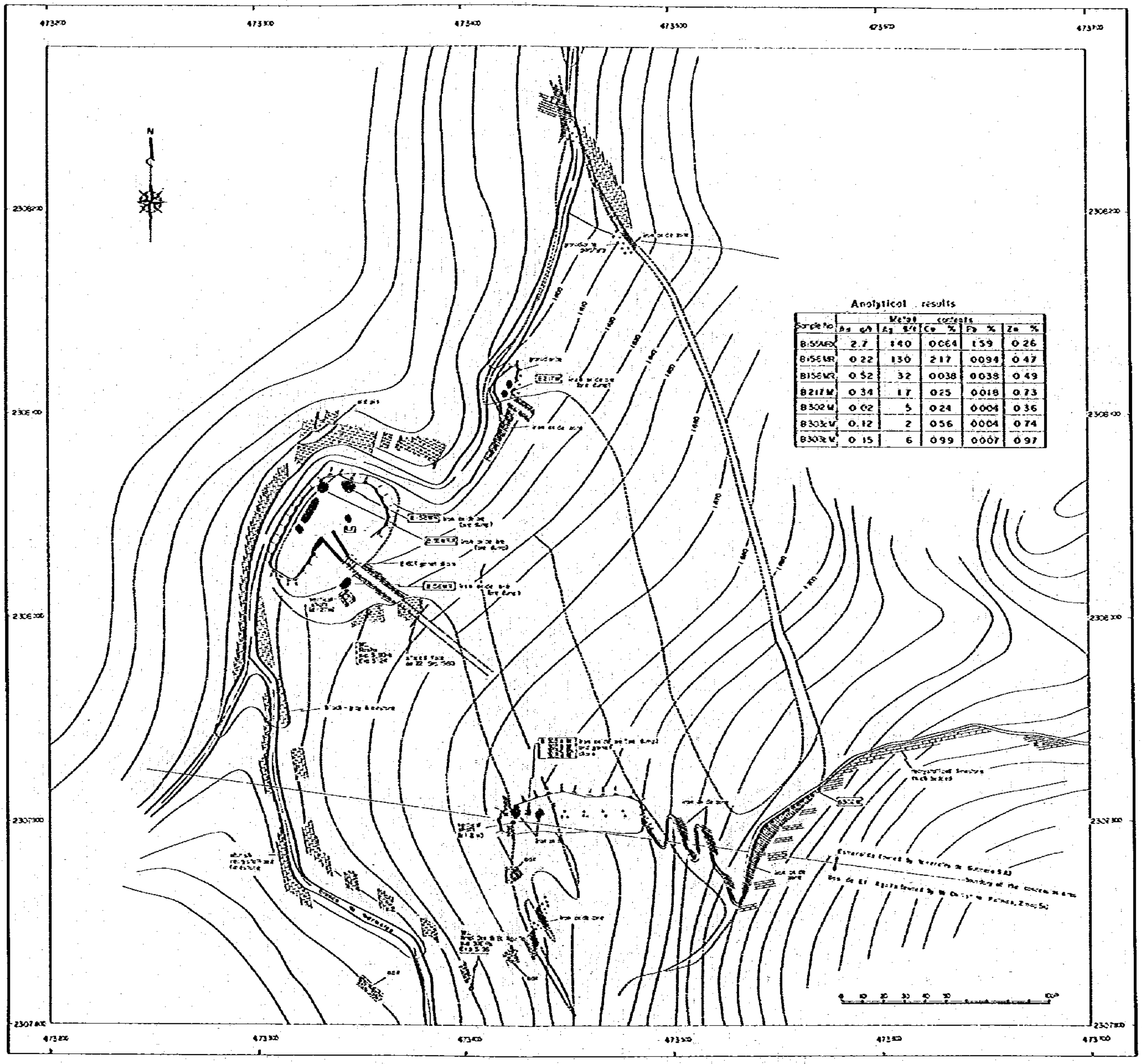
But, in the northern half of the area, especially to the west of the San Jose del Oro, it is presumed that latent skarn zone emplaces in the massive limestone by the geochemical Ag anomalies.

Furthermore, a similar occurrence of dioritic intrusive rock to that of in the EL ZAPOTE mining area, is observed 1 kilometer northeastwards from Las Piedras. A skarn zone, some 80 meters wide, is observed in the periphery of the diorite. They are situated under the similar geological conditions to that of in the EL ZAPOTE mining area. Future exploration programs to investigate any potentials of metal concentration in the environs of Las Piedras and San Jose del Ore, should be recommended.

4-4 DOS DE EL AGUILA Mineralized Zone (Ref. Fig. 4-5)

The zone is situated in the valley of Barranca de Los Mormoles to the west of Encarnación Village.

The Massive Limestone Member (kdl), intruded by dioritic small bodies, is observed in the mine area. Four bodies of the diorite are known in the mine area. The intrusive bodies are rather small in scale, some 300 meters long and some 60 meters wide. They are medium-grained, holocrystalline and partly porphyritic owing to euhedral plagioclase and quartz. A large amount of biotite and small amounts of hornblende and pyroxene are observed. Most of plagioclase phenocrysts are argillized and altered cloudy by weathering. Chloritization and epidotization are also observed at the contact to the limestone beds.



Analytical results

Sample No	Metal contents				
	Au g/t	Ag g/t	Cu %	Pb %	Zn %
B155WRX	2.7	140	0064	159	0 26
B156WR	0 22	130	217	0094	0 47
B156WR	0 52	32	0038	0038	0 49
B217M	0 34	17	025	0018	0 73
B302M	0 02	5	0 24	0004	0 36
B303kM	0.12	2	056	0004	0 74
B303kM	0 15	6	099	0007	0 97

Fig. 4 – 5 Geological Sketch of the Esmeralda and the Dos de El Aguila Mines

Pyrometasomatic ore deposits are observed in the area at the contacts of the limestone beds and dioritic intrusive rocks. Reddish-brown oxide ores by weathering are generally observed on ground surface. It is, however, considered that the ores are primarily composed mainly of disseminated magnetite, specularite (primary hematite), galena, sphalerite, chalcopyrite and pyrite, associated with gangue minerals, mainly garnet. Primary ore minerals are only discernible under the microscope in most cases. The major mineralized skarn zone in the adjoining area of the Dos de El aguila and the Esmeralda mines is well-developed on both sides of the dioritic intrusive body. The skarn zone is considered to be 20 to 40 meters wide, some 260 meters long in the eastern side and 15 to 25 meters wide, some 200 meters long in the western side, respectively.

The ores are properly oxidized by weathering. Chemical analyses of the ore samples show 0.02 to 2.7 g/t gold, 4 to 140 g/t silver, 0.00n to 14.49% copper, 0.004 to 1.59% lead and 0.098 to 1.62% zinc. Not so many results of high-grade showing were obtained that only some samples showed 126 to 140 g/t silver and 14.49% copper. A well-hematized sample shows 27.6% total iron.

Primary hematite (specularite), galena, pyrite and chalcopyrite are observed very rarely and otherwise hematite, maghemite, goethite, jarosite, cerussite and malachite are mostly observed as secondary minerals.

The mineralized zones in the amplification of the Esmeralda mine are observed near the bottom of stream. They occur on both side, east and west of the dioritic intrusive rock, 50 meters wide in maximum and some 100 meters long. The eastern zone occurs as a blackish-brown to reddish-brown, vesicular oxidized ore body, hemming round the diorite intrusive rock of irregular tongue-like form. It is observed in an open pit, 50 meters long and 15 meters high. The western zone is observed as a hematitized magnetite ore body, which is 3 - 7 meters wide, some 30 meters long, 10 meters high, N10°W-striking and 80° to 90°NW-dipping. It contacts itself to the limestone beds. Ore samples for assaying were collected from both of eastern and western zones.

It is interesting that a medium-ranked geochemical anomaly of lead has been revealed by stream-sediments in the northeastern end of the area. It is possibly conjectured that a blind ore mineralization of the Dos de El Aguila-Esmeralda mines-type or Cobrecito prospect-type may be expectable in the vicinity of the geochemical anomaly. Occurrences of dioritic intrusive rocks, similar type to that of the Dos de El Aguila and Esmeralda mines environ, are observed in mountainous part in the southwestern neighborhood of the area. They are considered to be generically related to the mineralizations of the La Luz, San Antonio and Bonaza mines. Some possibilities of new occurrences of mineralizations may be expected. It is likely proposed that the further-detailed investigation should be carried out in the southern area of the Luz mine, where dioritic intrusive rocks are observed, to examine the source of the geochemical lead anomaly and possibilities of new mineralizations other than that already known.

CHAPTER 5 MINERALIZED ZONE OF THE SAN CLEMENTE AREA

5-1 General Remarks

The gold-silver mineralized zone is comporised in an extent 300 m in N-S by 600 m in S-W at the western central part of the San Clemente potash rhyolite mountain mass (ref. Fig. 5-1, 5-2).

The SAN SEVERIANO mine which composed of two open cuts and many small pits and prospects, is located in the eastern part of the mineralized zone. In those days of the first phase survey, the mine was under mining operation by hand and pick on a small scale, and ore from the open cuts was being stored in plastic bags at mine site after crushing by a small jaw crusher. After that, mining operation had never been observed until October, 1981. Then, El Consejo de Recursos Minerales staked out a mining concession as national reserve in this area on November, 1981.

The survey works for four years consist of geological and geochemical (rock sample) surveys of the second phase to the all San Clemente mountain mass (2.5 km x 5 km), geological and geochemical (rock sample) surveys of the third phase to the three geochemically anomalous zone detected in the previous phase, and geological-geochemical surveys by trenching and channel sampling and diamond drillings of the final phase to the western mineralized zone which seemed to be most promising within the geochemically anomalous zone.

On the basis of the results of geological-geochemical surveys and laboratory examinations such as chemical analyses. microscopy.EPMA analyses and X-Ray diffractometry, scale, grade and distribution of the mineralized zone are deleneated, and also methods and area for next step exploration are synthetically studied. Outline of the results are described in following clause.

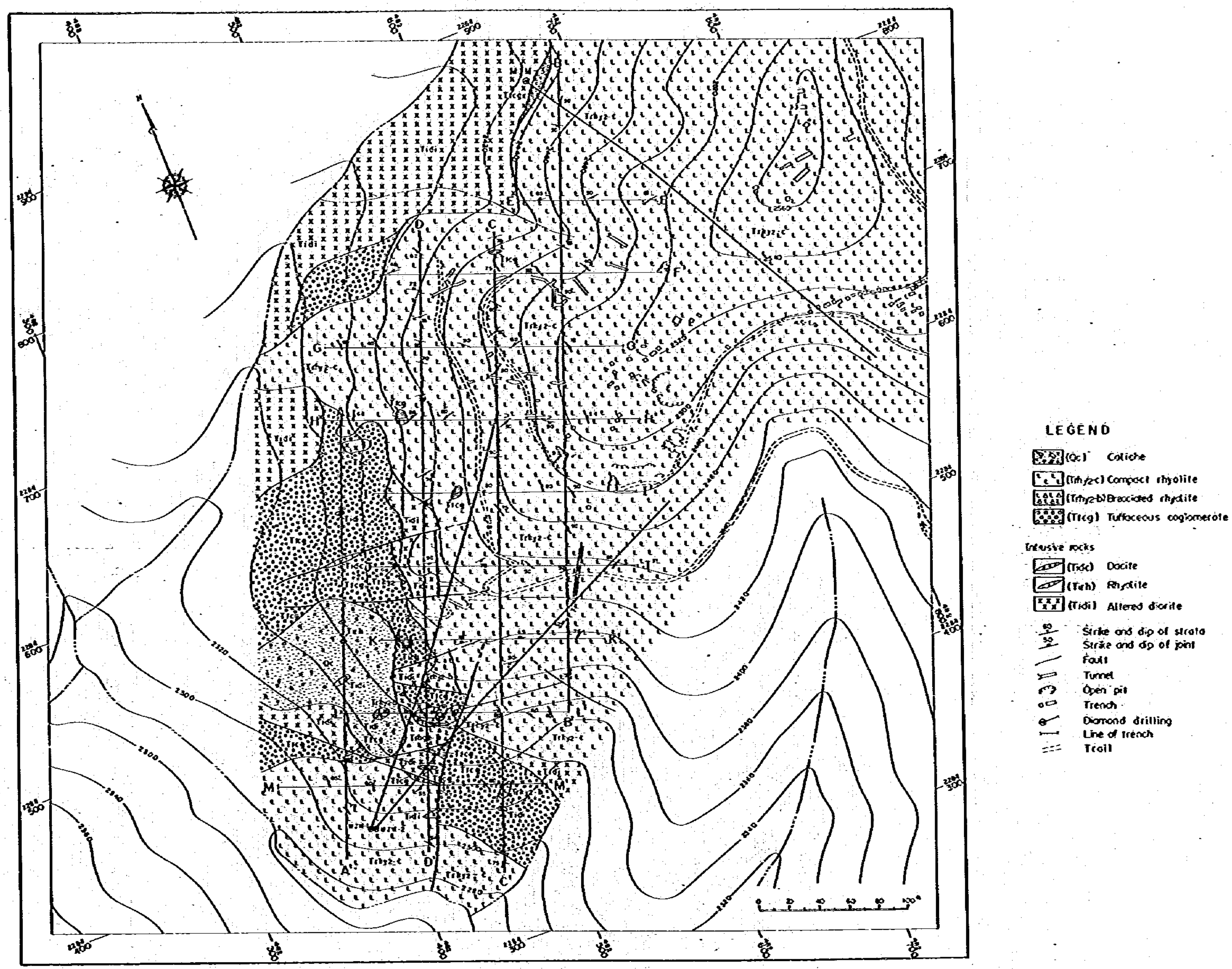


Fig. 5-1 Geological Map of the SAN CLEMENTE Area

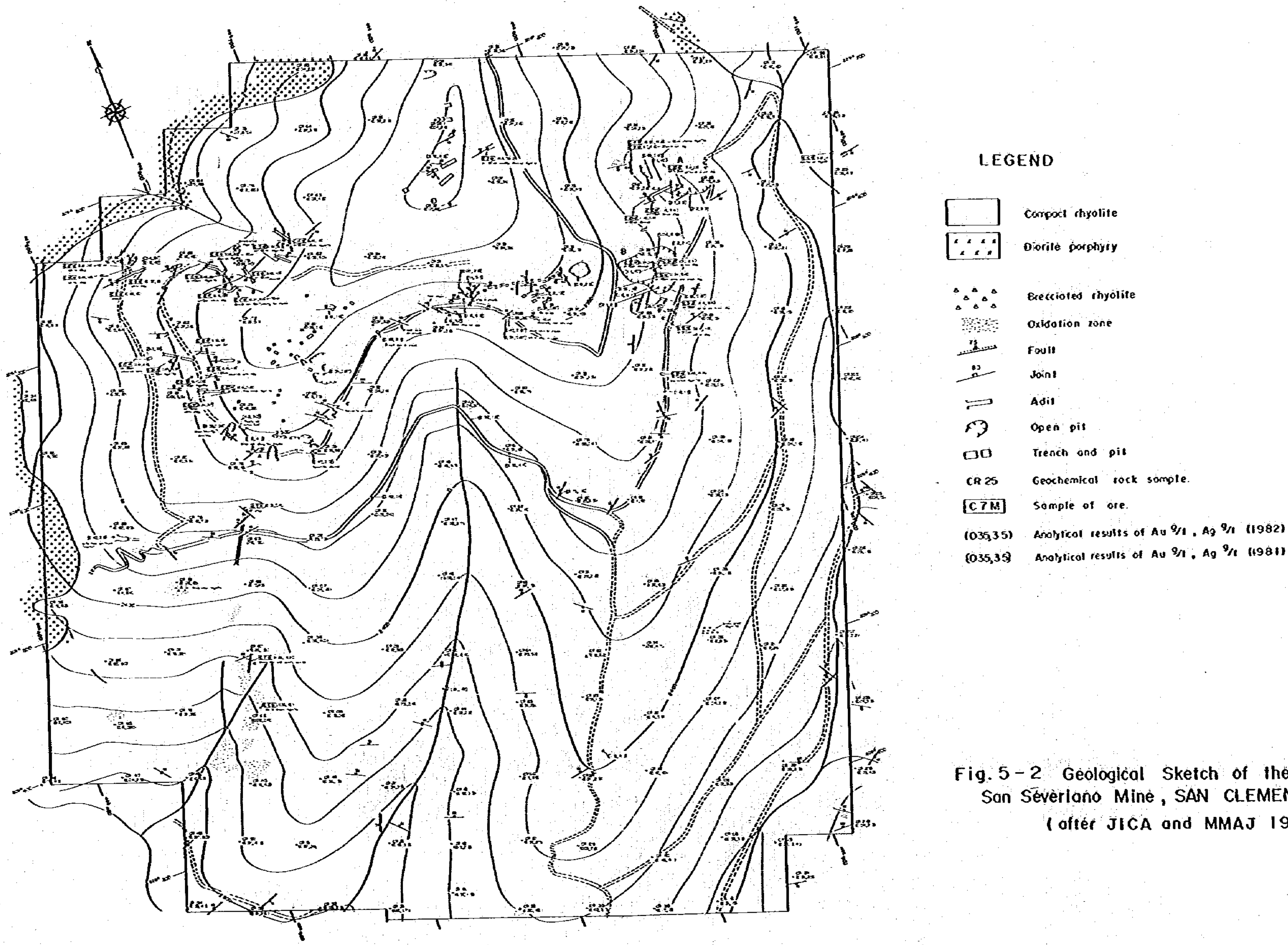


Fig. 5-2 Geological Sketch of the San Severiano Mine, SAN CLEMENTE (after JICA and MMAJ 1982)

5-2 Distribution (Ref. Fig. 7-1)

Within the geochemically anomalous zones, some portions are subdivided into the mineralized portions which contain Au 1 gram per ton and/or higher than it in average value. Extents and average grades of those are as follows:

Table 5-1 Extents and Average Au and Ag Contents of the Mineralized Portions

Location	Scale	No. of Sample	Average Contents (g/t)		Remarks
			Au	Ag	
SAN SEVERIANO Mining Zone					
Open pit-A	10m x 40m	4	1.95	2.32	channel sample (No.2∿No.5)
A-tunnel	5 m	2	1.43	4.40	chip sample (No. 6, 7)
Open pit-B	30m x 40m	10	1.31	2.41	channel sample (No.10∿No.19)
B-tunnel	5 m	2	4.05	2.45	chip sample (No. 20, 21)
Central Zone					
C-1 tunnel	0.5 m	1	18.6	728.2	chip sample (No. 24)
C-2 pits	20m x 30m	4	1.02	5.75	chip sample (No. 31∿34)
Western Zone					
W-1	10m x 20m	5	0.90	0.12	channel sample (No.43,44, 48,49,50)
W-2	15m x100m	11	1.18	0.85	channel sample B 45,46,47, I 36∿41 H 35,36
W-3	12m x 50m	6	1.50	0.72	channel sample C79∿81, G24∿26
W-4	15m x ?	3	2.59	0.13	channel sample F 44∿46

In these mineralized portions, (1) W-1 to W-4 belonging to the Western zone and (2) the other of the Central and the San Severiano Mining Zone were detected with channel-sampling of the final phase for the former and with chip-sampling of the second and the third phases for the latter respectively.

Accordingly, it is considered that average values of W-1 to W-4 portions are more reliable than those of the other.

Taking a wide view of the distribution, it can be said that gold mineralized portions are intermittently arranged from surroundings of the San Severiano mine to the west about 600 m in length.

Excepting the Western zone, there is need to clarify in detail geochemical behaviour of Au and Ag in the Central and the San Severiano zones by channel-sampling method as same as of the final phase.

5-3 Mode of Occurrence of Main Ore Mineral

The gold mineralization of this area occurs in weakly argillized zones, along some conjugate joint systems and rather fresh parts of the compact rhyolite showing a mode of irregular network to dissemination of fine electrum and sulfosalts grains with no remarkable hydrothermal-alteration such as quartz vein, silicification and carbonatization etc. which are commonly associated with ordinary gold deposits.

Because of absence of characteristic indications for prospecting and mining such as quartz vein or silicified zone, it is very difficult to observe the gold grain in the field directly.

As the result of observation of a number of samples containing gold grains to be observed with the aid of lens taken from the float ore scattered in the vicinity of old pits and the powder samples remained after chemical analysis, the occurrence of gold ore can be classified as follows.

(i) Hematite film type

Gold is observed as irregular to potato-like grains (0.05 mm - 0.2 mm across) on brown to chocolate-colored hematite film along tiny joint crack or fine network fissures. Sometimes microcrystals of quartz are observed on hematite film. In most cases, no crystal plane can be observed on the surface of gold grain.

(ii) Clay-hematite network type

It is the gold grain (about 0.05 mm across) which can be observed in clay of hematite network veins accompanied by greenish grey clay (montmorillonite and kaoline) cutting the fractured part of rhyolite. The gold grains of types (i) and (ii) show a golden color, which can obviously be discriminated with the aid of lens. These are abundantly observed at the pits of A and B of the San Severiano mine.

Quantitative analysis of these gold grains by EPMA revealed the composition to be of atomic rate of 65% - 67% in gold and 35% - 33% in silver, showing that they are electrum close to native gold (ref. Fig. 5-3).

(iii) Dissemination type

The gold and silver mineralized zone confirmed newly in the third phase at the position to correspond to the western end of the rhyolite body about 500 meters to the west of the San Severiano mine, is of the highest grade and of the largest scale in this area. This portion was named as Western Zone.

In order to investigate the occurrence of gold, sluicing was conducted on a small amount of powder sample obtained from the remains of the sample used for chemical analysis which showed the highest grade in the mineralized zone (No. CR-175, 17.0 g/t Au, 870 g/t Ag). As the result, a considerable amount of particles (0.05 mm - 0.2 mm across) of heavy minerals of dark silver grey with metallic luster having irregularly granular to potato-like shape, was obtained.

As the results of EPMA examination, those of heavy mineral grains were determined as the complex sulfosalts which consist of silver, copper, tellurium, antimony and lead as main components, and bismuth, selenium, arsenic, nickel, iron and sulfur including gold as accessories (ref. Fig. 5-4, 5-5).

At and around the sample position, no remarkable joint system, hydrothermal alteration nor old prospects are confirmed. The results of qualitative analysis by EPMA is as following table.

Table 5-2 Qualitative Analysis of Complex Sulfosalts Mineral by EPMA

	C	O	S	Fe	Ni	Cu	Zn	As	Se	Ag	Sb	Te	Pb	Bi	Au	Others
Type A	Δ	Δ	o	Δ	Δ	$	Δ	$	$	$	$	$	$	Δ	x	x
Type B	Δ	Δ	Δ	Δ	o	$	x	o	Δ	$	$	$	$	o	?	x
Type C	Δ	Δ	Δ	?	o	$	x	o	Δ	$	$	$	$	o	Δ	x

$: abundant o : Common Δ : rare x : not detected

? : difficult to identify

Beam spot size : approx. 80 μmφ

The ratio of silver to gold in average contents in each mineralized portions shows remarkable difference each other as seen in the Table 5-1. For example, one sample from the C-1 tunnel of the Central Zone has a ratio of fifty to one as an exception, but those of the Western Zone and the San Severiano Mining Zone are of one to two and also one to two or three respectively. This difference seems to be attributed to the fact that the principal ore mineral in the mineralized zone is of electrum which is close to native gold, and sulfosalts minerals are of accessories, whereas the sample of the C-1 tunnel contains mainly the sulfosalts minerals showing directly a marked difference.

In the many portions of drilling core samples of MJM-1 and MJM-2 in the final phase survey, base metal mineralization such as copper, lead and zinc is clearly observed within the tuffaceous conglomerate formation lain under

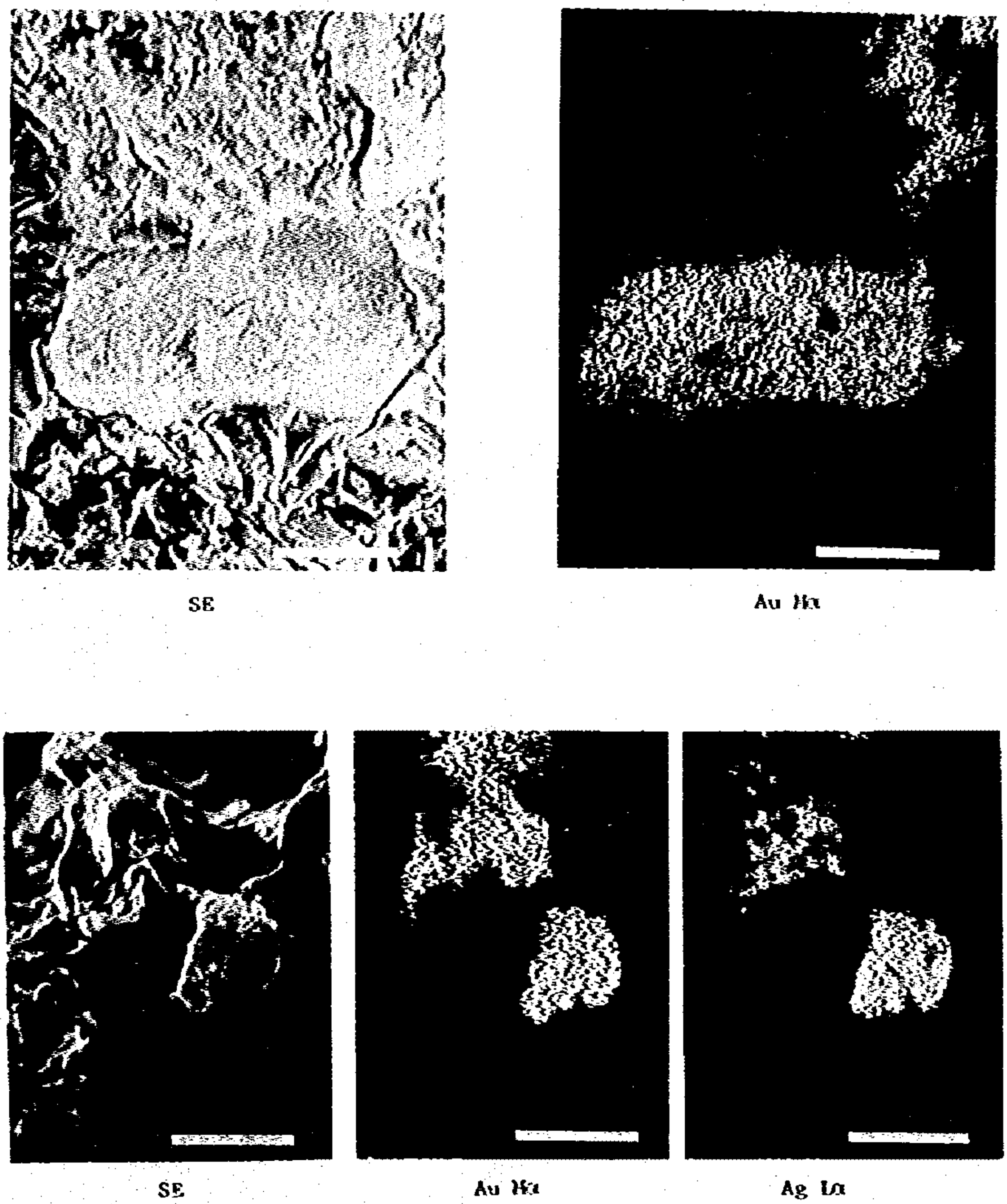


Fig. 5-3 Secondary Electron Images and Characteristic X-ray Images of Electrum Grains from the San Severiano Mine, San Clemente: bar scales show 40 μm.

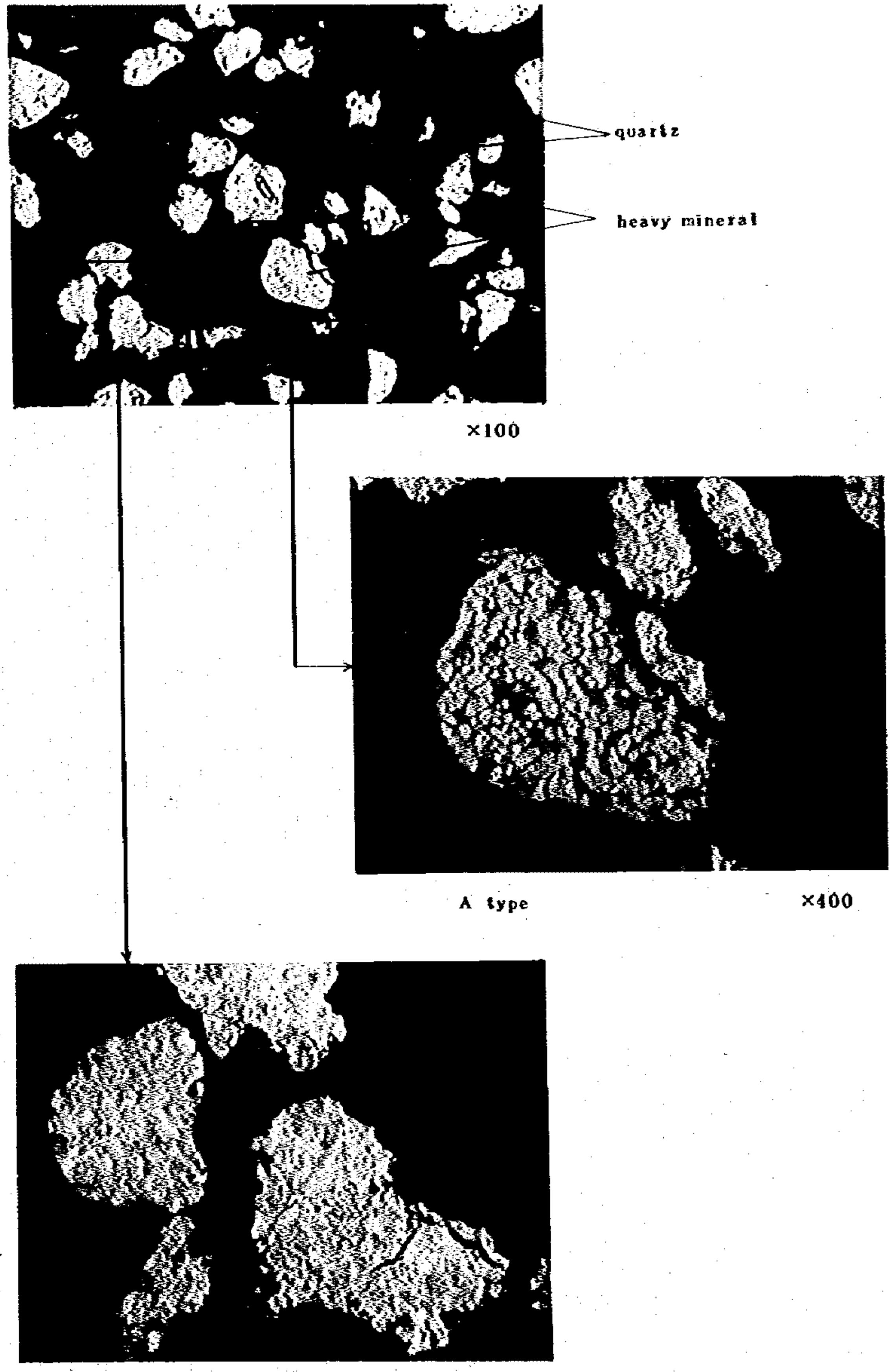
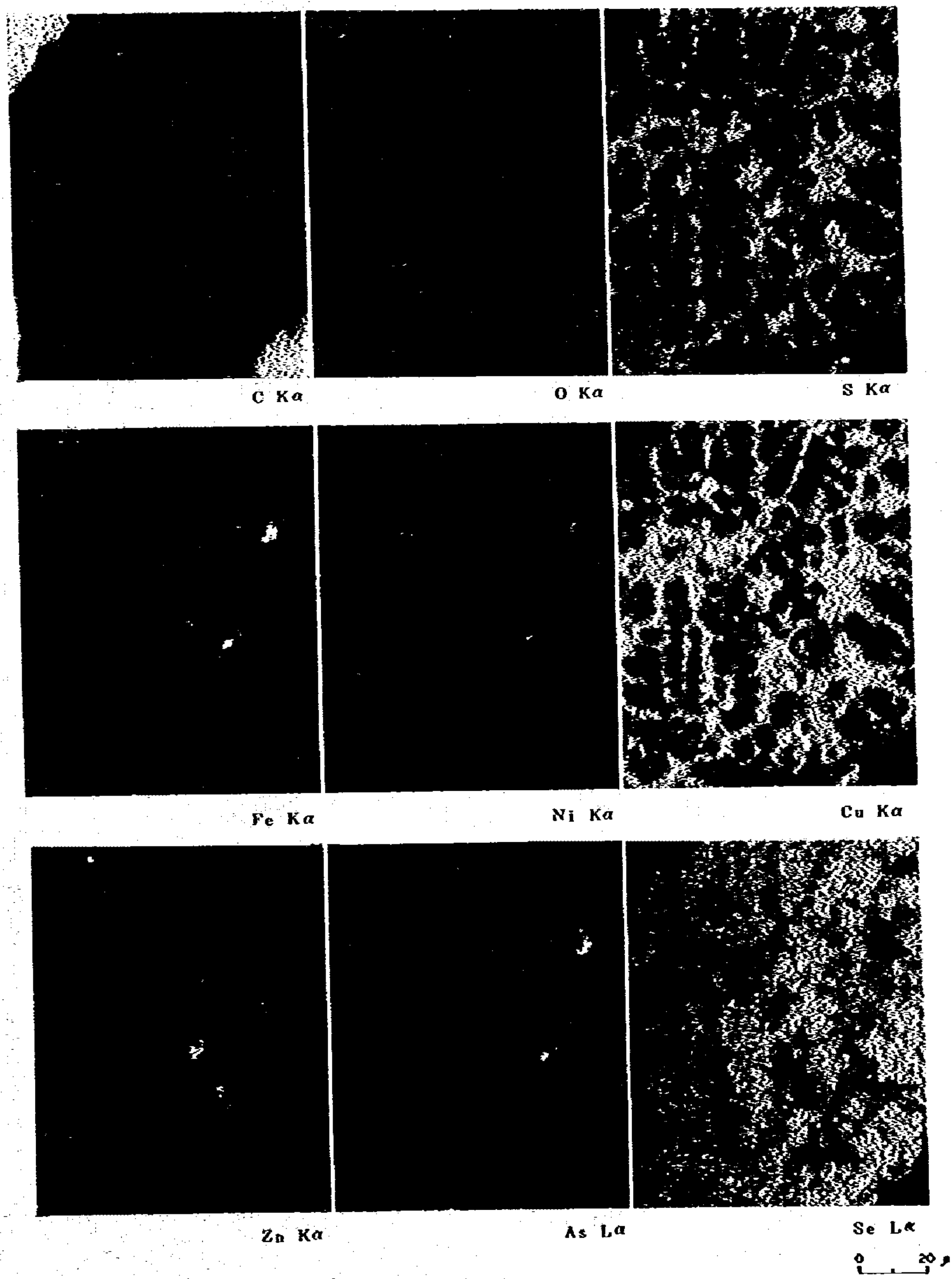


Fig. 5-4 Photomicrographs Showing textures of Complex-sulfosalts Minerals by Reflecting Microscope



(A type)

Fig. 5-5 Backscattered Electron Image and Characteristic X-ray Images of Complex-Sulfosalts Minerals

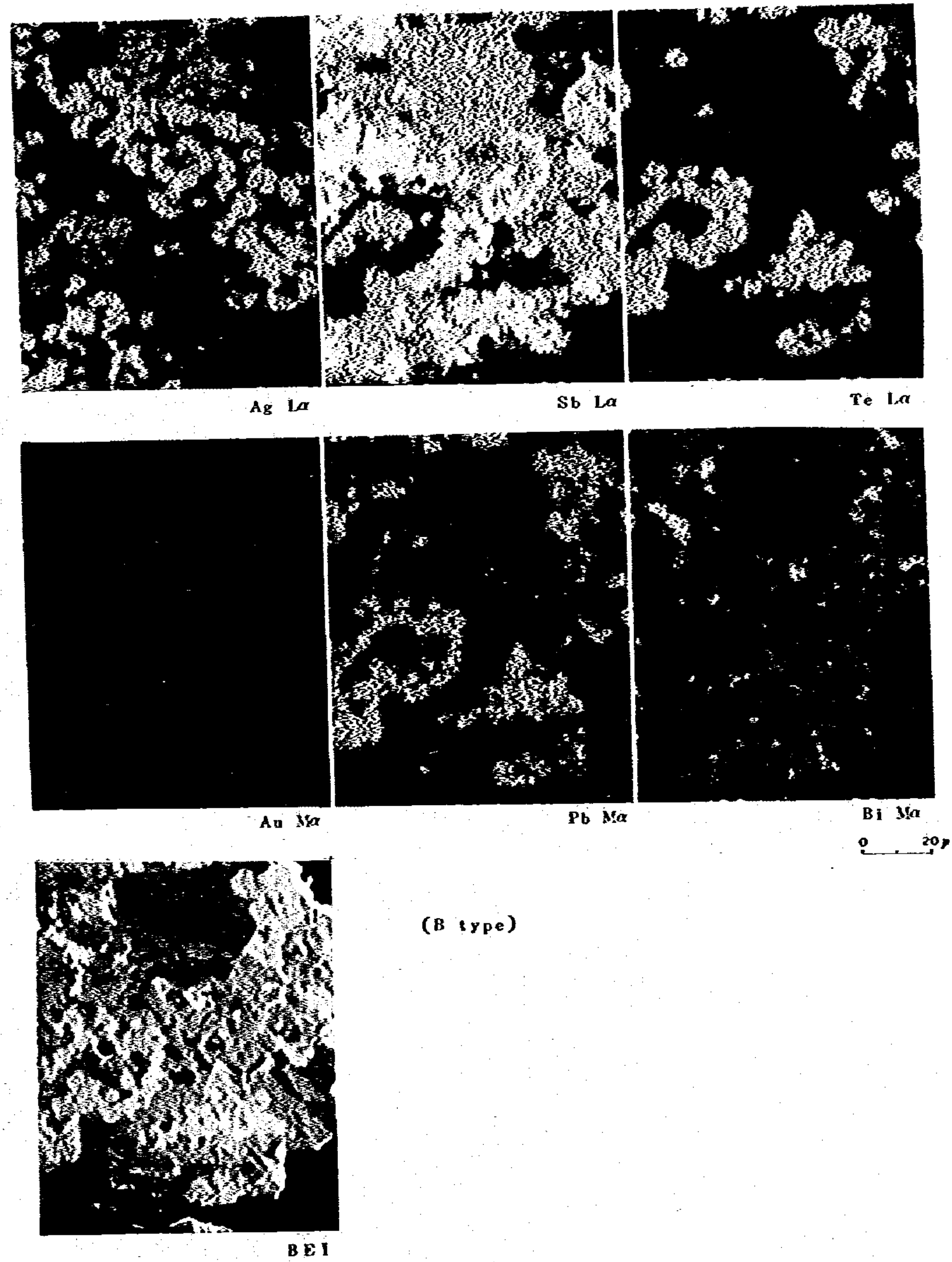


Fig. 5-5 (Continued)

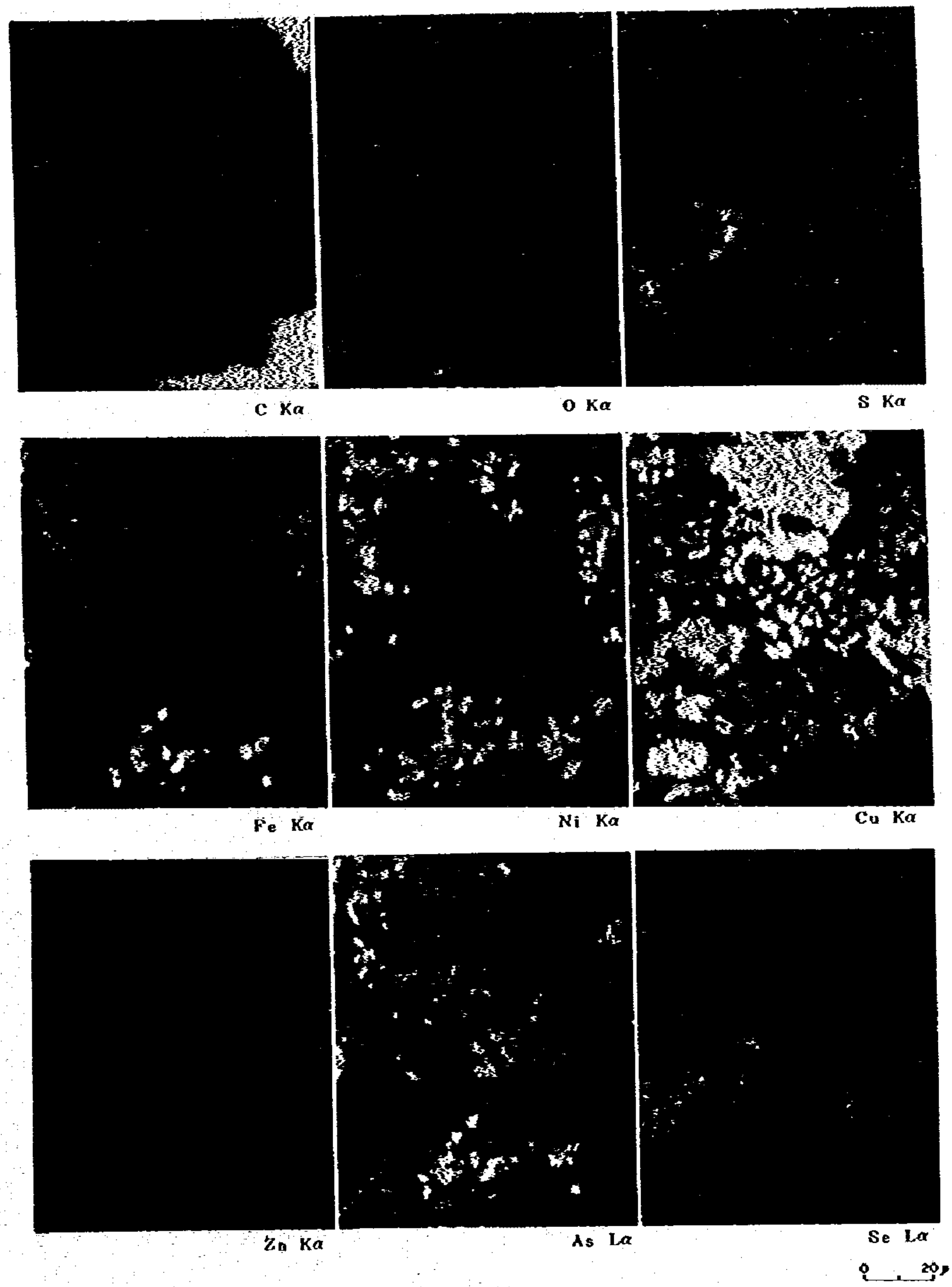


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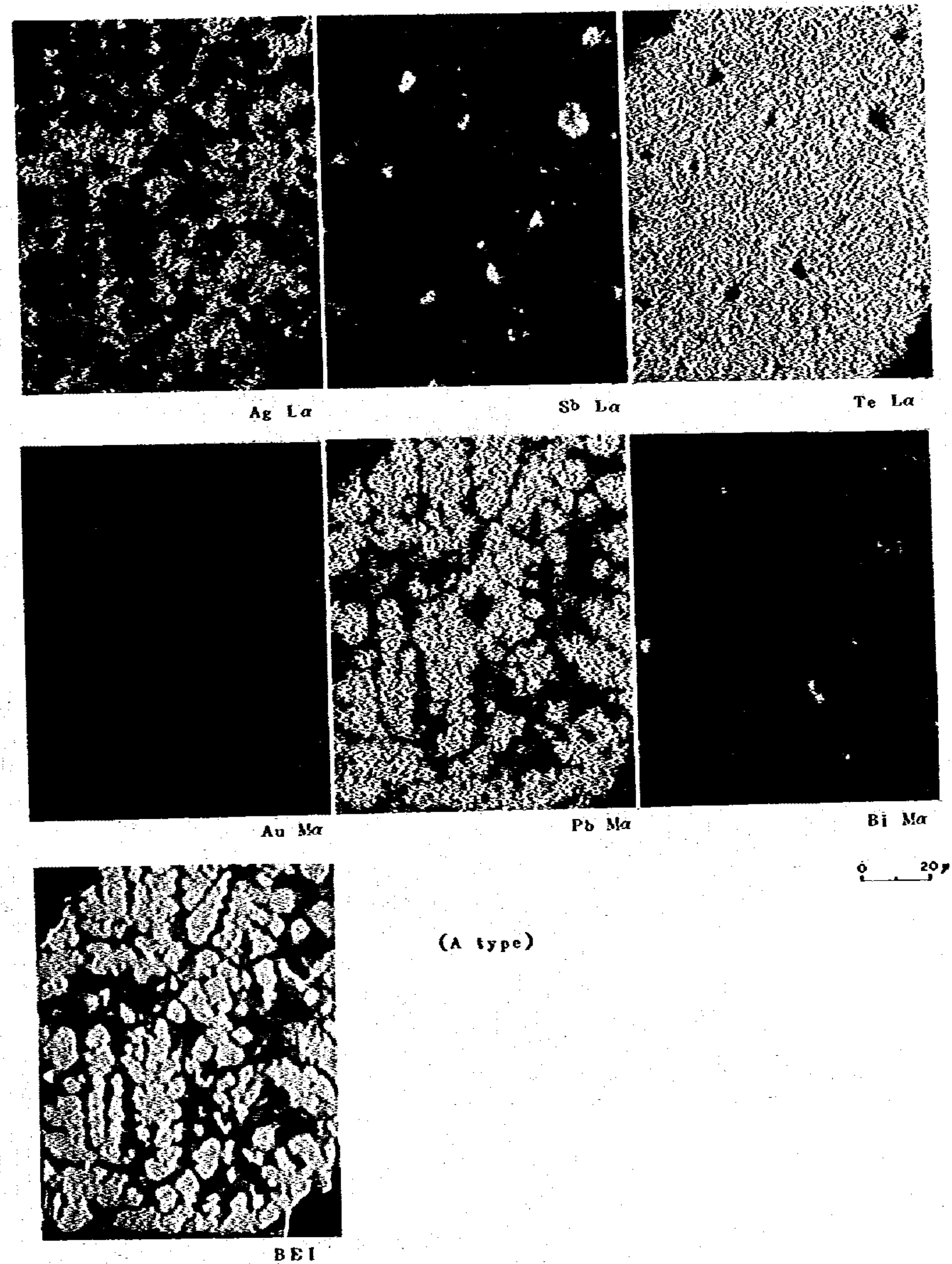
Fig. 5-5 (Continued)



(A type)

Fig. 5-5 (Continued)