REPUBLIC OF GUATEMALA
REPORT ON GEOLOGICAL SURVEY
OF
CUCHUMATANES AREA, WESTERN GUATEMALA

SUMMARY OF PHASE: I THROUGH III

FEBRUARY 1979

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

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Preface

The Government of Japan in response on the request of the Government of the Republic of Guátemala, decided to conduct a geological survey for mineral exploration in Huehuetenango and El Quiché Departments, western Guatemala and commissioned its implementation to the Japan International Cooperation Agency.

The Japan International Cooperation Agency, considering its technical characteristics, commissioned the Metal Mining Agency of Japan to accomplish the project within a period of three years(1976-1978). The survey has been carried out in three stages.

To carry on the field works, the Metal Mining Agency of Japan dispatched the survey teams headed by Dr.K.Uchida in the following terms: From October 20 to December 29,1976(1st stage). From September 7, 1977 to March 21, 1978(2nd stage). From June 23 to October 26,1978(3rd stage). During their stay, they could carry out the field works very successfully in special collaboration with Dirección General de Minería e Hidrocarburos (present Secretaría de Estado para Minería, Hidrocarburos y Energía Nuclear), and Embassy of Japan.

This report summarizes the results of the three stages, and the details of each stage are described in the report of that stage.

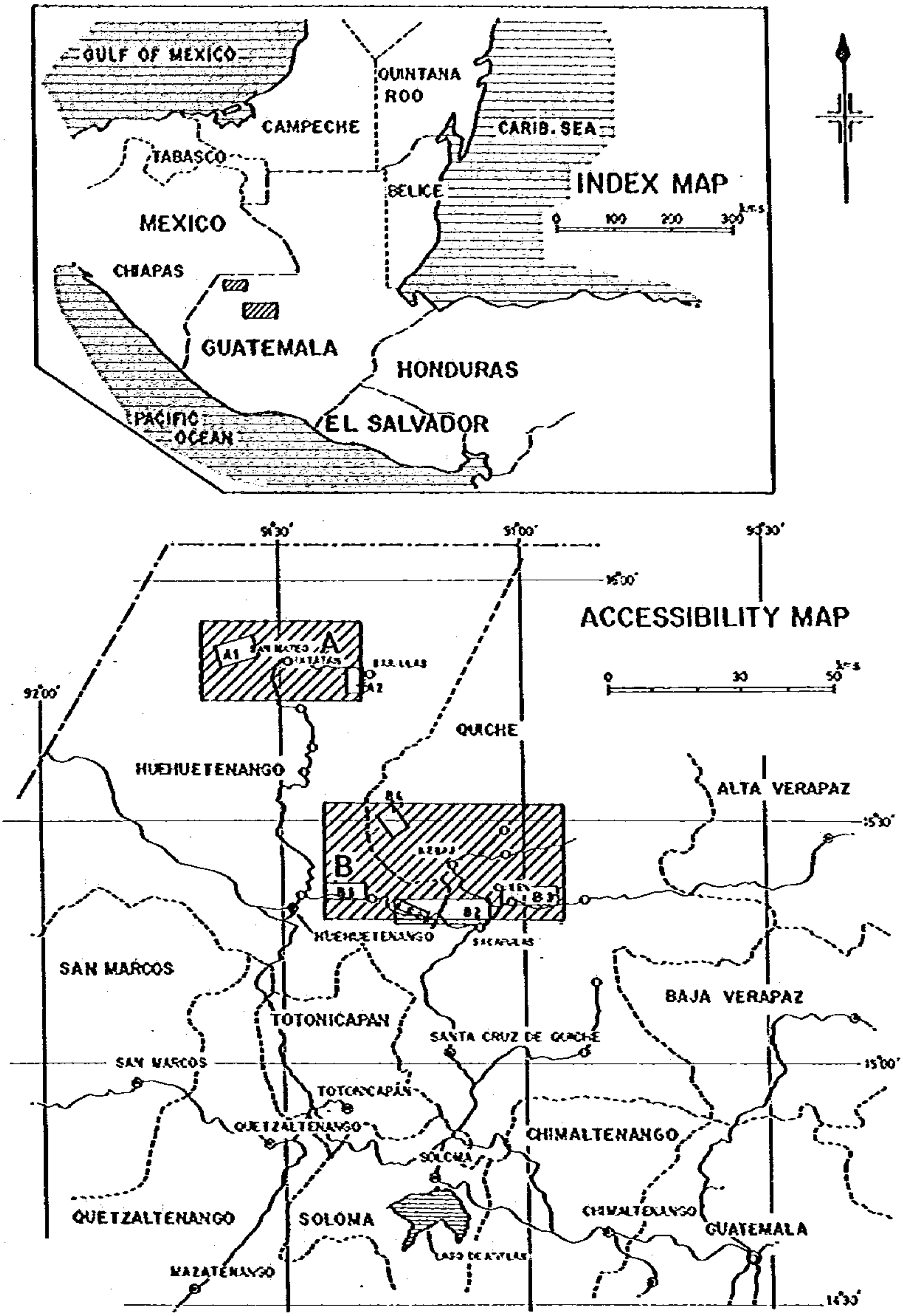
We wish to express our heartfelt gratitude to the Government of the Republic of Guatemala, Secretaría de Estado para Minería, Hidrocarburos, y Energía Nuclear, and other authorities and the Embassy of Japan for their cooperation and support extended to the Japanese Survey teams.

February,1979

Shinsaku Hogen
President
Japan International Cooperation Agency

Masayuki Nishiie
President
Metal Mining Agency of Japan

Fig 1. LOCATION MAP OF PROJECT AREAS



Abstract

A 3-year mineral survey project, was carried out in a term between 1976 and 1978 fiscal years, in the Altos Cuchumatanes area, western Guatemala. The effort was mainly concentrated in the exploration of non-ferrous metallic minerals.

The field works of the 1st phase were performed from October through December in 1976, in two areas totaling about 2,000 sq.km. It comprised works of so-called reconnaissance type, including geological mapping (1/50,000), and geochemical sampling of soil and stream sediments(2,352 samples. 3 elements Cu, Pb, and Zn, as indicators).

The field works of the 2nd phase were carried out from September 1977 through March 1978. The works consisted of follow-up works for six selected areas (total 297 sq.km) and exploration works for the Llano del Coyote Prospect(14 sq.km). The former six areas were selected from geochemical anomalies that had been located by the reconnaissance in the 1st phase. The latter was selected from the review of the UN report. The follow-up works comprised geological mapping in 1/20,000 scale and geochemical sampling of soil samples (1,671 samples. 4 elements Cu,Pb,Zn and Ag as indicators). On the other hand, the exploration works for Llano del Coyote comprised geological mapping in 1/10,000 scale, grid-sampling of geochemical soil samples (861 samples. 4 elements Cu,Pb,Zn and Ag as indicators), geophysical surveys (IP 42 line·km, ground magnetic 72 line·km), and three diamond drill holes totaling 830.7m.

The field works of the 3rd phase were carried out from June through November in 1978. The exploration works of this phase were concentrated in the Llano del Coyote area, after the results obtained in the 2nd phase had been compared. 7 diamond drill holes totaling 1,203m were carried out in geochemical and geophysical anomalies that had been located in the 2nd phase. Geological mapping in 1/5,000 scale was supplementarily performed in a 5-sq·km area in the central part of the prospect, where drill sites were situated.

Followings are the results of our 3-year project:

(1) Area-C Llano del Coyote: 10 DDHs totaling 2,033.7m were carried out in two phases, to explore Zn-mineralization of skarn to hydrothermal replacement type. As a result, a promising Zn-mineralization was intersected between 88.6m and 98.1m in DDH MJ-9(12.76% Zn for 9.5m) in Phase-III.

In the same hole, an intersection with supergene chalcocite (82.3-82.6m 3.80% Cu for 0.6m) was also intersected at the lowermost part in the oxide zone. These intersections are located in plan approximately 150m and 135m apart from the "%-order Zn-intersections" in MJ-1 (oxide, 1.42% Zn for 5.9m) and UN-4 sulfide, 2.96% for 5.5m), respectively. The Zn-intersections are stratigraphically situated in a skarn horizon that occurs near the boundary between the Tactic and Chicol Formations. The skarn is mineralogically rich in chlorite and tremolite-actinolite, at least in these three intersections.

The drill results very well correlate to geochemical anomalies of rock-chip samples collected on the surface in Phase-III: The "%-order Zn-intersections" of 3 DDHs mentioned above are all located just underneath anomalies delineated by 500 ppm Zn, and another DDH(MJ-10) in the anomalies also intersected "0.n%-order Zn-mineralization". On the other hand, all other DDHs with insignificant results are located outside the anomalies. The anomalies seem to reflect halos of primary dispersion accompanied by mineralization, as the mineralized skarn horizon in the three DDHs rarely expose on the surface in the proximity.

The 500ppm-Zn anomalies have an extent of 3.6km by 0.2km as a whole, therefore, further exploration is very much expected.

On the other hand drill results do not correlate well to geochemical anomalies of soil samples. This is probably due to displacement of indicators in soil to topographically lower positions by secondary dispersion (supergene alteration and/or mechanical transportation of soil).

IP anomalies, especially those defined by 3%-FE, very well reflect pyrite concentration underneath the leached capping, but not zinc.

No conclusion can be made at present on applicability of magnetic survey, as the most prominent inferred magnetic body (W4-0) has not been drilled as yet. A widely distributed weak magnetic body that occurs overlapping IP anomalies may be attributed to magnetite that occurs in pyrite zone.

(2) Other Anomalies: Only geochemical anomaly, among those selected from the follow-up works in the 2nd phase, to which we feel further exploration is required is "Peñasco-Pacumal Anomaly" in Area-A-1. The anomaly has an extent of 3.0km by 0.7km, and its average assay values in ppm are 678 Cu, 140 Pb, 2,117 Zn, and 9.7 Ag, and its maximum assay values in ppm are 2,875 Cu, and 12,000 Zn. This is located in an area that surrounds the old Laurita prospect, which is of Pb-Zn mineralization in the carbonate rocks of the Paleozoic, and resembles so-called Mississippi Valley type.

For this anomaly, we consider certain kinds of exploration works, such as clearing of old tunnels and trenching of the outcrops, are necessary some day in future.

Our conclusion on the exploration potential of the metallic (especially non-ferrous metallic) minerals in the project areas is as follows:

(1) Metallic, especially non-ferrous metallic mineralization is weak in the project areas. This may be attributed to the fact that there is very little acidic intrusive occurrence in the areas. We conclusively consider that there remains little possibility that a metallic deposit with mineable reserves of say n x 10^7T or more occurs in the areas.

(2) We guess that only mineralization types that have the possibility of yielding small scale operating mines in future are skarn-to-hydrothermal replacement type(Cu-Zn), Pb-Zn mineralization in the Paleozoic carbonate rocks,and massive chromite in peridotite.

(3) Skarn-to-hydrothermal replacement type: In Area-C Llano del Coyote, geochemical anomalies of rock-chip samples (≥500ppm Zn) are remained enexplored, in which HJ-9 is located. Therefore, possibilities that n x 10^5T to n x 10^6T reserves exist in the area are fairly great. A deposit may be exploitable even this size, should its Zn grade be as high as that of HJ-9, as the prospect is favorably located to minimize cost for infrastructures. Further exploration is strongly recommended.

(4) Pb-Zn mineralization in carbonate rocks: Only ground that was detected as a conspicuous geochemical anomaly is the above-mentioned "Peñasco-Pacumal anomaly". Other than this, Pechâc, Saclecân, Peña de Plata, and so forth, are the showings of this type, though they could not obviously be recognized as geochemical anomalies. We consider that there still remains the possibility that high grade bonanzas may locally exist somewhere in these showings or elsewhere. However, we also infer that their dimension might be of the order of 10^4T at most, if any. As most of the anomalies and showings of this type are located in remote areas where the infrastructure is poorly provided, we consider that it might be very difficult, if not impossible, to exploit these deposits in near future, even if some high grade small bonanzas occurred. Therefore, we believe that the exploration priority to this type in the project areas is fairly low, and that whether additional exploration is needed or not should be judged when the reconnaissance to all the possible fields in Guatemala has been completed.

(5) Chromite deposits in ultrabasic rocks: There is no known showing that warrants commercial production in near future. However, we could not entirely denny the possibility that small new ore bodies may be discovered. We speculatively guess that the dimension of an ore deposit, if it should be discovered, would probably be of n x 10^3T or smaller.Even such a small ore, deposit, it might have chance to be mined as a side business by local people, when the market price rose business.

Followings are our technical findings which may be referred to,or can be utilized in a further exploration program in other places in Guatemala:

(1) An area, where acidic intrusives(especially those from the Cretaceous to the Paleogene in age) abundantly occur, may be more favorable for a target area for regional reconnaissance of non-ferrous metals.

(2) Geochemical survey was the most usefull exploration tool in the present project, through out all the stages from reconnaissance to scout drill. As the statistical technique for data processing in the reconnaissance stage, "Rolling Mean Analysis or Moving Average Analysis" was very useful. Especially, the "high standard deviation areas" in that analysis well revealed the areas suffered from mineralization. Therefore, the application of the Rolling Mean Analysis is recommended in the future exploration.

The rolling mean analysis may also be applied to determination of threshold values: the surface formed by "rolling mean + 2 standard daviations of the values within the search area", which is prepared in the reconnaissance stage, could be used as threshold values in both the reconnaissance and follow-up stages. In this case, an area in which the residual of the assayed value less the calculated surface is positive, is taken as an anomaly. On indicators, it is recommended to add at least Au to the four elements.

(3) IP anomaly well revealed the pyrite zone that occurred below the leached capping. Therefore, naturally, IP is worth applying to exploration of a deposit in which useful minerals are expected to accompany pyrite. It is also worth applying as a supplementary tool, when the oxide zone is deep, or when mineral zoning is expected to exist with pyrite halo.

Table of Contents

Text

Preface ---------- i

Abstract ---------- iii

1. Introduction

1-1 Chronology, Works carried out, Personnel, and Ackowledgment ---------- 1

1-2 Previous Works in the Project areas ---------- 6

2. General Information

2-1 On Guatemala ---------- 8

2-2 On the Project Areas ---------- 10

2-2-1 Location ---------- 10

2-2-2 Access ---------- 12

2-2-3 Communication ---------- 13

2-2-4 On Huehuetenango City ---------- 14

2-2-5 Physiography ---------- 14

2-2-6 Climate ---------- 15

2-2-7 Vegetation ---------- 16

3. Geology

3-1 Introduction ---------- 17

3-2 Field Works ---------- 19

3-3 Description and Presentation of Results ---------- 19

3-4 Geological Setting ---------- 21

3-5 Stratigraphy and General Geology ---------- 25

3-6 Intrusive Rocks ---------- 29

3-6-1 Acidic to Intermediate Intrusive Rocks ---------- 29

3-6-2 Ultrabasic (ultramafic) rocks ---------- 39

3-7 Structural Geology ---------- 41

3-8 Mineralization ---------- 43

3-8-1 Metallic Minerals ---------- 43

3-8-2 Non-metallic Minerals ---------- 55

3-9 Localization of metallic Mineralization ---------- 55

3-9-1 Localization of Metallic Minerals other than Chromite ---------- 56

3-9-2 Localization of Chromite Mineralization ---------- 57

4. Geochemical Survey

4-1 General Remarks ---------- 58

4-2 Field Works, Samples, Preparation, and Chemical Analysis ---------- 59

4-3 Assay Result and its Presentation ---------- 60

4-4 Statistical analysis of results ---------- 61

4-4-1 Selection of Statistical Techniques ---------- 61

4-4-2 Determination of Threshold Values ---------- 63

4-4-3 Determination and Presentation of Anomalies ---------- 83

4-4-4 Rolling Mean Analysis ---------- 86

4-4-5 Correlation Analysis ---------- 90

4-5 Selection and Evaluation of Target Areas ---------- 90

4-5-1 Selection of Follow-up Areas from Phase-I Anomalies ---------- 90

4-5-2 Selection of Target Areas from Phase-II Anomalies ---------- 91

4-5-3 Correlation between Geochemical Anomalies and Drill Result ---------- 92

4-5-4 On Unexplored Geochemical Anomalies ---------- 92

4-6 Discussion ---------- 92

4-6-1 On Indicators and Path Finders ---------- 93

4-6-2 On Data Processing Method ---------- 93

4-6-3 On Threshold Values ---------- 94

4-6-4 Limonite Zone and Geochemical Results ---------- 94

4-6-5 Pb-Zn Anomaly in Carbonate Rocks ---------- 95

4-6-6 Geochemical Exploration by Rock-chip Samples ---------- 95

5. Geophysical Survey

5-1 Introduction ---------- 96

5-2 Works carried out ---------- 97

5-3 Induced Polarization (IP) ---------- 98

5-3-1 Kinds of Works and their Specifications. ---------- 98

5-3-2 Field Measurements and Equipments ---------- 98

5-3-3 Results and their Presentation ---------- 100

5-3-4 Summary of the Results ---------- 103

5-4 Ground Magnetic Survey ---------- 110

5-4-1 Results of Measurement ---------- 111

5-4-2 Results of Interpretation ---------- 111

5-5 Discussion ---------- 112

6. Diamond Drilling

6-1 Works carried out -- 115

6-2 Purpose --- 115

6-3 Results of DDHs -- 115

7. Conclusion and Recomendation

7-1 On the Exploration potential of the Project Area ------------- 120

7-1-1 General -- 120

7-1-2 (Cu-Zn) Skarn-to-Hydrothermal Replacement Type ---------- 120

7-1-3 Pb-Zn Mineralization Carbonate Rocks -------------------- 120

7-1-4 Chromite Ore in Ultrabasic Rocks ------------------------ 121

7-2 On Selection of Further Target Areas in Guatemala ----------- 121

7-3 On Exploration Methods -------------------------------------- 121

7-3-1 Geochemical Survey -- 121

7-3-2 On Geophysical Survey ------------------------------------- 122

References -- 124

Plates in Attached Map Folders

PL-1 Geologic Map ------------- Area A --------------- 1:50,000

PL-2 Geologic Map ------------- Area B --------------- 1:50,000

PL-3 Geological Sections ------ Area A --------------- 1:50,000

PL-4 Geological Sections ------ Area B --------------- 1:50,000

PL-5 Composite Map showing Geochemically Anomalous Areas
------ Area A --------------- 1:100,000

PL-6 Composite Map showing Geochemically Anomalous Areas
------- Area B -------------- 1:100,000

Tables in Text

		Page
Table 1	Field Works carried out in Phase I~III	3
Table 2-A	Personnel from MMAJ-JICA	4
Table 2-B	Counterpart from DGMH of Guatemala	5
Table 3-A	Major Economic Indicators of Guatemala	9
Table 3-B	Major Exporting and Importing Nations	9
Table 3-C	Major Commodities for Export and Import	9
Table 4	Location of Project Areas(Phase-II)	10
Table 5-A	Chemical Analysis of Igneous Rocks (Phase-I)	33
Table 5-B	Chemical Analysis of Igneous Rocks (Phase-II)	34
Table 6-A	Norm of Samples Taken in Phase-I	35
Table 6-B	Norm of Samples Taken in Phase-II	35
Table 7	K-Ar Ages of Granitic Rocks	38
Table 8	Summary of known Prospects & Showings	45
Table 9-A	Statistics of Geochemical Sampling(Phase-I)	59
Table 9-B	Statistics of Geochemical Sampling(Phase-II)	59
Table 10-A	Summary of Statistical Data of Geochemical Samples (Phase-I) (1) Area-A, Stream Sediments by Drainage Basins	66
Table 10-B	Summary of Statistical Data of Geochemical Samples (Phase I) (2) Area-B, Stream Sediments by Drainage Basins	67
Table 10-C	Summary of Statistical Data of Geochemical Samples (Phase I) (3) Area-A, Soil by Formation	68
Table 10-D	Summary of Statistical Data of Geochemical Samples (Phase I) (4) Area-B, Soil by Formation	69
Table 11	Comparison of Threshold Value & Population by the Graphical & the Classical Methods	74
Table 12	Summary of Statistical Data of Geochemical Samples (Phase-II)	78
Table 13	Summary of Threshold Value(Phase-II)	80
Table 14	Anomalous Areas Chosen Statistically(Phase-I)	84
Table 15	Summary of Major Geochemical Anomalies (Phase-II)	85
Table 16	Correlation between Geochemical & Geophysical Anomalies, & DDH Results.	113
Table 17	Summary of Diamond Drill Holes	116
Table 18	Summary of Mineralized Diamond Drill Intersections	117

Figures in Text

		Page
Fig.- 1	Location Map of Project Areas	ii
Fig.- 2	Road Map of Project Areas	11
Fig.- 3	Map showing Geological Setting & Previous Works	7
Fig.- 4	Relationship between Mineralization & Structure(Area-A)	23
Fig.- 5	Relationship between Mineralization & Structure(Area-B)	24
Fig.- 6	Correlation Chart for Geological Uints in Northern Guatemala	26
Fig.- 7	Schematic Stratigraphical Column	27
Fig.- 8	Locality of Granitic Rocks Tested	31
Fig.- 9	Differentiation Index vs. SiO_2 of Acidic Igneous Rocks	32
Fig.-10	Plots of Quartz-K-Feldspar-Plagioclase of Norms of Acidic-Intermediate Igneous Rocks	32
Fig.-11	Results of K-Ar Dating of Granitic Rocks	37
Fig.-12	Schematic Geologic Profile of Project Areas	22
Fig.-13	Location Map of Known Mineralization	44
Fig.-14	Drainage Basins in Project Areas	64
Fig.-15	Means and Standard Deviations of Cu-content for Individual Drainage Basins &/or Geological Units (Phase-I)	70
Fig.-16	Means and Standard Deviations of Pb-content for Individual Drainage Basins &/or Geological Units (Phase-I)	72
Fig.-17	Means and Standard Deviations of Zn-content for Individual Drainage Basins &/or Geological Units (Phase-I)	72
Fig.-18	Cumulative Frequency Distribution(Area-A)	75
Fig.-19	Cumulative Frequency Distribution(Area-B)	76
Fig.-20	Mean-Standard Deviation-Threshold (Phase-II)	79
Fig.-21	Flow Chart of Simulation	99
Fig.-22	Dipole-Dipole Configuration	101
Fig.-23	Geophysical-Geochemical Anomalies & DDHs Location	104
Fig.-24	Result of Simulation Analysis for Line-W6	106
Fig.-25	Result of Simulation Analysis for Line-O	107
Fig.-26	Result of Simulation Analysis for Line-E4	108
Fig.-27	Result of Simulation Analysis for Line-E12	109

1. Introduction

This report summarizes the results of a 3-year mineral survey carried out in the Altos Cuchumatanes area in the western part of the Republic of Guatemala. The survey was undertaken by the Japan International Co-operation Agency(JICA) and Metal Mining Agency of Japan(MMAJ) in collaboration with the Dirección General de Minería e Hidrocarburos(DGMH). The project comprises three phases from the phase-I in 1976 through the phase-III in 1978. The details of each phase are described in the report of that phase.

In November 1978, DGMH was reorganized to La Secretaría de Estado para Minería, Hidrocarburos, y Energía Nuclear. However, in this report DGMH is used for convenience sake to stand for the above-mentioned new organization.

1-1 Chronology, works carried out, personnel, and ackowledgment

On July 26,1976, the General Survey Schedule of Mineral Exploration in the Republic of Guatemala was agreed between the first JICA-MMAJ mission and DGMH. Two areas Area-A and -B in the Altos Cuchumatanes area, totaling about 2,000 sq·km, were selected as target areas for the reconnaissance, after technical discussion between the two parties. Some parts of these areas overlap the area covered by United Nations Mineral Survey in 1966 and 1967 (Fig.3).

The 1st phase field works were performed from October 21 through December 26 in 1976, and the reconnaissance geological mapping with geochemical sampling was carried out in both Area-A(650 sq·km) and -B(1,350 sq·km)

The 2nd phase field works were performed from September 1977 through March 1978. The field works comprised the follow-up works in six areas (297 sq·km), and some additional exploration works in Llano del Coyote (14 sq·km).

The former six areas were selected mainly from geochemical anomalies that had been located by the 1st phase reconnaissance. Geological mapping, and geochemical sampling of soil samples were practiced in these areas.

The latter was selected as a target, because the area was considered to be worth exploration, after the review of UN report(1973), re-logging of drill cores, and quick visit to the prospect. The reasons why the area was judged to be prospective, were as follows(MMAJ-JICA;1977):

(1) The surface of the area is widely and extensively limonitized, and both the geophysical and geochemical anomalies by UN were still open to both sides, so that the mineralization was expected to extend further outward.

(2) Leached capping some 50 to 70m deep was recognized, therefore, we considered that exploration to the sulfide zone below the capping was necessary though the absolute values of Cu anomalies were not very high. At the same time, we thought that Zn values were worth exploration.

(3) All the UN DDHs were planned only to their IP anomalies, though most of them were abondoned in the oxide zone before reaching the expected depth. No drill was performed to their geochemical anomalies at all.

(4) No DDH was carried out to the extension of the mineralized intersection in UN-4 (5.5m 2.96%). In this area, geological mapping, grid-sampling of geochemical soil samples, geophysical survey(IP and ground magnetic), and 3 DDHs totaling 830.7m were completed.

The 3rd phase works were carried out from June through October in 1978. The works were concentrated in Area-C Llano del Coyote, as this area was judged to be the most prospective among the anomalies located by the 2nd phase works. Seven diamond drill holes totaling 1,203m were completed and geological mapping was supplementarily practiced in a 5-sq.km area that covered drill sites.

Details of the locations of the project areas are described in 2-2-1 of this report, and their approximate locations are illustrated in Fig.1 and 3. The break-down of the works carried out is shown in Table-1 ,and the peesonnel engaged in the present project are tabulated in Table-2A and 2B.

Acknowledgment: We heartily wish to express our thanks to Lic. Jorge Luis Monzón Juárez, the Secretary of the Secretaría de Estado para Minería, Hidrocarburos, y Energía Nuclear (EX-general director of DGMH), and to all the staffs of the same Secretaría who have been engaged in the project, for their collaboration. We all indebted to His Excellency Mr. Fujio Hara, the Ambassador of Japan to Guatemala, Mr. Junzo Mori ex-ambassador, and all the staffs of the Embassy for their assistance.

Table 1 Field works carried out in phase I ~ III

	Area	Topo. Map* (sq·km)	Area (sq·km)	Route Mapped (km)		Geochemical Samples Collected		Geophysical Survey IP	Geophysical Survey Mag.	Diamond Drilling
Phase I	A		650	375.0	Fact Map 1/25,000, Geol. Map 1/50,000	Stream. Soil.	204 695			
	B	-	1,350	793.5		Stream. Soil.	581 872	-	-	-
	Total		2,000	1,168.5		Stream. Soil.	785 1,567			
Phase II	A-1, Pechac-Laurita		36	83.0	Fact Map 1/10,000, Geological Map 1/20,000	Soil.	262			
	A-2, Peña de Plata		24	65.6		"	169			
	B-1, La Barranca		36	75.8		"	266			
	B-2, Río Blanco	-	126	224.1		"	537	-	-	-
	B-3, Cunén		48	98.4		"	259			
	B-4, Salquíl		27	64.8		"	178			
	Total		297	611.7		"	1,671			
	C, Llano del Coyote	14	14	88.1	Fact map 1/5,000 Geol. map 1/10,000	Soil	861	42 line.km	72 Line.km	3 Holes 830.70m
Phase III	C. Llano del Coyote	-	5	66	Fact map 1/2,000 Geol. map 1/5,000	-		-		7 Holes 1203.0m

* Preparation of photogrammetrical topographic map from IGN air photographs.

Table 2-A, Personnel from MMAJ-JICA

		Phase I (1976)		Phase II (1977)		Phase III (1978)	
Planification and Administration		Mr.Takeshi Minagawa	Ministry of International Trade & Industry of Japan	Mr.Tuneaki Mizuno	MMAJ Geologist	Mr.Takeo Kuroko	MMAJ Gen. Manager of Overseas Dept.
		Mr.Kunio Asakura	MMAJ (EX-Representative of Mexico office)	Mr.Toshio Kawaguchi	ditto	Mr.Yukio Harada	MMAJ, Representative of Mexico office
		Mr.Tsuyoshi Kanno	JICA Geologist	Dr.Tadao Hamachi	ditto Geologist	Mr.Kenzi Sawada	MMAJ Geologist
		Mr.Akira Sato	MMAJ Geologist			Mr.Sadayuki Nagahata	JICA
						Dr.Tadao Hamachi	MMAJ Geologist
Field Party	Leader	Dr.Kinsuke Uchida	MMAJ Geologist	Dr.Kinsuke Uchida	MMAJ Geologist	Dr.Kinsuke Uchida	MMAJ Geologist
	Sub-Leader	Mr.Yōichi Takeshita	ditto	Mr.Masakazu Kawai	ditto	Mr.Masakazu Kawai	ditto
	Geological Survey Group	Mr.Masakazu Kawai	MMAJ Geologist	Mr.Masayoshi Matsugi	MMAJ Geologist	Mr.Hideo Zyanome	MMAJ Geologist
		Mr.Susumu Takeda	ditto	Mr.Yasuo Endo	ditto	Mr.Tadayoshi Kiyono	ditto
		Mr.Ichiro Abe	ditto	Mr.Susumu Takeda	ditto		
		Mr.Takashi Kuriyama	ditto	Mr.Tadashi Ito	ditto		
				Mr.Shigehisa Fujiwara	ditto		
	Geophysical Survey Group			Mr.Takao Ogawa	MMAJ, Geophysicist		
				Mr.Norio Watanabe	ditto		
				Mr.Naoyoshi Takahashi	ditto		
				Mr.Norikiyo Sugiura	ditto		
				Mr.Akira Kodama	ditto		
	Drilling Group			Mr.Isamu Hazama	MMAJ Drilling Superviser	Mr.Akio Chida	MMAJ, Drilling Superviser
				Mr.Akio Chida	MMAJ, Driller	Mr.Sōzi Kannari	MMAJ, Driller
				Mr.Katsuei Narita	ditto	Mr.Yasuo Kanemitsu	ditto
						Mr.Sakae Hirono	ditto
						Mr.Katsuei Narita	ditto

MMAJ: Metal Mining Agency of Japan.
JICA: Japan International Co-operation Agency

Table 2-B Counterpart from Dirección General de Minería e Hidrocarburos

(Present Secretaría para Minería, Hidrocarburos y Energía Nuclear)

Phase I (1976)		Phase II (1977)		Phase III (1978)	
Ing. Fernándo R.Santiago	Leader, Mining engineer Chief of the Metal Mining Section.	Ing. Fernándo R.Santiago	Leader, Mining engineer Chief of the Metal Mining Section.	Ing. Fernándo R. Santiago	Leader, Mining engineer Chief of the Metal Mining Section.
Sr.Armando Castellanos	Geophysical technician	Ing. Antonio Gonzáles C.	Sub leader Chemist Chief of the Department of Investigation & Technical Services	Ing. Antonio Gonzáles C.	Sub leader Chemist Chief of the Department of Investigation & Technical Services
Sr.Rollando Licona	ditto	Sr. Hugo Lucero	Geological technician	Sr. Hugo Lucero	Geological technician
Sr.Mario Lima	Geological Technician	Sr. Mario Lima	ditto	Sr. Armando Castellanos	Geophysical technician
Sr. Jorge Mario Quñonez	ditto	Sr. Armando Castellanos	Geophysical technician	Sr. Armando Rivera	Driller
Sr. Edgar Fernandez	Draftsman	Sr. Ronald Licona S.	ditto	Sr. Felipe Gálvez	ditto
Sr. Edwin Valenzuela	ditto	Sr. Armando Rivera	Driller	Sr. Obdulio Calderon	ditto
		Sr. Felipe Gálvez	ditto	Sr. Julio Valdéz	ditto
		Sr. Julio Validéz	ditto	Sr. Gonzalo Morataya	ditto
		Sr. Gonzalo Morataya	ditto	Sr. Fredy D. Recinos	ditto
		Sr. Fredy D. Recinos	ditto	Sr. Carlos Medrano	Surveyor
				Ing. Marco Antonio Kopp M	Chemist. Ex-Chief of Laboratory
				Br. Jorge Mario Ruano P.	Chemist Chief of Laboratory
				Profa. Flor de María Cintora R.	Chemist
				Br. Pedro Valencia	ditto

1-2 Previous works in the project areas

A regional geochemical reconnaissance survey for minerals was carried out by UN from 1966 to 1967 in two areas totaling about 12,000 sq·km (UN;1968). The Area-II of the two partly overlaps the present project areas(Fig.3). This UN Mineral Survey disclosed 31 anomalies of Cu,Pb,Zn and Mo, seven of which are wholly or partly located within the present project areas; these are No.10 Llano del Coyote, No.11 Pichiquil, No.12 Sacapulas, No.16 San Luis, No.18 Nebáj, No.19 Chiantla, and No.21 Laurita (UN;1968). UN subsequently undertook follow-up works in these areas (UN; unpublished; 1969 to 1970?). The follow-up works in Llano del Coyote by UN comprised geological mapping, geochemical sampling, IP,EM,ground magnetic survey, and seven DDHs totaling 751.4m(UN;1973, MMAJ-JICA;1977 and 1978). UN also performed 2 DDHs totaling 116.8m (one of which was carried out by DGMH) in the Cu anomaly in the Cerro Bobí area, which is located in Area-A of the present project. Details of the exploration works by UN and DGMH in Llano del Coyote are described in Part-III of our 2nd phase report and in the 3rd phase one.

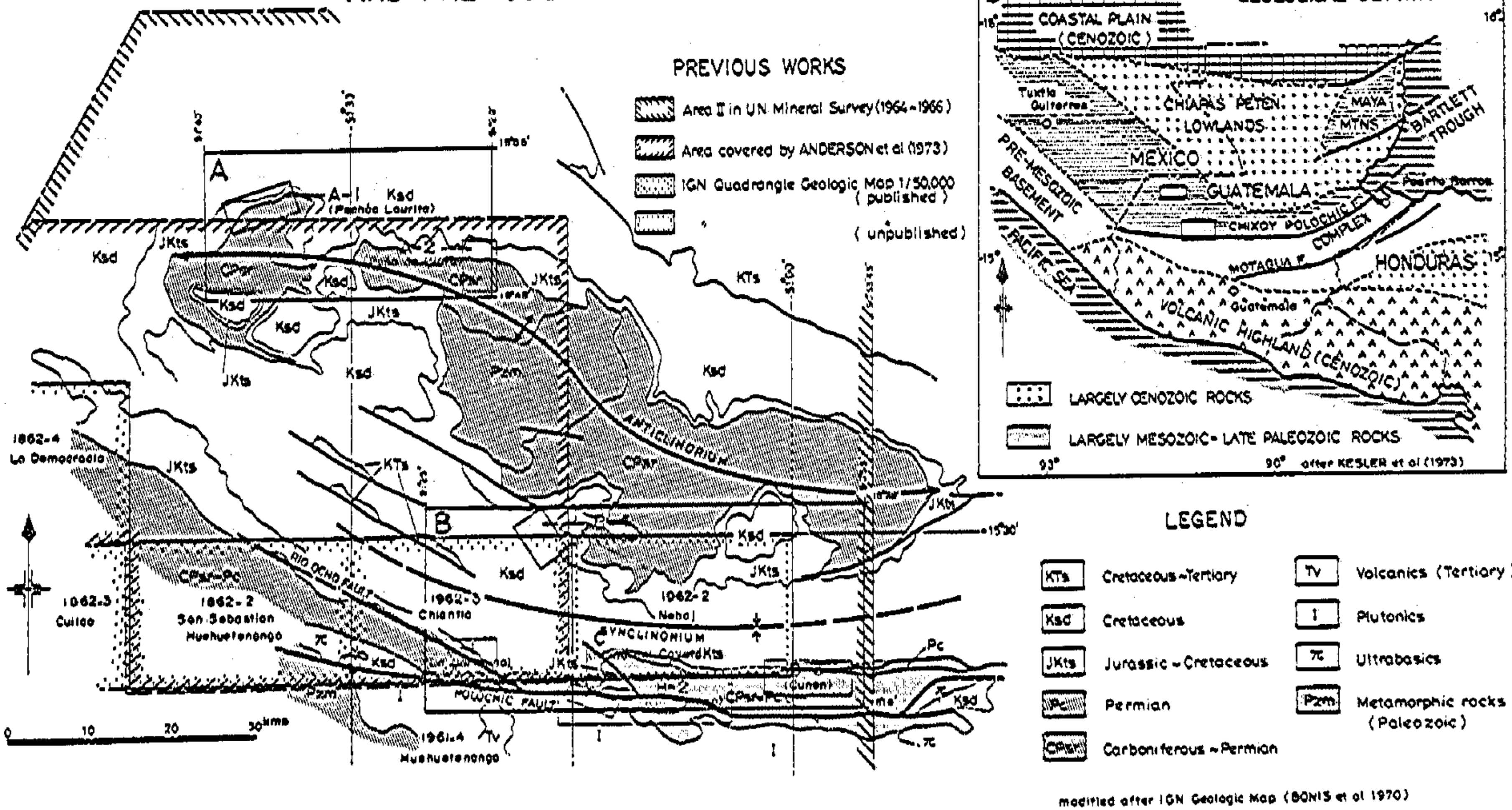
Regarding a regional geologic map that covers all the present project areas, there is 1/500,000 scale Geological Map of the Republic of Guatemala published by IGN (Instituto geográfico Nacionál) (Bonis et al;1970). The map was compiled, utilizing various existing local geologic maps and photogeology.

Anderson et al(1973) published their comprehensive stratigraphic study in the Altos Cuchumatanes area (Anderson et al;1973), based on their field works in the years from 1966 to 1967. Their mapped area overlaps the southern half of our Area-A and the southwestern quarter of Area-B in the 1st phase(Fig.3).

The IGN quadrangle geologic map of Chiantla (Blount;1967) covers approximately a quarter of Area-B at its southwestern corner, and an unpublished quadrangle geologic map of Nebáj(IGN; unpub.) overlaps some another quarter of the Area at its central to eastern part.
Kesler et al studied Pb-Zn mineralization in carbonate rocks in Central Guatemala, and mentioned conclusively that the mineralization had the characteristics similar to both the magmatic hydrothermal and the so-called Mississippi Valley type.

The areal relationship among these previous works and the present study is illustrated in Fig.3.

Fig 3 MAP OF GEOLOGICAL SETTING AND PREVIOUS WORKS



2. General Information

2-1 On Guatemala

The Republic of Guatemala is located in the northwestern part of Central America, and borders Mexico on the northwest, Belice on the east, and Honduras and El Salvador on the southeast (Fig.1). She is the largest in area (approx. 109,000 sq.km) and the second largest in population (approx. 6.26 millions in 1976) among the Central American countries. Guatemala City the capital of the country is a traffic center to the Central American and Caribbean countries.

The local currency is called Quetzál(Q), and its exchange rate to US dollar is stably maintained at 1 to 1. U.S. dollar, either in cash or traveler's check, can be freely exchanged for the local currency in Guatemala, anywhere there is a bank.

The Gross Domestic Product(GDP) in 1976 is inferred to have reached 4.36 billion US $, consequently GDP per capita is estimated to be approximately 700 US $. The economy of Guatemala has depended almost totally on agricultural products such as coffee, cotton, sugar and banana. These four commodities account for about 57% of the total exports in 1976. Major economic indicators, and major exporting and importing countries are listed below as well as major commodities for export and import.

The mining industry has not yet been very much active in Guatemala. However, the mining operation of nickeliferous laterite ores and its smelting were commenced in July 1977 in the Lago de Izabál area in eastern Guatemala. The project is being operated by EXIMIBAL (Exploraciones y Explotaciones Mineras Izabál, S.A.) which is a joint venture among Inco Ltd., The hanna Mining Co., and the Government of Guatemala. It is announced that the scheduled production rate from the open pit mine is about 4,200 wet STPD (1.3 to 1.7% Ni), and that from the smelter is 14,000 STPY as metal nickel in the matte which contains 75% Ni.

To the west of the nickel mine, a small but modern underground copper mine called Oxec is being operated by Basic Resources, Canada.

Exploration works for petroleum are being carried on in both Alta Verapaz and southern Petén. No commercial production has so far been commenced, though some exploration holes were successful.

Table-3A Major Economic Indicators

	1975	1976	1977
Gross Domestic Product (million US $)	3,646	4,363	
GDP per capita (US $)	600	697	
Iflation rate (%)	13	11	13
Balance of international payments(million US $)	194	212	149
Balance of trade(million US $)	-31	-111	47
Exports in F.O.B.(")	641	794	1,189
Imports in F.O.B.(")	672	905	1,142
Foreign exchange reserve (million US $)	304	511	690

*Source: IFS (International Financial Statistics)

Table-3B Major Exporting and Importing Nations

To	Exports Million US $	%	From	Imports Million US $	%
United States	278	33	United States	303	35
West Germany	105	12	Japan	99	12
El Salvador	80	10	Venezuela	77	9
Japan	77	9	El Salvador	64	8
Costa Rica	43	5	West Germany	60	7
Other nations	260	31	Other nations	249	29
Total	843	100	Total	852	100

Table-3C Major Commodities for Export and Import

Exports in F.O.B.			Imports in F.O.B.		
Commodities	Million US $	%	Commodities	Million US $	%
Coffee	264	31	Raw & Intermediate goods	302	35
Sugar	95	11	Capital goods	297	35
Cotton	85	10	Consumers' goods	234	28
Chemicals	50	6	Others	19	2
Banana	45	5			
Others	309	37			
Total	843	100	Total	852	100

2-2 On the project areas

2-2-1 Location

The location of the project areas of each phase is indicated in Fig.1 and Fig.3.

1st Phase: The project areas of the 1st phase program comprise two areas, Area-A and -B, and cover approximately 2,000 sq. km. The Area-A is located about 169 air kilometers northwest of Guatemala City, and is in department of Huehuetenango. The area is bounded by north latitudes 15°55' and 15°45', and west longitudes 91°20' and 91°40'. It covers an area of about 650 sq. km.

The Area-B is located about 110 air kilometers northwest of the capital and is in both the departments Huehuetenango and El Quiché. The area is bounded by north latitudes 15°32' and 15°18', and west longitudes 90°55' and 91°25'. It covers an area of about 1,350 sq.km.

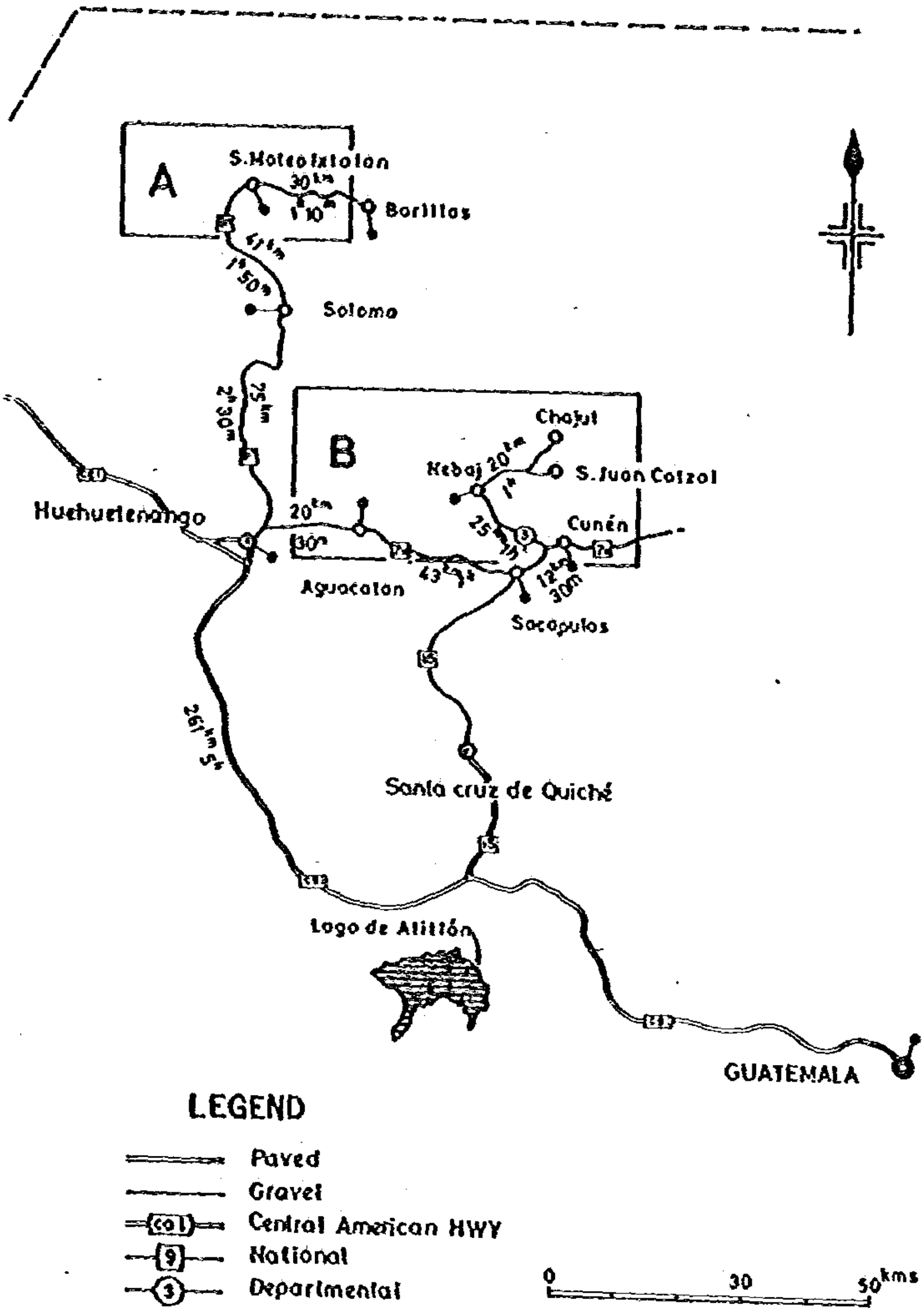
2nd Phase: The location of the seven target areas in the 2nd phase program is tabulated in the table below. In this table, latitudes and longitudes of the four corners of an area are given as well as the titles of the IGN quadrangle maps that cover the area. A-1 and A-2 Areas are in Area-A of the 1st Phase, whereas the areas with prefix B- and Area-C are within Area-B of the 1st phase.

Table-4 Location of Project Areas (Phase-II)

Area		1	2	3	4	IGN Quadrangle Map
A-1 Pechac-Laurita	N.Lat. W.Long.	15°51'42" 91°51'42"	15°53'16" 91°33'58"	15°51'14" 91°33'15"	14°49'38" 91°38'02"	Ocanté San Miguel Acatán
A-2 Peña de Plata	N.Lat. W.Long.	15°48'45" 91°21'35"	15°48'45" 91°19'20"	15°45'35" 91°19'20"	15°45'35" 91°21'35"	Barillas
B-1 La Barranca	N.Lat. W.Long.	15°22'50" 91°24'59"	15°22'50" 91°19'57"	15°20'40" 91°19'57"	15°20'40" 91°24'59"	Chiantla
B-2 Río Blanco	N.Lat. W.Long.	15°20'40" 91°16'04"	15°20'40" 91°04'23"	15°17'21" 91°04'23"	15°17'21" 91°16'04"	Nebaj, Chiantla Sacapulas, Huehuetenango
B-3 Cuzfa	N.Lat. W.Long.	15°21'25" 91°02'10"	15°21'25" 90°55'30"	15°19'45" 90°55'30"	15°19'45" 91°02'10"	Telaja, Sacapulas, San Andres Sajcabajá, Nebaj
B-4 Salquil	N.Lat. W.Long.	15°30'40" 91°19'07"	15°32'07" 91°17'10"	15°29'31" 91°15'08"	15°28'03" 91°17'10"	Saloma Chiantla
C Llano del Coyote	N.Lat. W.Long.	15°20'15" 91°15'00"	15°18'46" 91°11'47"	15°17'45" 91°12'14"	15°19'15" 91115'49"	Sacapulas, Nebaj. Huehuetenango, Chiantla.

N.Lat. : North latitude W.Long. : West longitude

Fig 2 ROAD MAP OF PROJECT AREAS



3rd Phase: The exploration works of the 3rd phase have been carried out within Area-C in the 2nd phase.

2-2-2 Access

Guatemala-Huehuetenango: Access from Guatemala city, the capital, up to Huehuetenango, which is the base to project areas, is fiarly convenient (261 road km). A 2-lane asphalted national highway CA-1(Pan American HWY) passes about 4km southwest of the city center of Huehuetenango, which can be reached by 4 to 6 hours' drive from the capital, Several bus services are daily available between the two cities, and it takes about 6 to 8 hours. No regular commercial flight is available, though there is a small air strip in Huehuetenango.

Area-A: Accessibility to and within Area-A is quite bad: Only a mortorable road that crosses the area is national highway 9N. This is unpaved, narrow(3 to 3.5m wide), and very much crooked, although it is the major all-weather road between Huehuetenango and Barillas. It is quite often densely foggy on the way along the route even in the drier season, as the route is mostly situated on the ridges of high altitude (around 3,000m A.S.L. in some sections). Therefore, it takes about 4 and a half hours (only 115 road.km)by car from Huehuetenango to San Mateo Ixtatán, which is located at the center of Area-A, and at which local helpers, mules, and supplies for Area A-1 are available. The time required between Huehuetenango and Barillas, which is the preparation base to Area A-2, is likewise 6 hours by car, though the road distance is only 146 km. No other motorable road is served in the area, and therefore, all the places except those situated near this road can only be accessed on foot or by mule. The travelling speed of a mule is around 4 to 4.5km/h. Use of a helicopter in Area-A may be quite restricted both in time and place by weather and topography.

Area-B: Accessibility to and within Area-B is also unfavorable, except the places near from several motorable roads.

In the southern part of this area, a national highway Route 7W passes eastward nearly parallel to the fault valley of the Chixoy-Polochic fault. The road links such villages as Aguacatán, Llano del Coyote, Río Blanco Sacapulas, and Cunén.

Therefore, access to the project areas B-1, B-2, B-3 and C, which are not far from the road is fairly convenient. The Route 7W is a major all-weather road between two important cities Huehuetenango and Cobán, though it is unpaved and only 3 to 3.5m wide. Time required for a 75km-section between Huehuetenango and Cunén is about 3 hours by car. The road condition from Cunén eastward is much worse than the above.

Bifurcating from the Route 7W, an all-weather gravel road Departmental Route 3 leads to Nebáj. Two narrow, unpaved but all-weather roads are extended from Nebáj to San Juán Cotzál and to Chajúl. Another dirt road is built from Nebáj to Acúl, however it can only be motorable by a 4-wheel-drive car during dry days.

Several secondary dirt tracks are extended from the Route 9N to the villages on the karst plateau in the southwestern part of the area, however, these are not motorable in the rainy season.

Besides these, a few local motorable roads were recently built in the northern side of the Río Blanco.

Access to most places in the area, other than those which can be reached via the roads above mentioned, is on foot or by mule.

Distances and times required between main municipalities and villages are graphically shown in Fig.2

2-2-3 Communication

Telephone has not yet spread throughout the country in Guatemala. Telephone call from Huehuetenango to Guatemala city can be made only from the telephone booth in Guatel office, as little extension has been made to individual houses in Huehuetenango as yet. No telephone line is available to the public in the project areas other than Huehuetenango.

Only telecommunication that can be utilized between the project areas and Huehuetenango is telegram. This can be sent from the post office which is in the center of a municipality.

Both foreign and domestic mails are safely delivered to and from the project areas. It takes about 1 to 2 days between Huehuetenango and the capital, and 6 to 8 days by air mail between the former and Japan.

Telex can be sent from the Guatel office in Quetzaltenango city that can be reached from Huehuetenango by 1 hour 30 minutes' drive.

2-2-4 On Huehuetenango city

Huehuetenango city is the departmental capital of the department of the same name, and is the entrance to the Altos Cuchumatanes. In our reports, the description on location and access to the project areas was often made, taking the city as a starting point.

The population of the city is said some 50 to 100 thousand, and is ranked the fourth or the fifth in the Republic. Huehuetenango city tolerably provides the urban functions, though it is small: There are various offices of departmental and federal governments. There also are a Guatel office, a post office, three banks, two radio stations, a hospital, several repair shops and hotels, and two supermarkets in the city.

Our field office was established in the city during the field works of the 1st and 2nd phase programs. Most of our supplies for the field works such as food, fuel, and so on were purchased in the city except special goods.

2-2-5 Physiography

The project areas are topographically classified into two characteristic areas. One is the highlands where most parts of the Area-A and -B are situated. Another is the southern foothill of the Altos Cuchumatanes that comprises the fault valley and the scarp of the Chixoy-Polochic fault, and their adjacent areas. B-1, B-2, B-3, and C are located in this southern foothill. The elevation of the highlands varies from 1,000 to 3,335m above sea level, whereas that of the foothill varies from 1,700 to 2,450m.

The topography of the highlands shows characteristic features place by place, reflecting the bed-rock geology: In the terrain of the calcareous rocks of the Cretaceous Ixcoy Formation, vast karst plateaus with thin vegetation are usually developed. Inaccessible steep cliffs are often formed at the peripheries of the plateaus. These areas are less inhabited and less cultivated. In the terrain of the Jurassic Todos Santos Formation that mainly consists of continental red bed sandstone and shale, a relatively flat topography is generally formed, reflecting the soft rocks. The terrain mostly provides cultivated lands and housing sites. However, the basal conglomerate of this Formation locally forms very steep cliffs. In the terrain of the Paleozoic Santa Rosa Group and the metamorphic rocks, an extremely steep topography usually predominates, comprising deeply dissected canyons, and narrow and ragged ridges. Local relief in the terrain often reaches some 1,000m or more.

The southern foothill area of the Altos Cuchumatanes comprises the fault scarp and the fault valley of the Chixoy-Polochic fault. The scarp dips to the south,and extends linearly in E-W direction. The valley is situated to the south of the former, and it includes comparably gentle hills, and drainages parallel to subparallel to the trend of the fault. The topographical relief rarely exceeds 300m in this area. In the Llano del Coyote, a characteristic topography, easterly extending flat-topped hill with steep sides both to the north and west, is observed. This is considered to have been formed reflecting the alteration zone accompanied with mineralization.

2-2-6 Climate

The project areas latitudinally belong to the subtropical to tropical region. However, the climate is generally as mild as in spring or autumn throughout the year, as the altitude is fairly high in most areas, ranging from 1,500 to 3,000 A.S.L.

The temperature ranges from 5° to 25°C in most places in the project areas. Nevertheless, it locally varies in a fiarly wide range, depending on altitides and local topography: For examples, the temperature is rather subtropical to tropical in some areas of the eastern part of Area-A, such as certain loci in Area A-2, which is located near the northeastern periphery of the Highlands, and the altitude of which is rather low. Also in some areas along the Chixoy-Polochic fault valley, there are some days in March and April just before the rainy season, when the temperature exceeds 30°C in the day time.

The areal fluctuation is also observed in precipitation: In most of the Area-A, which is near from the region of the heviest rain fall in Guatemala, the annual precipitation is inferred between 2,500 and 5,000mm with more than 200 rainy days per year. Here, the dry and the rainy seasons cannot clearly be distinguished: The rainy months fluctuates year by year, though local people say that relatively drier months are usually three months from June through August,and four months from November to next Feburary. In Area-B, the climate in the highlands resembles Area-A, and the annual precipitation ranges from 2,000 to 3,000mm. On the contrary, the climate is fairly dry in the foothill area where the altitude is lower than 2,500m.

The annual precipitation is estimated between 1,200 and 1,500mm in this area. Here, two seasons, the dry and the rainy, can clearly be distinguished. The dry season is from November to next April, and most of the annual precipitation falls in six months in the rainy season.

2-2-7 Vegetation

In the project areas, the vegetation varies place by place, reflecting climate, and bedrock geology and other artificial factors caused by inhabitation.

In the highlands that occupy most of the project areas, the vegetation is generally thick. Here, the vegetation clearly reflects the difference in bed rock lithology: The terrains, where the Paleozoic Santa Rosa Group and the Metamorphic rocks crop out, are densely covered by the forests that comprise tall pine and broadleaved trees, such as oak, with dense underbrush. On the contrary, the areas underlain by the Todos Santos Formation have totally been utilized as cultivated lands so that little natural vegetation is preserved. In the karst plateau of the calcareous rocks of the Ixcoy Formation, sparsely grown pine trees predominate with less underbrushes.

On the other hands, the vegetation that is more similar to the tropical rain forest is observed in the transitional zone from the Cuchumatanes Highlands to the Petén Lowlands, where the altitude is lower,and heavier rain fall takes place. This zone includes the eastern part of Area-A and the northeastern part of Area-B.

The vegetation that resembles the semi-arid type is observed in certain loci in the southern part of Area-B, along the fault valley of the Chixoy-Polochic fault. Here, less rain fall occurs and recent volcanic ash often covers the surface. In these loci, there often grow sparse forests of evergreen trees such as pines and oaks with thin underbrush and maguey.

3. Geology

3-1 Introduction

Throughout the present 3-year-project, geological mapping has been carried out changing the extent of target areas and the mapping scale.

In the 1st phase(1976), the reconnaissance geological mapping with geochemical sampling was carried out in two areas Area-A and -B (totaling about 2,000 sq.km). The result was compiled in 1/50,000 IGN quadrangle maps.

In the 2nd phase(1977), the follow-up geological mapping with geochemical sampling for 6 areas (totaling about 297 sq.km), and the detailed mapping with grid geochemical sampling and geophysical survey for Area-C Llano del Coyote (14 sq.km) were carried out. The 6 follow-up areas (Area A-1, A-2, B-1, B-2, B-3 and B-4) were selected chiefly from geochemical anomalies in the 1st phase. The result for the six areas was compiled in 1/20,000 scale topographic maps that had been photographically enlarged from the IGN quadrangle maps, while that from Area-C was compiled in 1/10,000 scale topographic map that had been photogrammetrically prepared from IGN air photographs.

In the 3rd phase(1978), the detailed geological mapping was supplimentarily carried out in the central part of the Area-C (5 sq.km), where diamond drill sites were located. The result was compiled in 1/5,000 scale topographic maps that had been photographically enlarged from the above-mentioned photogrammetrical map.

Integrating the results from both the geological mapping and the geochemical exploration, it may conclusively be said that the mineralization, especially the metallic one, is rather weak in the present project areas. This could be attributed to the facts that the distribution of the intrusive rocks is rather rare in the project areas, as an intimate relationship can be inferred between the acidic intrusives and the metallic mineralization both in space and genesis. Therefore, it is necessary to select exploration targets in the grounds where intrusives especially acidic ones occur abundantly, when the exploration is to be carried on in Guatemala from now on. For reference, three stages of acidic igneous activity are inferred from the result of K-Ar age dating obtained during the present project.

These are 117-135m.y.(early Cretaceous), 74-85m.y.(later Cretaceous), and 58-62m.y.(paleocene), and the latter two might relate to the mineralization of non-ferrous metals in the present project areas.

Metallic mineralization in the project areas seems to be controlled structurally by NW-SE fault system (same trend to the Río Ocho fault) and WNW-ESE one (same trend to the Chixoy-Polochic fault). Almost all the known showings, and prospects are apparently aligned in these directions (Fig.13). The effect of the two directions is also obvious in the geochemical zonal arrangement and in the trends discernible in the rolling mean analysis of geochemical data (Fig.4,5).

Area-C Llano del Coyote was considered the most prospective for Zn and Cu, and was drilled in Phase-II, and -III. As a result, a promising sulfide Zn-mineralization was intersected in MJ-9(12.76% Zn;9.5m), as well as an intersection with chalcocite (3.80% Cu;0.60m) at the lowermost part in the oxide zone. The Zn-mineralization occurs in a skarn at the boundary between the Tactic and Chicol Formations. The possibilities that reserves of n x 10^5T to n x 10^6T exist in the area are fairly great, being judged from the extent of rock-chip geochemical anomalies. A deposit may be exploitable even this size and grade, as location of this prospect is very favorable. An intensive exploration program is proposed.

In the Pb-Zn mineralization in the calcareous rocks, such as Pechác, Laurita, and Peña de Plata, there might be some exploitable deposits as small scale-high grade mines. However, we believe that the expected ore reserves of such deposits may not exceed the order of 10^4T at most.

Aside from the matter related with mineral exploration, following geological contribution was made during the geological mapping in the present program. (1) A sequence lithologically inferred to be of Paleozoic, distributes in the southwestern part of Area-A where the Cretaceous sequence is assigned in 1/500,000 IGN Geologic Map (Bonis, et al: 1970) (p.22,23 in 1st Phase Report) (2)*Fusulinella* sp. that indicates upper Carboniferous (Pennsylvanian) was found in a certain part of the so-called Chochal limestone, to which upper Permian had been assigned (A-51, and A-54 in 1st Phase Rept.). (3)Trace amounts of following minerals were identified through the present exploration works, though they are not of economical significance but only of mineralogical interest: They are bismuthinite (P-37 in 1st phase Rept.), *coninue to next page*

pentlandite and awaruite(p-48 in 1st Phase Rept. and p.100-102 in 2nd phase Rept.), and chalcophanite($(Zn,Mn,Fe) Mn_3O_7 \cdot 3H_2O$; p in 3 rd Phase Rept.).

3-2 Field Works

The detailed description on the organization of the field parties, mapping procedure, base maps used, numbering of handspecimens and so forth is omitted here. These are to be referred to the following pages in the report of each phase. The work procedure of the filing, compilation, interpretation, etc. in each phase was carried out following the procedure illustrated in the flow-chart attached to the 1st Phase Report(PL-75).

1st Phase Report	P-11
2nd Phase Report	pp.-9 and 10
3rd Phase Report	p.

3-3 Description and Presentation of Result

The result of the geological mapping carried out in each phase is described and presented in the following pages and maps.

1st Phase (1976):

Description on Geology	pp.12-51 in text	
Geologic map of Area-A	1/50,000	PL-1
Geologic map of Area-B	1/50,000	PL-2
Geologic Sections Area-A	1/50,000	PL-3
Geologic Sections Area-B	1/50,000	PL-4
Geologic map of cerro Bobí-Quetzál Zone		
Sheet-1 through-3	1/10,000	PL-54,55 and 56
Geologic Sections of Cerro Bobí-Quetzál Zone		
	1/10,000	PL-57

2nd Phase(1977):

Area	Description page in Rept.	Geologic Plate No.	Map scale	Geologic Plate No.	Sections scale
A-1	63 to 69	PL-1	1/20,000	PL-2	1/20,000
A-2	75 to 87	PL-10	"	PL-11	"
B-1	94 to 102	PL-19	"	PL-20	"
B-2	110 to 122	PL-28 & 29	"	PL-30	"
B-3	130 to 134	PL-45	"	PL-46	"
B-4	141 to 143	PL-54	"	PL-55	"
C	155 to 178	PL-63	1/10,000	PL-64,65 & 66	1/10,000

3rd Phase(1978):

Description of Geology	p.	in text
Geologic Map	1/5,000	PL-1-1∿1-2
Geologic Sections	1/5,000	PL-2-1∿2-5

3-4 Geological Setting

The project areas are geologically located in a fold belt that extends southeastward from Chiapas in Mexico and mainly comprises sedimentary sequences of both Paleozoic and Mesozoic ages. At the southernmost part of the project areas, the Chixoy-Polochic fault that is considered a landward extension of the Bartlett Trough runs in the EW direction, intersecting the fold belt. (Fig.3)

Area A-1 and A-2 are located about 50 to 60km north of the fault, and B-4 is about 20km north of it. On the other hand, areas B-1,B-2, B-3, and C are situated along the intersection between the fault and the fold belt so that the geology in these areas are very much complicated. (Fig.3 and 12)

The fold belt physiographically forms the highland which is called Altos Cuchumatanes. A-1 and A-2 are located at its northwestern and northern peripheries respectively, B-4 is at its central part, and B-1, B-2, B-3, and C are at its southern periphery respectively.(Fig.3 and 13)

Structurally, a domed anticlinorium runs northwesterly along the backbone of the highland. A-1 and A-2 are on its northern limb, and B-4 is on the southern limb. All these three areas are situated at the periphery of the Paleozoic sequences that form the core of the anticlinorium. On the otherhan hand, B-1, B-2 and B-3 can be said to be located on the southern limb of a synclinorium that appears to occur between the anticlinorium and the Chixoy-Polochic fault. C is located at the southern side of the Chicoy-Polochic fault. (Fig.3 and 12)

With regard to the ralationship with igneous rocks, four areas B-1, B-2, B-3, and C are in the vicinity of a granitic batholith of Jurassic to Cretaceous age that occurs to the south of the Chixoy-Polochic fault, and extends eastward for some 65km from Huehuetenango. A-1 and A-2 are located around several to some teen km from small stocks ranging from granite to acidic hypabyssal rocks. However, no igneous rock is observed to exist around B-4.(Fig.4,5 and 12)

From the metallogenic point of view, the project areas seemingly belong to the Pb-Zn-Ag mineralization belt that extends for some 250km from Mexico down to Honduras. However, in more local, rather geochemical and relative sense, there some metallic zonal arrangement systems with radii of some teen to 20 km are observed, surrounding small bodies of acidic intrusives at their centers. B-2 and C appear to belong to a Cu-Zn zone, and other five areas to Pb-Zn zones in the systems. (cf.3-9-1, Fig.4 and 5)

Fig 12. Schematic Geologic Profile of Project Areas

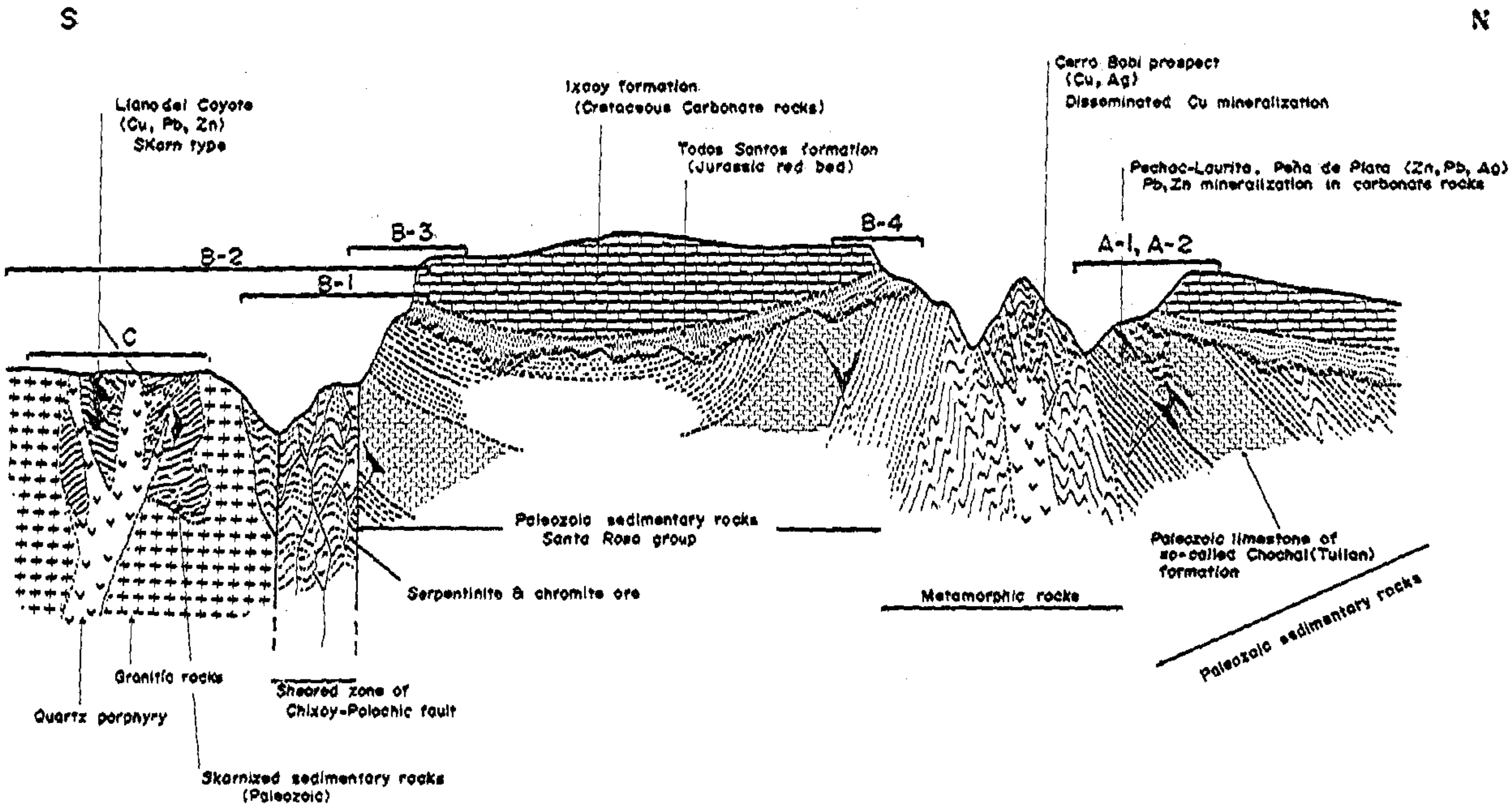


Fig. 4 RELATIONSHIP BETWEEN MINERALIZATION & STRUCTURE AREA — A

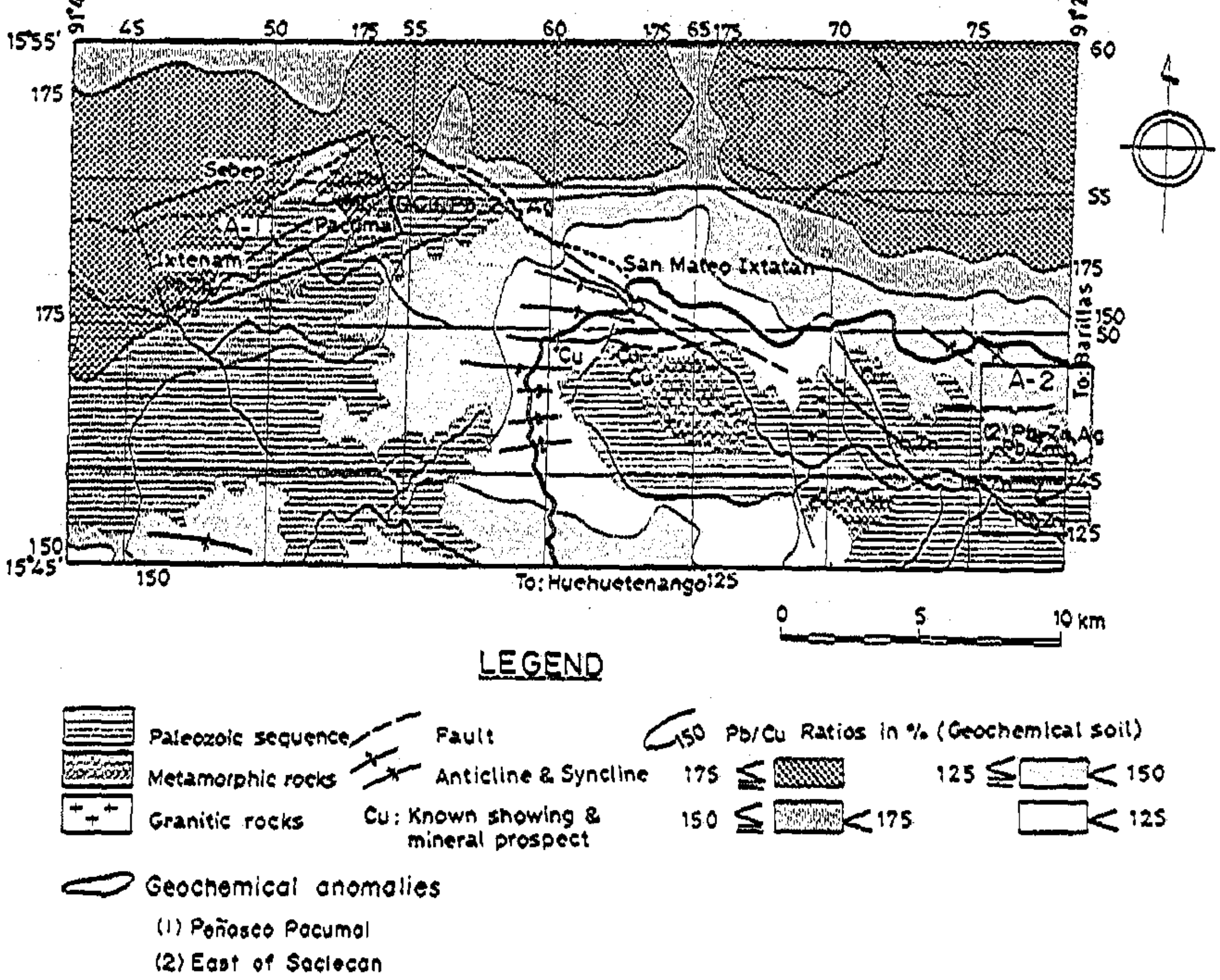
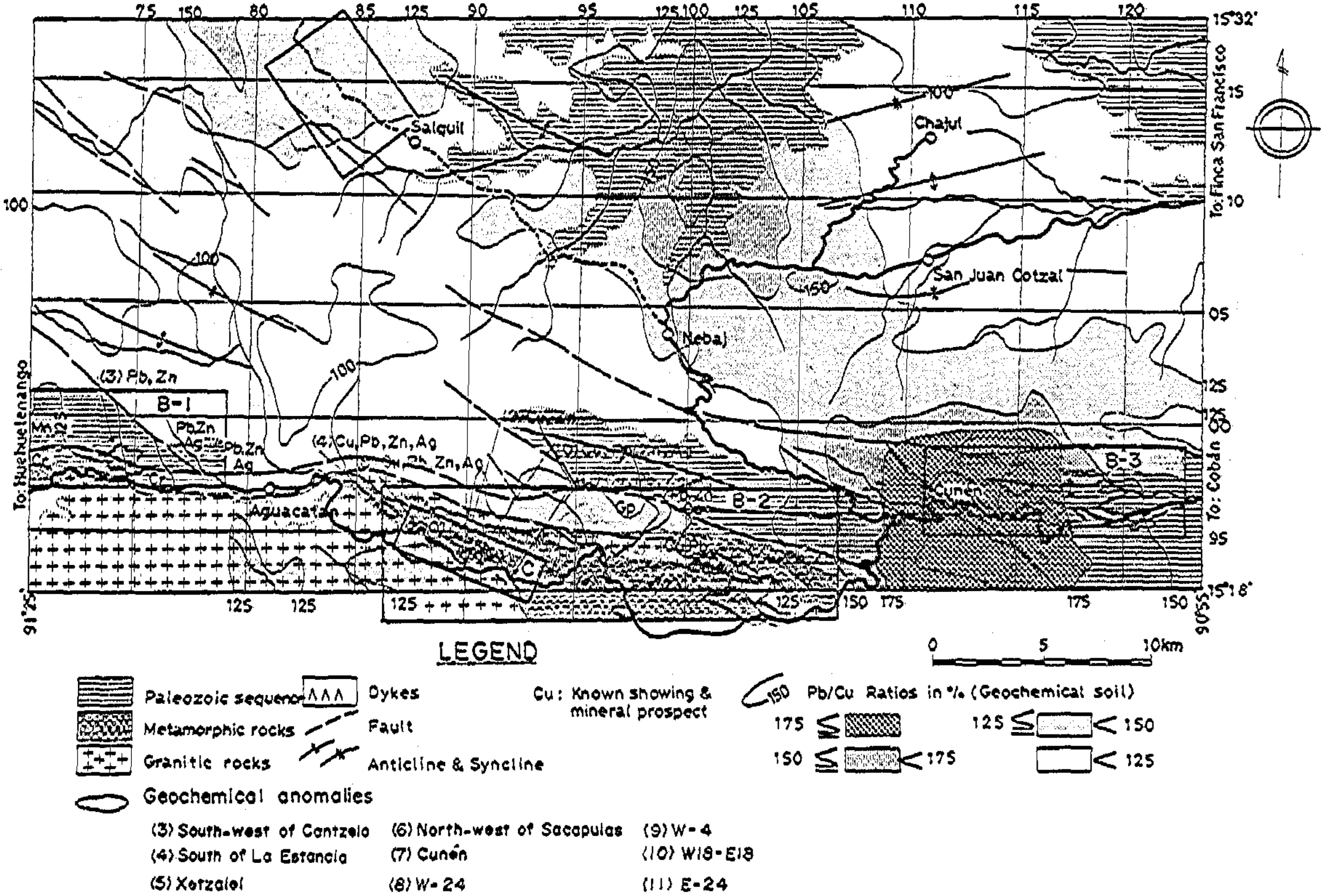


Fig. 5 RELATIONSHIP BETWEEN MINERALIZATION & STRUCTURE

AREA — B



3-5 Stratigraphy and General Geology

In Guatemala no standard stratigraphic classification throughout the country has been established yet, both in time and lithofacies. However, a systematic study on the stratigraphy in the western Altos Cuchumatanes including compilation and correlation of previous works was made by Anderson et al (1973)(Fig.6). Here in this report, the names of Group, Formation and Member are adopted and adapted from their work. Correlation between the stratigraphies constructed by mapping in individual project areas and that by Anderson et al is graphically shown in Fig.5.

The sequences in the Altos Cuchumatanes can be stratigraphically divided into the Santa Rosa Group of Paleozoic and the Todos Santos and Ixcoy Formations of Mesozoic.

The Santa Rosa Group consists of the Chicol, Tactic, Esperanza, and Chochal Formations, and overlies the basement of metamorphic rocks of unknown age (pre-Permian). Some part of metamorphic rocks of the so-called basement is considered to be the metamorphic facies of the Chicol that is the lowermost Formation of the Santa Rosa Group. The metamorphic rocks are generally suffered from regional metamorphism to show the green schist facies, but are locally affected by the contact metamorphism due to granitic intrusion to form porphyroblastic garnet and/or larger grained muscovite (as in Area-C).

The Chicol Formation is also correlated to the Sacapulas Formation by Bohnenberger (1966a & 1966b) from its lithological similarity. The Sacapulas mainly comprises clay slate and conglomerate intercalating sandstone layers, and locally accompanies some volcanics (Forth,1971). Acidic intrusives occur as dykes or sills in some places. The metamorphic rocks that distribute in the northeastern part of the Area-C mainly consist of green schists and conglomerate schist and intercalate smaller amounts of schistose limestone, sandstone, and slate. At the hanging wall side (southwestern part) of these metamorphic rocks, a sequence of tuffaceous shale, shale and sandstone occurs overlying the former. The metamorphic rocks could be metamorphic equivalent of the Sacapulas or the Chicol from the lithological similarity, while the overlying sequence could be correlated to the Tactic.

Fig. 6. Correlation Chart for Geological Units in northern Guatemala

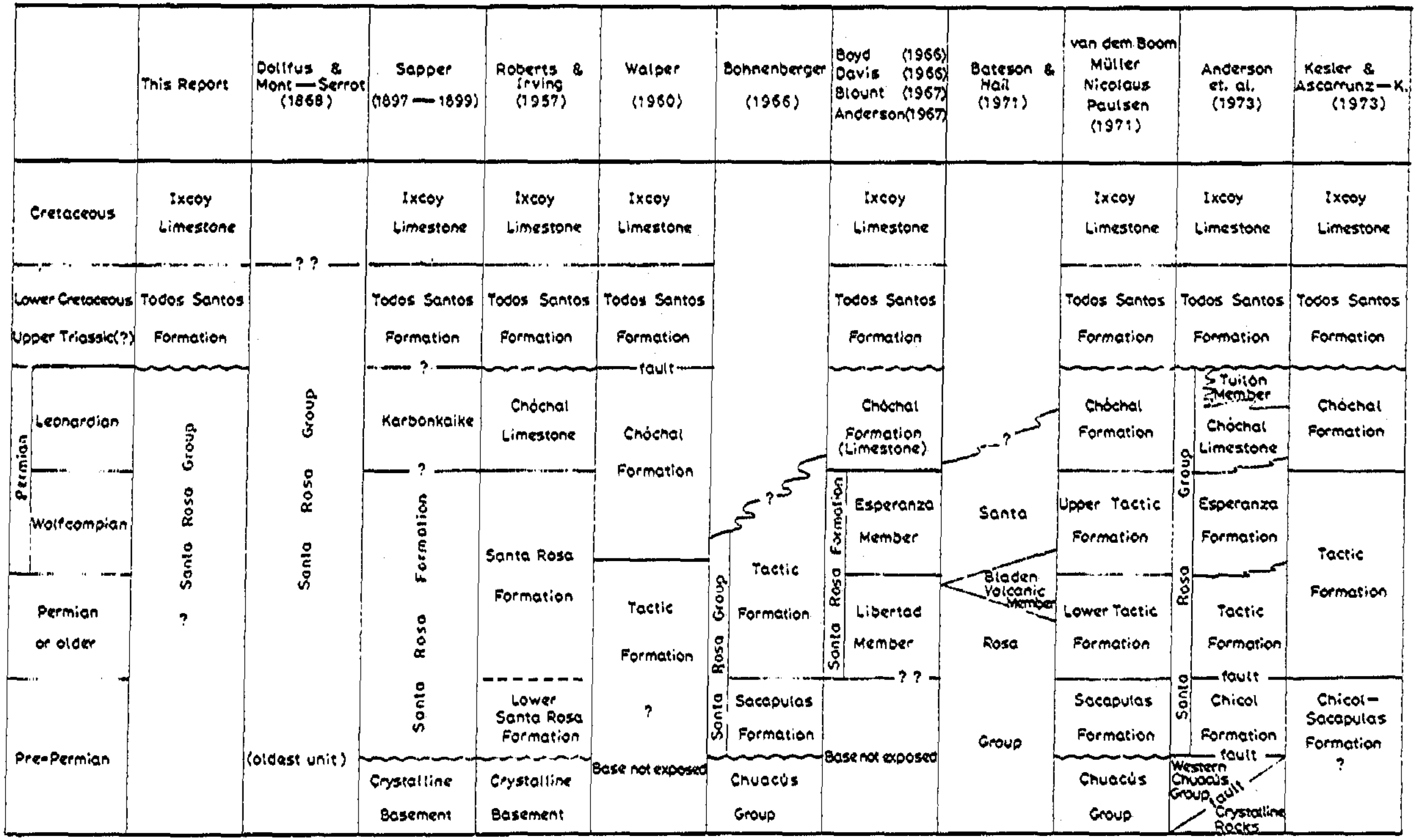


Fig. 7 Schematic Stratigraphical Column

Geological Age			Formation		Lithology
			Western Altos Cuchumatanes — Anderson et al. (1973)		
Cenozoic	Quaternary		Quaternary Deposits		Alluvium, Till & Volcanic Ash
Mesozoic	Cretaceous		Ixcoy Formation		-Lower 1,000m- Dolomite, Limestone & Dolomite interbedded with limestone breccia; dark-grey, medium crystallized; unfossiliferous ; probably Cretaceous
Mesozoic	Lower Cretaceous / Upper Triassic( )		Todos Santos Formation		Conglomerate, Sandstone, Siltstone & shale; red, terrigenous; probably Jurassic but may be as old as Late Triassic; Limestone, lenticular thin beds, marine, in the upper part of the sequence. Late Jurassic Early Cretaceous
Paleozoic	Permian	Leonardian	Santa Rosa Group	Tuilon Member / Chochal Limestone	-excluding Tuilon Member- Dolomite & Limestone, grayish-black brownish dark grey, massive-bedded, cliff forming; fossiliferous ; fusulinids, corals, brachiopods, crinoids, sponges, echinoid spines, bryozoa & algae
Paleozoic	Permian	Wolfcampian	Santa Rosa Group	Esperanza Formation	Shale, mudstone & siltstone, brown black; Limestone & Dolomite, interbeds, 5m in thickness; weathered red, brown, yellow or grey; fossiliferous ; Schwagerina cf S compacta Thompson 1954, Wolfcampian
Paleozoic	Permian or Older		Santa Rosa Group	Tactic Formation	↑ increasing amount of limestone beds; Shale & Mudstone, brown black; Quartzite, local; Limestone & Dolomite, rare; unfossiliferous
Paleozoic	Pre-Permian		Santa Rosa Group	Chicol Formation / Sacapulas Formation (Forth, 1971)	Conglomerate & Sandstone, greenish & light bluish grey; Tuff, grayish-green, gray & maroon; crinoid plates in conglomerate; -Sacapulas F.- Conglomerate, Shale & Sandstone, Volcanic & Metavolcanic interbeds, locally
Paleozoic	Pre-Permian			Chicol F. Metamorphic Rock Sequence	Low grade regional & dislocation metamorphism & probably to a lesser degree contact metamorphism altered conglomeratic & volcanic rocks to the quartz-albite-muscovite-chlorite subfacies of the green schist facies

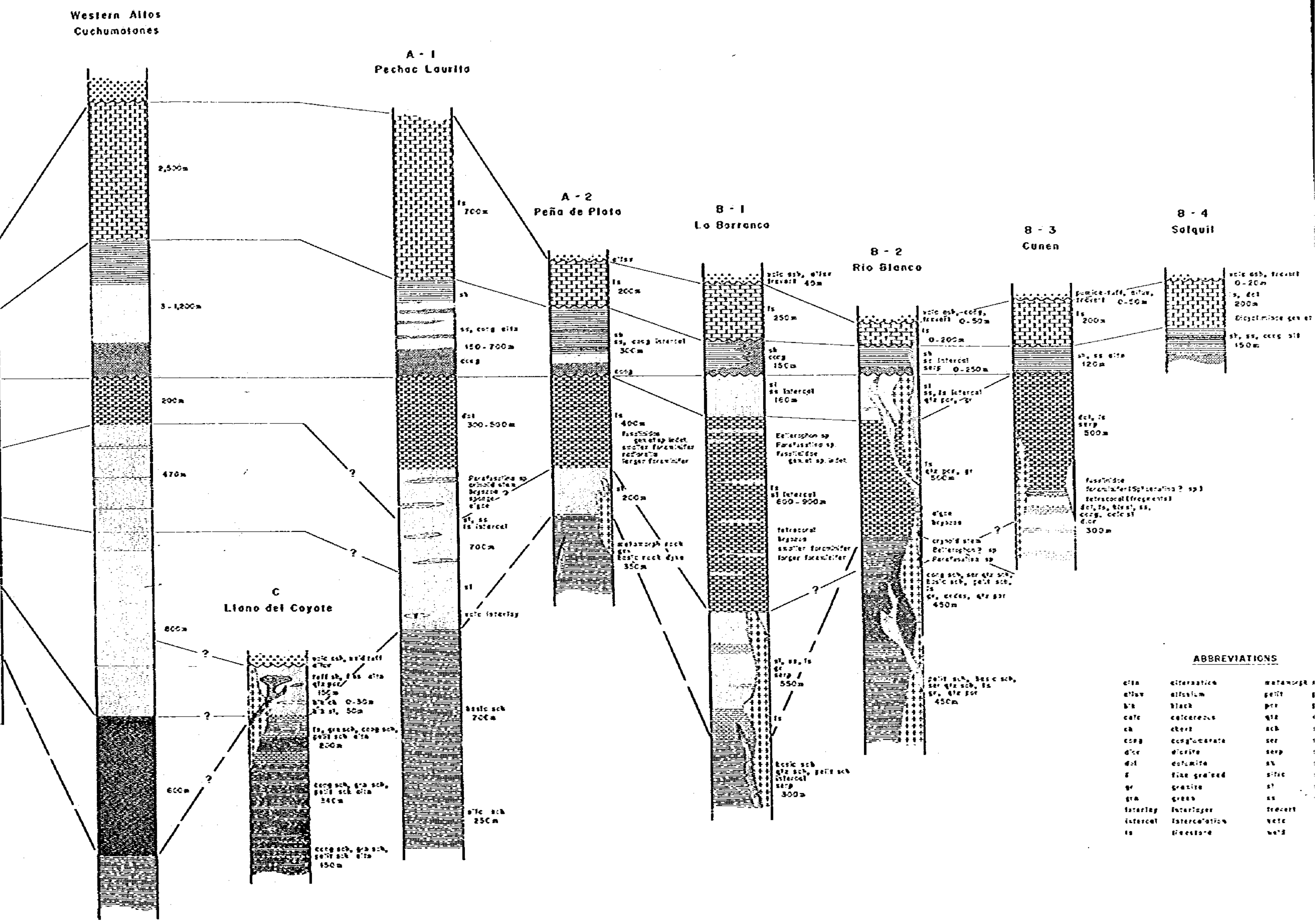
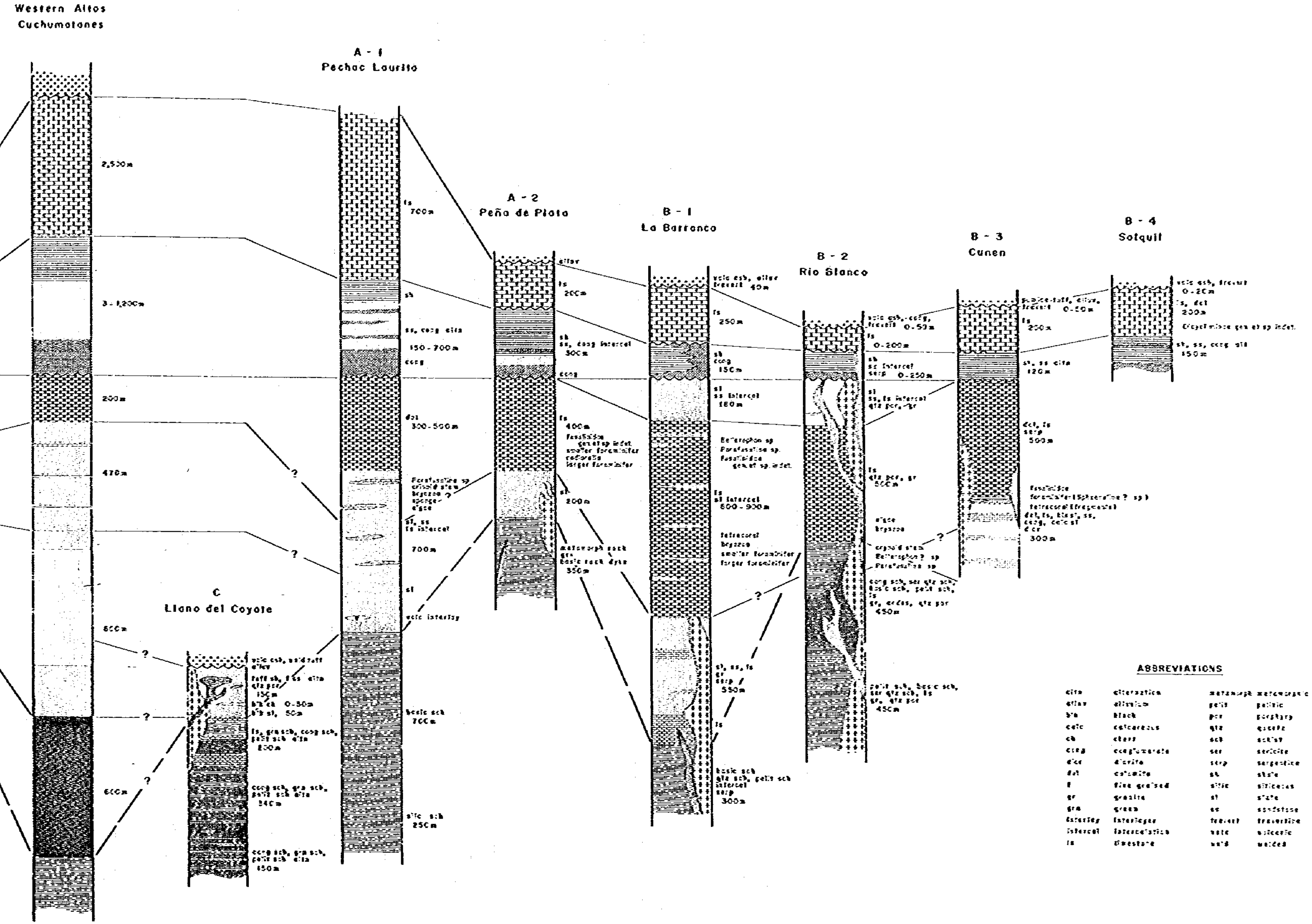


Fig. 7 Schematic Stratigraphical Column

Western Altos Cuchumatanes Anderson et al. (1973)		
	Formation	Lithology
	Quaternary Deposits	Alluvium, Till & Volcanic Ash
	Ixcoy Formation	-Lower 1,000m- Dolomite, Limestone & Dolomite interbedded with limestone breccia; dark-grey, medium crystallized; unfossiliferous ; probably Cretaceous
	Todos Santos Formation	Conglomerate, Sandstone, Siltstone & shale; red, terrigenous; probably Jurassic but may be as old as Late Triassic; Limestone, lenticular thin beds, marine, in the upper part of the sequence. Late Jurassic Early Cretaceous
Santa Rosa Group	Tuilan Member / Chochal Limestone	-excluding Tuilan Member- Dolomite & Limestone, grayish-black brownish dark grey, massive-bedded, cliff forming; fossiliferous ; fusulinids, corals, brachiopods, crinoids, sponges, echinoid spines, bryozoa & algae
Santa Rosa Group	Esperanza Formation	Shale, mudstone & siltstone, brown black; Limestone & Dolomite, interbeds, 5m in thickness; weathered red, brown, yellow or grey; fossiliferous ; Schwagerina cf S compacta Thompson 1954, Wolfcampian
Santa Rosa Group	Tactic Formation	increasing amount of limestone beds; Shale & Mudstone, brown black; Quartzite, local; Limestone & Dolomite, rare; unfossiliferous
Santa Rosa Group	Chicol Formation / Sacapulas Formation (Forth, 1971)	Conglomerate & Sandstone, greenish & light bluish grey; Tuff, grayish-green, grey & maroon; crinoid plates in conglomerate; -Sacapulas F.- Conglomerate, Slate & Sandstone. Volcanic & Metavolcanic interbeds, locally
Santa Rosa Group	Chicol F. Metamorphic Rock Sequence	Low grade regional & dislocation metamorphism & probably to a lesser degree contact metamorphism altered conglomeratic & volcanic rocks to the quartz-albite-muscovite-chlorite subfacies of the green schist facies



ABBREVIATIONS

alte	alteration	metamorph	metamorphic
alluv	alluvium	pelit	pelitic
bla	black	por	porphyry
calc	calcareous	qtz	quartz
ch	chert	sch	schist
cong	conglomerate	ser	sericite
dior	diorite	serp	serpentine
dol	dolomite	sh	shale
f	fine grained	silic	siliceous
gr	granite	sl	slate
grn	green	ss	sandstone
interlay	interlayer	travert	travertine
intercal	intercalation	volc	volcanic
ls	limestone	weld	welded

Both the two sequences are suffered from skarnization and hydrothermal alteration in the vicinity of the contact with granitic rocks that occur widely in the southwestern part of the Area-C to form a mineralized altered zone. Metamorphic rocks crop out also in the vicinity of Cerro Bobí in Area-A and in the southern part of Area-B other than C (PL-1,-2).

The Tactic and the Esperanza Formations comprise mostly slate and mudstone, however the latter contains more clacareous interlayers than the former. Within the Tactic itself, the calcareous interlayers increase their abundance upward toward the Esperanza. Most of the sequences, which mainly comprise clay slate in Area A-1, and A-2, may be correlated to the Tactic or Esperanza from their lithostratigraphical similarity.

The Chochal Formation consists of massive and cliff-forming dolomite and limestone that contain abundantly such fossils as Fusulinidae. The sequences that occur in all the project areas other than Area-C and abundantly contain Fusulinidae, *Bellerophon*,crinoid, and corals could be correlated to the Chochal. At the uppermost horizon of the Chochal, a Member called Tuilán that consists of sandstone and mudstone occurs in some places. Probably the sequences, which occur overlying the Chochal in Area B-1 and B-2, and consist of sandstone and slate may be correlated to this member.

The lowermost Mesozoic sequence that unconformably overlies the Santa Rosa Group is the Todos Santos Formation which comprises terrestrial sediments such as conglomerate, sandstone and shale. The Formation distributes in all the project areas except Area-C, cropping out as narrow belts at the peripheries of the Paleozoic terrain. The Formation is overlain by the upper horizon, the Ixcoy Formation, conformably or disconformably.

The Ixcoy Formation most widely distributes on the surface of the western Altos Cuchumatanes and chiefly comprises non-fossil massive calcareous rocks. The Formation occurs in all the project areas except Area-C, and generally accompanies so-called brecciated limestone near its basal horizon , which is considered to be sedimentary conglomerate in nature. Dicycliminal gen. et. sp. indet. that indicates the age ranging from Jurassic to Eocene was collected from this Formation in Area B-4. This might belong to *Orbitolinella* of the late Cretaceous.

The quaternary deposits include recent volcanics, alluvium, and so-called travertine which occurs on the fault scarp at the northern side of the Chixoy-Polochic fault as in Area B-1 and B-2. The recent volcanics in the southern part of the Area-B comprise ash and pumice tuff, and overlie the unconsolitated gravel and sand beds.

3-6 Intrusive Rocks

(A) Distribution

The relatively common intrusive rocks that occur in the project areas are acidic to intermediate plutonic rocks and ultrabasic plutonic rocks. Other than these, acidic hypabyssal to volcanic rocks, and basic plutonic rocks are observed as well. Intermediate to basic dykes locally occur here and there.

These intrusive rocks distribute only in very limited areas. That is to say, the acidic-intermediate plutonics mainly occur in the southern side of the Chixoy-Polochic fault, at the southern foothill of the Altos Cuchumatanes (B-1,B-2, and C). In the central part of the highland, on the other hand, they only scatteredly occur as small stocks in such areas that the erosion has progressed to expose the basement (South of A-1, Area-A in 1976, and A-2). Ultra-basic rocks (serpentinized peridotite) mainly occur intermittently in the sheared zones of the Chixoy-Polochic fault system as small lenses in the southern part of Area-B(PL-2). No description on the intermediate to basic dykes is made here, as they are of less significance.

3-6-1 Acidic to Intermediate Intrusive Rocks

The northern margin of the granitic batholith, which occurs eastward from Huehuetenango (ca.65km E-W, and 10 to 15km N-S), is in the southern parts of Area-B. The batholith intruded the sedimentary-metamorphic rocks of the Paleozoic sequences and also includes locally the latters as roof-pendant within it (B-2, C,etc). Within the Paleozoic sequence at the peripheral zone of the batholith, small intrusive bodies (dykes &/or sill) of rhyolitic (or dacitic) to porphyric rocks are observed (B-2, C: PL-2). The Paleozoic rocks are locally suffered from skarnization and hydrothermal alteration near the batholith, especially in such a place as mentioned above, and sometimes mineralized (B-2,C, etc). Most of the metallic mineralization in the project areas are considered to be genetically related with these acidic to intermediate intrusive rocks.

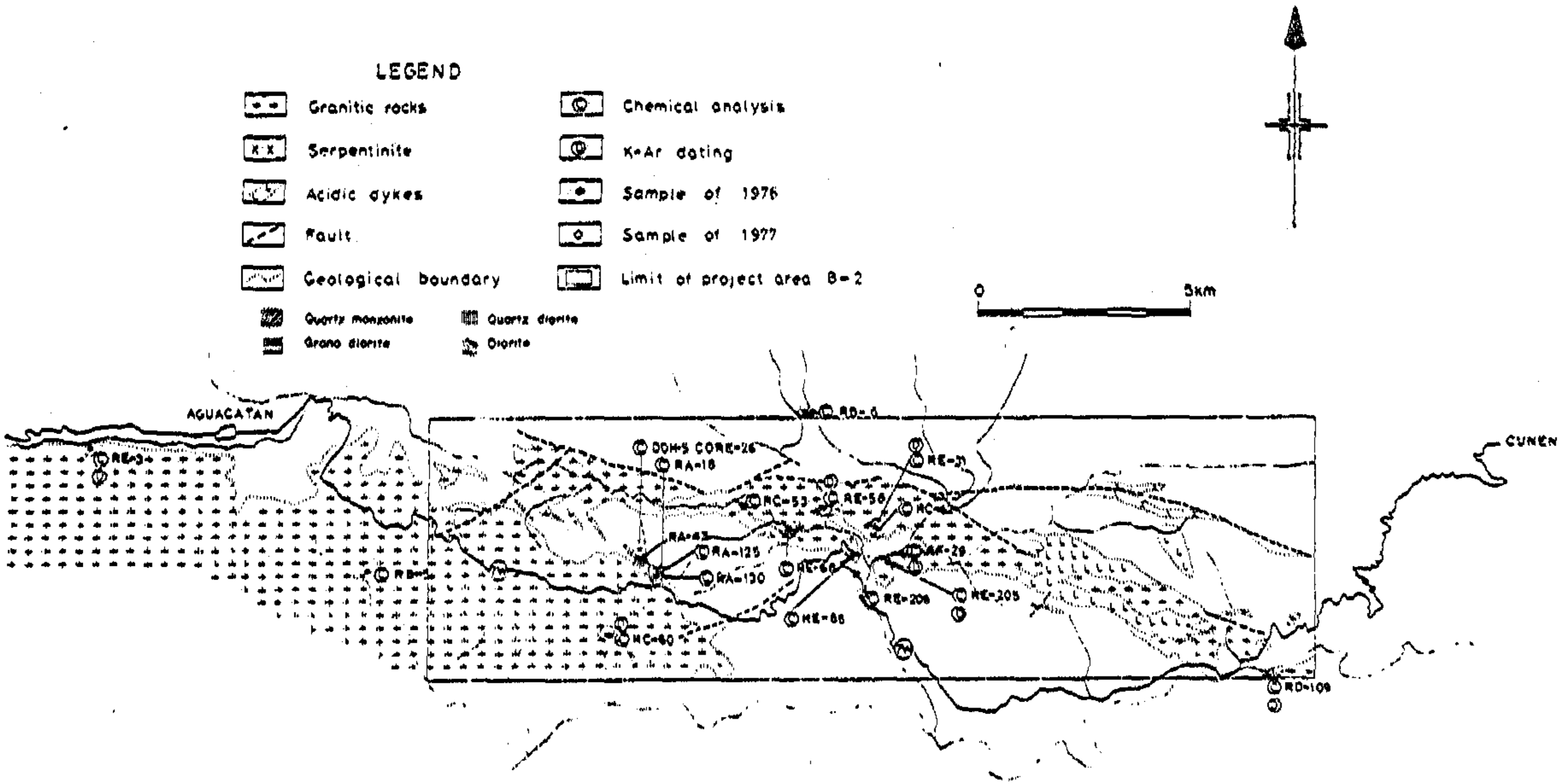
The rocks comprising the batholith petrographically range from quartz diorite to syenitic granite, while the dykes and sills range from rhyolite (or dacite) to quartz porphyry.

In Area-A, no intrusive bodies of the batholithic scale are exposed, but very small acidic to intermediate intrusive bodies of hypabyssal to plutonic rocks sporadically occur as dykes and stocks in the areas where the surface is dissected deeply by erosion. These are; (1) In tha vicinity of Jolomchipál (1863-I; X=55, Y=51), (2)Yolaxito(1863-II; X=54 Y=42), (3)On the southeastern ridge of Cerro Bobí (1963-III; X=64-67, Y=47±), (4) near the village of Yolaba(1963-III; X=71, Y=43), (5) north of Sacleçán(1963-III; X=76-78, Y=47), and (6) west of Peña de Plata(1963-III; X=75, Y=43), and so forth (PL-1).

(B) Chemical composition

Bulk chemical analysis of intrusive rocks was carried out for 20 hand-specimens during the present program, and 13 elements were assayed(Table 5-A,B). Localities of the assayed samples are shown in Fig.8. Norms were calculated from these results (Table 6-A,B). Ratios of normative Quartz, K-feldspar, and Plagioclase were subsequently calculated and plotted in a triangular diagram, on which non-altered Arizonan porphyries related with porphyry copper deposits (Creasy, 1966) were also plotted for reference and comparison(Fig.10). The plots indicate that most of the rocks from our project areas fall in the fields of granodiorite and quartz monzonite by Bateman (1961). It is quite interesting that the plots of the Guatemalan samples are located outside of those from Arizonan ones, especially in the quartz-rich field. However, no precise discussion can be made so far, as ours include altered rocks. Differentiation indices were calculated from the normative minerals and plotted in a diagram taking SiO_2 as abscissa (Fig.9). The plots indicate that the acidic to intermediate intrusive rocks in our project areas are apparently located in two separated fields; one is the field more differentiated that Arizonan porphyries and another is less differentiated. It is interesting that there are few plots being located in the same field to Arizonan porphyries'.

Fig.8 Locality of Granitic Rocks Tested



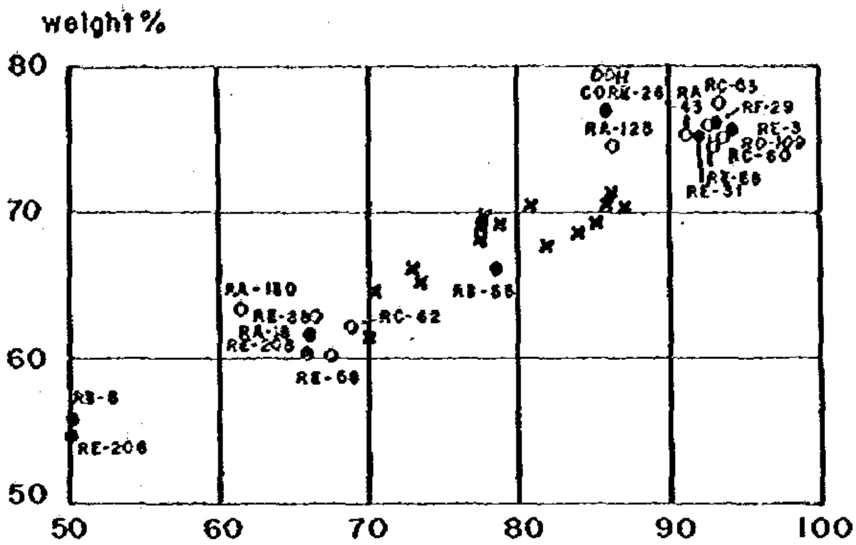


Fig.-9 Differentiation Index vs. SiO_2 of Acidic Igneous Rocks

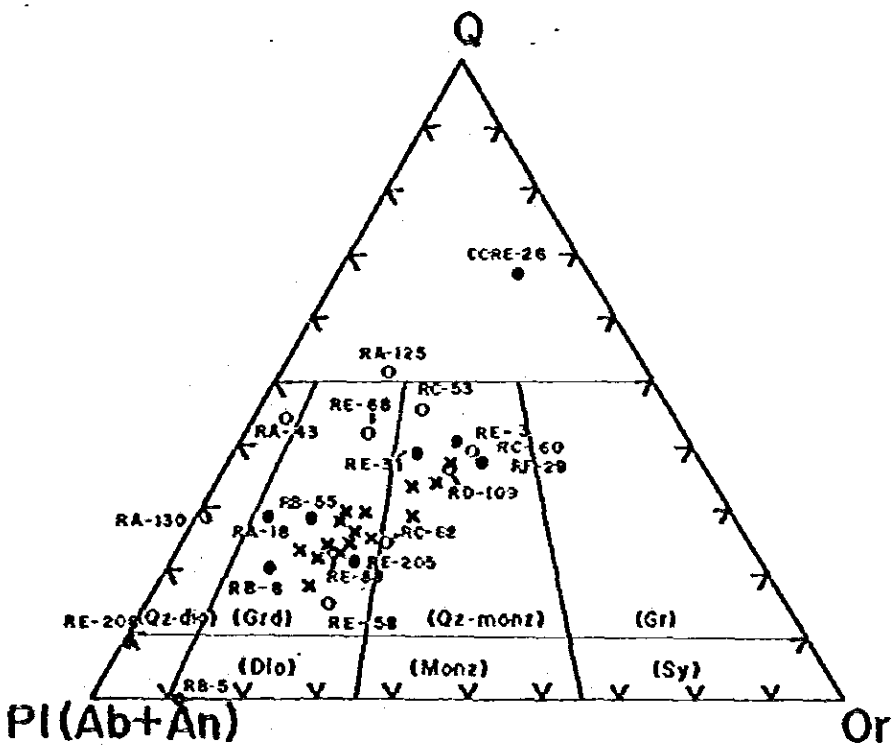


Fig.-10 Plots of Quartz-K-feldspar-Plagioclase of Norms of Acidic-Intermediate Igneous Rocks

Classification from Bateman (1961)

O Samples taken during Phase-II of Present Project

● Samples taken during Phase-I of Present Project

x Unaltered Arizonan Porphyries related with Porphyry Copper Deposits, after Creasy(1966)

Table 5-A Chemical Analysis of Igneous Rocks (Phase I)

Sample No.	RA-18	RB-5	RB-6	RB-55	RE-3	RE-31	RE-205	RE-206	RF-29	DDH-CORE 26 *2
Rock Type	Meta-Quartz porphyrite	Meta-Hornblende porphyrite	Cataclastic Q-diorite porphyrite	Meta-Quartz porphyrite	Coarse-grained Syenitic granite	Aplite vein in granitic rock	Meta-grano-diorite	Meta-grano-diorite	Syenitic granite	Altered quartz porphyry
Topo Map *1	1961-1	1961-4	1962-2	1863-2	1962-2	1961-1	1961-1	1961-1	1961-1	1961-1
UTM GRID X - Y	91-93	93-84	94-97	51-51	78-96	96-94	96-93	96-92	97-94	91-93
SiO_2	61.82	46.42	55.73	66.21	75.97	75.40	61.48	54.97	75.70	76.64
TiO_2	0.68	1.70	1.53	0.65	0.10	0.13	0.69	0.55	0.17	0.15
Al_2O_3	17.81	15.28	17.07	15.90	14.18	13.61	17.17	19.10	12.92	13.41
Fe_2O_3	3.64	6.90	2.10	1.30	0.46	0.69	3.08	4.05	0.55	1.59
FeO	1.15	6.00	6.55	3.38	0.23	0.62	2.31	2.34	0.33	0.54
MnO	0.09	0.20	0.12	0.05	tr	0.02	0.11	1.32	0.02	0.01
MgO	1.87	7.22	4.12	2.08	0.12	0.16	2.18	2.59	0.25	0.23
CaO	3.29	8.02	3.91	0.34	0.11	0.56	3.80	6.89	0.61	0.05
Na_2O	4.08	3.29	3.15	5.21	3.31	3.75	3.16	5.07	2.84	0.86
K_2O	1.40	1.17	1.60	2.10	4.71	4.02	3.57	0.08	5.58	3.51
H_2O+	2.80	3.18	3.54	2.04	0.45	0.51	1.89	2.40	0.55	2.34
H_2O-	1.23	0.56	0.20	0.45	0.15	0.10	0.11	0.08	0.06	0.14
P_2O_5	0.15	0.37	0.30	0.14	0.01	0.05	0.17	0.23	0.01	0.05
Total	100.01	100.31	99.92	99.89	99.80	99.62	99.72	99.67	99.59	99.52

*1 Sheet number of I.G.N. quadrangle maps

*2 Taken from 97' of "Llano del Coyote DDH-4" by UNDP.

Table-5-B Chemical Analysis of Igneous Rocks

Sample No.	RA-43	RA-125	RA-130	RC-53	RC-60	RC-62	RD-109	RE-53	RE-68	RE-88
Rock Type	Dacite	Altered dacite tuff(?)	Altered dacite	Quartz porphyry	Syenitic granite	Hornblende granodiorite	Biotite granite	Altered granodiorite	Rhyolite (dyke) ?	Altered granodiorite
Area	C	C	C	B2	B2	B2	B2	B2	B2	B2
Topo Map*1	1961-1	1961-1	1961-1	1961-1	1961-1	1961-1	1961-1	1961-1	1961-1	1961-1
UTM GRID X - Y	91-93	91-93	91-93	93-94	90-92	96-94	105-91	95-94	94-94	96-93
SiO_2	75.47%	74.57%	63.31%	77.51%	74.92%	62.34%	75.21%	60.42%	75.90%	62.69%
TiO_2	0.29	0.33	0.71	0.07	0.29	0.70	0.11	0.71	0.08	0.62
Al_2O_3	15.13	14.67	16.77	13.14	14.16	17.17	13.85	16.67	14.32	16.73
Fe_2O_3	0.48	1.04	3.93	0.38	0.34	3.27	0.63	3.09	0.47	3.13
FeO	0.26	0.27	0.66	0.29	0.56	2.32	0.29	2.72	0.39	1.76
MnO	0.01	0.01	0.10	0.06	tr	0.10	0.01	0.16	0.01	0.09
MgO	0.13	0.40	1.33	0.12	0.29	2.25	0.22	2.33	0.21	1.72
CaO	0.16	0.43	5.37	0.26	0.16	2.80	0.16	3.43	0.23	4.32
Na_2O	5.54	3.20	4.19	3.39	3.06	3.02	3.56	4.18	4.82	3.37
K_2O	0.76	2.25	0.28	3.49	5.07	4.00	4.95	3.46	2.62	3.18
H_2O+	1.09	1.96	2.22	0.81	0.65	2.04	0.57	2.05	0.46	1.69
H_2O-	0.27	0.47	0.86	0.09	0.07	0.11	0.11	0.15	0.11	0.14
P_2O_5	0.05	0.04	0.12	tr	0.07	0.07	tr	0.21	tr	0.16
Total	99.64%	99.64%	99.85%	99.61%	99.64%	100.19%	99.67%	99.58%	99.62%	99.60%

* sheet number of I.G.N. quadrangle maps

Table 6 A Norms of Samples taken in 1976

Rock Type	Meta-Quartz Porhyrite	Meta-Hornblende Porhyrite	Cataclas-tic Q-diorite Porhyrite	Meta-Quartz Porhyrite	Coarse-grained Syenitic granite	Aplite vein in granitic rock	Meta-grano-diorite	Meta-grano-diorite	Syenitic granite	Altered Quartz Porphyry
Norm mineral \ Sample No.	RA-18	RB-5	Rb-6	RB-55	RE-3	RE-31	RE-205	RE-206	RF-29	DDH-CORE-26
il	1.37	3.19	2.88	1.21	0.15	0.30	1.37	1.06	0.30	0.30
ap	1.01	3.03	2.02	1.01	-	-	1.01	2.02		
or	8.35	6.68	9.46	12.24	27.83	23.93	21.15	0.56	32.83	20.59
ab	34.60	27.79	26.74	44.04	27.79	31.46	26.74	42.99	24.15	7.34
an	15.49	23.64	17.63	0.75	0.56	2.78	18.00	28.93	3.06	0.28
c	3.90	-	3.63	4.82	3.47	2.41	1.46	-	1.12	8.16
mt	2.08	9.72	3.01	1.85	0.46	0.93	4.40	5.79	0.69	1.85
hm	0.64	-	-	-	0.16	-	-	-	-	0.32
Di	-	10.57	-	-	-	-	-	2.69	-	
hy	4.62	8.23	18.29	9.44	0.30	0.80	6.21	7.76	0.60	0.60
ol	-	2.81	-	-	--	-	-	-	-	-
Q	23.16	-	13.83	22.58	38.44	36.64	18.05	6.79	36.16	57.78
$H_2O^{\pm}$	4.03	3.74	3.74	2.49	0.60	0.61	2.00	2.48	0.61	2.48
Total weight %	99.25	99.40	101.23	100.43	99.76	99.59	100.39	101.07	99.52	99.70
Differentiation Index	66.31	34.47	50.03	78.86	94.06	92.03	65.94	50.34	93.14	85.71

Table 6-B Norms of Samples taken in 1977

Rock Type	Dacite	Altered dacite tuff	Altered dacite	Quartz porphyry	Syenitic granite	Hornblende grano-diorite	Biotite granite	Altered granodiorite	Porphyrite (dyke)	Altered grano-diorite
Norm mineral \ Sample No.	RA-43	RA-125	RA-130	RC-53	RC-60	RC-62	RD-109	RE-58	RE-68	RE-88
il	0.61	0.61	1.37	0.15	0.60	1.37	0.15	1.37	0.15	1.21
ap	-	-	1.01	-	-	-	-	1.01	-	1.01
or	4.45	13.36	1.67	20.59	30.05	23.37	29.49	20.59	15.58	18.92
ab	46.66	27.26	35.65	28.84	25.69	25.69	29.88	35.13	37.75	28.31
an	0.83	2.23	25.78	1.39	0.83	13.90	0.83	16.05	1.11	20.50
c	4.89	6.12	0.13	3.26	3.36	2.75	2.34	0.23	3.67	0.23
mt	-	-	0.23	0.23	0.46	4.63	0.69	4.40	0.69	4.17
hm	0.48	1.12	3.83	-	-	-	0.16	-	-	0.32
hy	0.30	1.00	3.21	0.70	0.96	6.15	2.21	7.53	0.63	4.32
Q	40.00	45.65	24.66	43.42	36.88	19.94	33.87	11.99	39.04	19.56
H_2O	1.36	2.43	3.08	0.90	0.72	2.15	0.68	2.20	0.57	1.83
Total weight %	99.58	99.78	100.62	99.48	99.55	99.95	100.30	100.50	99.19	100.38
Differentiation Index	91.11	86.27	61.98	92.85	92.62	69.00	93.24	67.71	92.37	66.79

(C) K-Ar age dating

K-Ar age dating was performed for 7 samples of acidic rocks that were collected in Area-B during the Phase-I and II. The result is listed in Table-7, and shown in Fig.11.

K-Ar dates range from 58m.y. (Paleocene to Eocene) to 135m.y. (early Cretaceous). The youngest rock (RE-31-1976) is a small dyke that clearly intrudes the granitic batholith. It shows macroscopically aplitic appearance, but is microscopically spherulitic rhyolite (Differentiation Index =94.06; in Quartz monzonite field). This may probably belong to the same group that includes dykes-sills of rhyolite to quartz porphyry in Llano del Coyote area.

The three samples that indicate 74 to 85 m.y. are from the central part of the northern one of the two granitic bodies that occur in B-2. These are as follows: RE-205-1976,74m.y.,Granodiorite,Differentiation Index= 65.94, in granodiorite field; RF-29-1976, 83 m.y.,Fine grained syenitic granite, Differentiation Index=93.14, in quartz monzonite field; RE-58-1977, 85 m.y., Granodiorite, Differentiation Index=67.71, in granodiorite field.

The oldest rocks ranging from 117 to 135 m.y. are syenitic granite, and are from the main part of the southern and northern bodies in B-2. The samples were collected from relatively inner locations from the sedimentary contact than others. These are as follows: RC-60-1977, 117 m.y., Differentiation Index=92.62, in Quartz monzonite field; RD-109-1977, 135 m.y., Differentiation Index=93.2, in Quartz monzonite field).

Interpreting the facts described above, we tentatively infer the intrusive sequence of the acidic to intermediate igneous rocks as follows:
(1) Intrusion of quartz monzonitic rocks(D.I.=93±) in the early Cretaceous (135-117 m.y.). This might indicate the main phase of the intrusion of the batholith. (2) Intrusion of granodiorite (D.I.=66 to 68) in the later Cretaceous(85-74 m.y.) (3) Intrusion of dykes and sills of rhyolite-quartz porphyry(D.I. 92-94) in the Paleocene-Eocene(62-58 m.y.). However, there still remains a possibility that "(2)" might be the "(1)" rejuvenated by the alteration accompanied with the intrusion of "(3)", as the dated samples of "(2)" are affected by alteration more or less.

Fig.11 Results of K-Ar Age Dating of Granitic Rocks

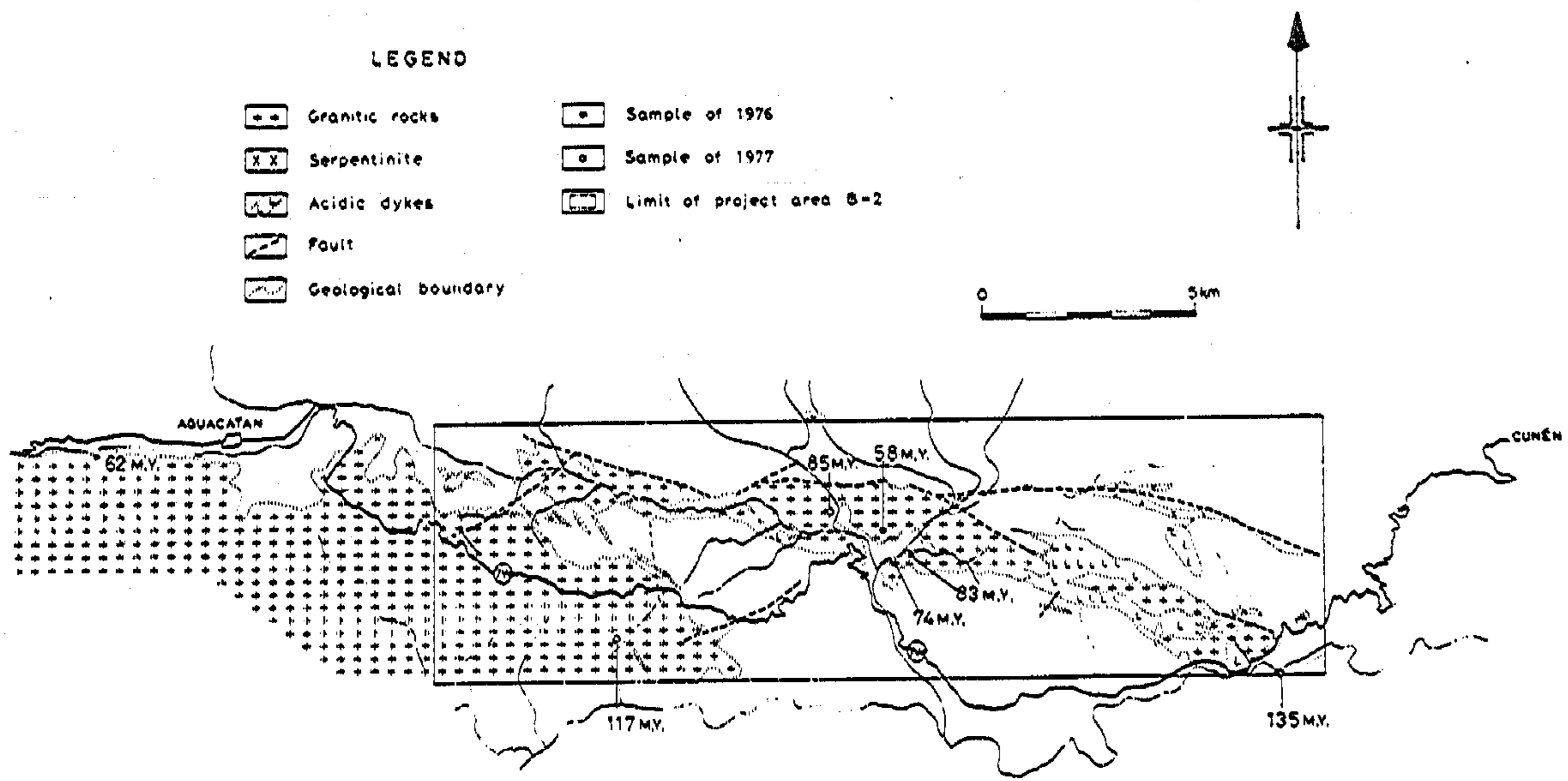


Table - 7 K-Ar Ages of Granitic Rocks

Area	Location	Location	Rock Name	Mineral	Sample wt. %	K %	$^{40}Ar^R / ^{40}K$	Air Contamination %	Age M.Y.	Remarks
B2	RE-58	1961-1 X=95+ Y=94+	Altered granodiorite	Salic	1.4457	3.28	0.005072	24.32	85	
B2	RD-109	1961-1 X=105+ Y=91+	Biotite-granite	Salic	1.0744	4.33	0.008180	23.53	135	
B2	RC-60	1961-1 X=60+ Y=92+	Syenitic granite	Salic	1.0754	4.10	0.007022	17.90	117	
B2	RE-31 *	1961-1 X=96+ Y=94+	Aplitic vein in granitic rock	Whole	1.0105	3.25	0.003449	19.67	58	Aplitic vein intruding granitic rock.
B2	RE-205 *	1961-1 X=96+ Y=93+	Meta-granodiorite	Whole	1.0589	2.55	0.004393	13.20	74	
B2	RE-206 *	1961-1 X=96+ Y=92+	Meta-granodiorite	Whole	1.0221	0.08	excess	-	-	Can not be analysed due to lack of K
B2	RF-29 *	1961-1 X=97+ Y=94+	Syenitic granite	Whole	1.0363	2.37	0.004983	20.79	83	
8km west of B2	RE-3 *	1962-3 X=78+ Y=96+	Syenitic granite	Whole	1.0116	3.97	0.003689	10.24	62	Surrounding rocks are gneissic. Near to the Chixoy-Polochic fault

* Five samples in lower rows were analysed in 1976

λ_e : $0.585 \times 10^{-10} yr^{-1}$ $^{40}K/K$: 1.19×10^{-2} atom %

λ_β : $4.72 \times 10^{-10} yr^{-1}$ $^{40}Ar^R$: Radiogenic argon 40

(D) Alteration

Granitic rocks and rhyolite-quartz porphyries are pervasively suffered from alteration. As to the alteration types, the propylitic and argillic predominate, though very locally the potassic and phyllic assemblages can be observed. Also an assemblage resembling the advanced argillic is also observed here and there (Part-III of Phase-II report).

3-6-2 Ultrabasic(ultramafic) rocks

In the present project areas, small lenticular bodies of serpentinized peridotite(lherzolite) crop out intermittently in the sheard zones of the Chixoy-Polochic fault system; at present 12 to 13 bodies are discernible within a total distance of 36km along the fault.

The dimensions of the larger bodies are as follows;

(1) At the western corner of the Area-B; 3km by 1km

(2) Near La Barranca, about 3 to 6km west of Aguacatán; 2.5km by 400m

(3) A locality about 2km east of Chiúl near the Nebáj road; 1.5km by 800m

The rests are much smaller in size than these listed above.

Most of these bodies are bounded by sheard zones so that rocks are often foliated near their boundary and sometimes show slicken sides. Peridotite is dark gray to dark green in color. It is massive and compat at the center of a comparatively larger mass, though it is often foliated at the margins of such mass, or even at the core in the case of a smaller body.

The fresh rock may petrographically be called lherzolite: Principal constituent minerals are originally olivine, orthopyroxene, and clinopyroxene, but they are usually serpentinized more or less. Accessory minerals are magnetite, spinel, and chromite.

The peridotite provides the host to massive chromite "ores" in some places as "Cata Santa María"in Area B-1 (p.100-102 in Phase-II report). However, the dimension of peridotite bodies in the project areas is mostly small, and the chromite "ores" within them are also small, and very irregular in shape. Therefore, we consider there is little possibility that significant chromite deposits occur in the project areas.

The presence of a trace amount of pentlandite and awaruite(native Fe-Ni alloy) was identified by EPMA in magnetite host in a handspecimen of serpentinized peridotite, *continue to next page*

which had been collected in the adjacent area of the massive chromite occurrence in Cata Santa María(p.32 in Phase-I report, p.100-102 in Phase-II report). This does not mean any economic significance, but is interesting in connection with the genesis of the nickeliferous laterite in eastern Guatemala. The lateritic nickel deposit, which is being operated in the Lago de Izabál area in eastern Guatemala, also occurs along the Chixoy-Polochic fault, and in this sense the serpentinite bodies occuring in the present project areas are situated in the similar geological setting. However, little exploration potential for the laterite nickel could be expected in our project areas, as the lateritization here is not so advanced due to the climatological and topographical conditions, and as dimensions of the host peridotite bodies here are by far the smaller.

The geological age of the intrusion of the ultrabasic rocks is unknown so far. This partly due to the fact that the time relationship can hardly be inferred by the spatial (cutting) relationship with the adjacent rocks, as remobilization by the post-intrusion fault movement is expected. At the moment, followings are the only comments that can safely be made on the age: (1) Some part of serpentinite, though only in very limited area, was exposed to the erosion surface during the time of the sedimentation of the basal conglomerate of the Todos Santos Formation (McRee,1966). (2) Most parts of the serpentinite bodies are believed to have been exposed to erosion in the Cretaceous or later.

3-7 Structural Geology

The most important structural factors that control the geological structure in the Altos Cuchumatanes, in which the present project areas are located, are a regional anticlinorium trending in EW to N80°W, the Chixoy-Polochic fault, and the faults that trends in N55°-70°W such as the Río Ocho fault. A synclinorium is also inferred to exist about 10 km north of the Chixoy-Polochic fault, running parallel to it and the Río Ocho. (Fig.3 and 12)

Both the rocks of the metamorphic basement and the Santa Rosa Group are moderately folded, being affected by the anticlinorium. The Paleozoic rocks generally trend in NW to WNW in the project areas, however, in Area A-1, which is situated fairly near to the northwestern nose of the Paleozoic core of the anticlinorium, they trend predominantly in ENE, and at the very nose they complicatedly strike in NE,NS, and NW (PL-1).

On the contrary, the Todos Santos rocks that unconformably overlie the Paleozoic usually dip very gently, showing less than 30° inclination. These facts suggest that the main phase of the fold movement which formed the anticlinorium must have taken place before the sedimentation of the Todos Santos Formation, though there might have been some secondary deformation due to the uplifting after the Jurassic. The paleotopography at the time of the sedimentation of the Todos Santos is inferred to have been considerably steep, being judged from the distribution of the contact plane between the Todos Santos and the Santa Rosa. Near the paleotopographical peaks of the Paleozoic basement, the Todos Santos locally dips to various directions concordantly with the peak slope (western part of Area A-1).

The Chixoy-Polochic fault strikes almost in E-W direction near the present project areas. It transverses the southern part of B-1, the northern part of B-2, and the northern part of B-3 respectively. The sheard zone of the fault is 1 km or more wide, and accompanies strongly sheared and crushed rocks. However, there are few localities where the individual constituent sheared planes can be observed, as the fault zone usually forms a topographical low and is generally covered with soil, travertine, alluvium, or recent volcanic ash.

It is described that some sheared planes observed near Chiantla, which is located west of B-1, dip moderately to steeply to the north. It is also said that the present fault zone coincides with a zone of pre-Permian defomation (Anderson, 1968b, Bonis, 1968). It is quite possible that dislocation may have repeatedly taken place through the long geological history. Most recent movement inferred from the altitude difference between the Ixcoy Formation along the present fault scarp and that in the graben-like fault zone is about 1,000m of relative uplift on the north side of the fault. However, dislocation between the fault zone and its south side is unknown at least near the project areas, as there is no place where the Ixcoy Formation occurs in the south side. There is an interpretation that "Holocene" displacement inferred from drainage patterns is of left-lateral with offsets along fault from 100m at least to about 1 km at greatest (Kupfer and Godoy, 1967).

The Río Ocho fault is considered to bifurcate northwestward from the Chixoy-Polochic fault near the southeastern margin of B-1. The fault strikes in N55°-60°W and extends for some 80km together with branch faults. It is said that it generally dips steeply to the south. The southwest block is relatively uplifted against the northeast block in B-1.

The relationship between these structural factors and mineralization is discussed in later in 3-9-1.

3-8 Mineralization

Summary of the mineral occurrences in the present project areas is tabulated in Table-8. Most of the data in the table are taken from references by UN and others, as we could not cover the all. Localities of mineral occurrences are plotted in Fig.13, regardless of their dimension and intensity.

3-8-1 Metallic Minerals

General: Generally speaking, mineralization is weak in the project areas. That is to say, there is neither operating mine nor an abandoned one that recorded continual commercial production in the past. Almost all the old works, abandoned prospects, and showings are of very small. They are mostly very difficult even to locate at present. They are mostly very difficult even to locate at present.

We consider that there may be little possibility that an ore deposit, which has reserves of say 10^7T order or more, will be discovered within the areas, judging from outcrops, ore floats, and geochemical anomalies we have encoutered, and from previous discriptions.

We believe that the only mineralization types which may yield small scale operating mines in future are so-called skarn type (Cu-Zn), and the Pb-Zn-Ag mineralization in carbonate rocks that resembles so-called Mississippi Valley type. Both occur in the calcareous rocks of the Paleozoic and are seemingly related spatially and genetically with acidic to intermediate intrusives of Cretaceous to Paleogene.

Skarn to hydrothermal replacement type mineralization is mainly observed in Area-C and B-2, and was thought the most prospective among various metallic mineralization types in the project areas. 10 DDHs totaling 2,033.7m were carried out in Phase-II and -III. As a result, a promising sulfide Zn-mineralization was intersected in MJ-9 of Phase-III (12.76% for 9.5m). In the same hole, an intersection of secondary enrichment Cu was intersected at the lowermost part of the oxide zone(3.80% for 0.60m). The possibilities that reserves of n x 10^5T to n x 10^6T exist in the area are fairly great, being judged from the extent of the geochemical anomalies of rock chip-samples. A deposit may be exploitable even of this size and grade in this area, as location of the prospect is quite favorable so that expenditures for infrastructures will be minimized. The result of the further exploration is hopefully expected.

Fig.13 Location Map of Known Mineralization

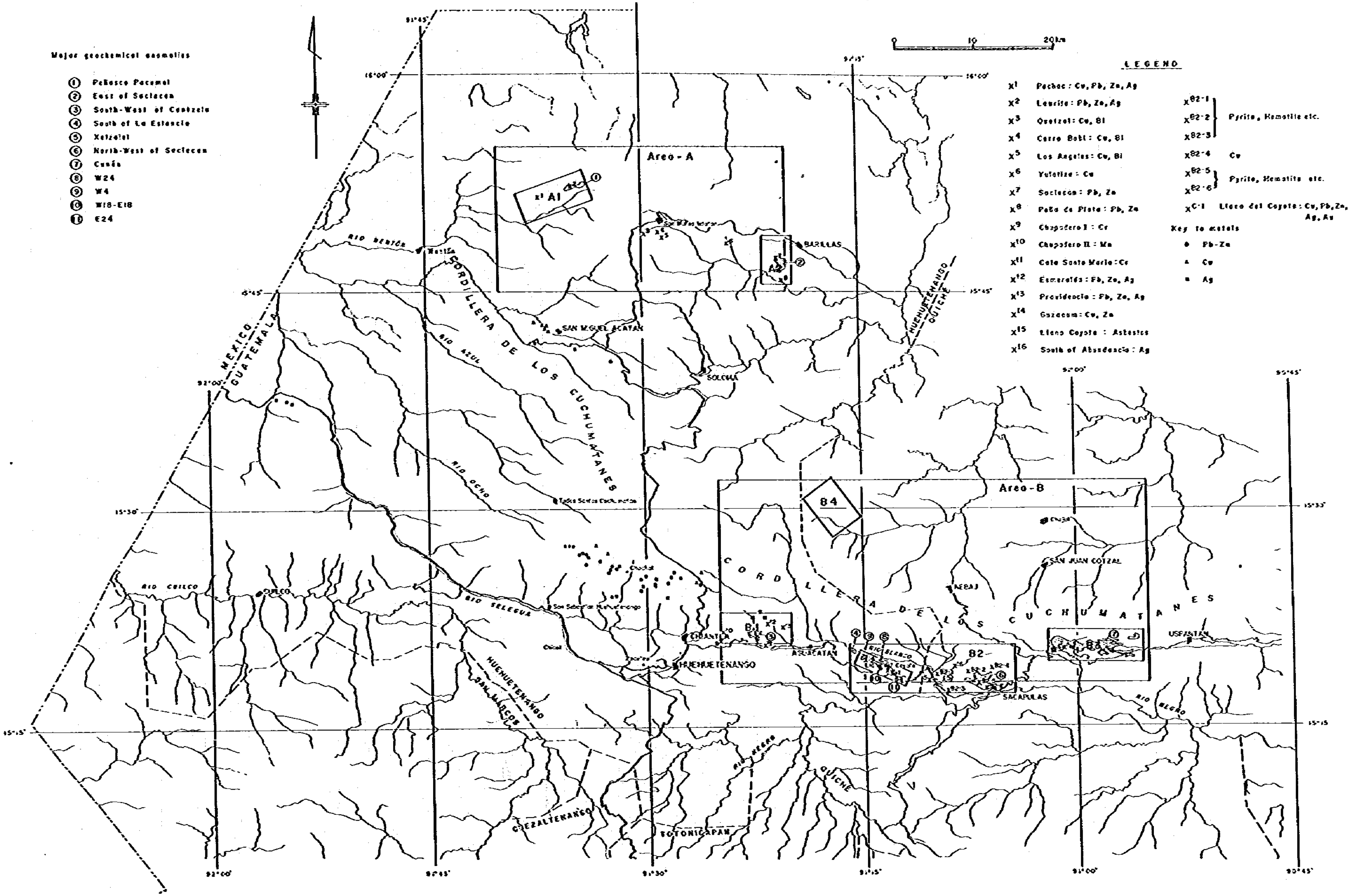


Table-8 Summary of Known Prospects and Showings

(1) Area-A

Name of Prospect or Showing	Type of Deposit	Location				Information source	Old works and/or Production records, etc	Brief description of Local geology	Remarks
		ICM map	UTM co-ord. X	UTM co-ord. Y	Nearest village, etc				
Pechac (Cu-Ag-Pb-Zn)	Massive Cu-Ag-Pb-Zn sulfide fragments in soil	1863-I	47*	52*	Near Yocultac	UN, 1971 P-57.	A shaft (6M) and several rat holes (2-3M deep). 12.1T of ore shipped between 1963 and 1965. Total value 2,991 US$.	Angular fragments of massive Cu-Pb-Ag-Pb-Zn ore in soil on a shaft wall. Only bed rock reached contains fractured and weathered barite.	Not visited during this phase. Pb-Zn anomaly has been located in the enclosing area
Laurita (Pb-Zn-Ag)	Cash vein(?) of galena and massive Pb-Zn-Ag sulfides fragment in soil	1863-I	52*	54*	Near Cuaiana at the foot of the north slope of Peñasco Pachumal at el. 2,100M	UN, 1971 P. 36-37	*A 25M- long trench in unconsolidated superficial material to a depth of 6 to 7M *A 25-M tunnel (in the same meterial above) at 4 to 5M below the trench *A small amount of cobble-size fragments was mined and locally smelted.	The "mine" occurs in a faulted contact between limestone and dolomite of Chochal Formation and red beds of Todos Santos Formation. Veins of galena with pockets of cerussite occur in the red beds with calcite, barite and minor amount of chalcopyrite and copper oxides	Mostly caved. Not visted during this phase. Pb-Zn anomaly has been located in the enclosing area.
Cerro Bobí *Quetzál	Hydrothermal (Mesothermal) Cu-(Bi) dissemination	1963-III	61-1	49-3	Approx. 1 km south of San Mateo Ixtatán	(1) UN, 1971 (2) UN, unpublished internal reports, 1966-67 (3) Our observation	"A vein striking E-W, width about 3M". Not visible in 1966	Cu dissemination in green rock and recrystallized chart of mesothermal type. Presence of bismuthinite coexisting with chalcopyrite is observed. Anomalous area delineated by 100ppm Cu (stream sed.) by UN follow-up is 800m (EW) by 700m (NS). DDHs and chip samples indicate Cu-content locally reaches in the order of 0.5%.	By. Sr. A. Recinos Solis Can not be located during this phase
*Los Angeles			63-1	48-8			A short adit (6-7M). Caved as in 1966. A veinlet strikes E-W, dipping 60°N		" Can not be located
*California			?	?			No information available		Can not be located
*DDHs Site			62-8	49-4			2DDHs No.1 46' (UN) No.2 116.78M (DGMH)		Visited during present works

Table- 8 Summary of Known Prospects and Showings (cont'd)

(1) Area-A

Name of Prospect or Showing	Type of Mineralization	Location: IGN map	Location: UTM co-ord. X	Location: UTM co-ord. Y	Location: Nearest village, etc	Information source	Old works and/or Production records, etc	Brief description of Local geology	Remarks
Yulatiz (Cu)	Quartz-Chalcopyrite vein	1963-III Barillas	71-3	48-1	Approx. 1 km NE of El Campamento	UN, unpublished internal reports. 1970(?)	Short trenches(?)	"The mineralization occurs in black slate. The mineralization in form of a vein cuts the beds, striking N50°E, dipping 60°-70°NW. Width varies from 1 to 2m. Visible length is 6m, then it thins out, but is visible for another 10m. Vein material is mostly quartz. Pyrite and chalcopyrite are observed. Selected samples assayed at Cu 10.3% and 17.6%"	We tried to locate the prospect, but could not find out during present operation
No name (Pb, Zn)	?	1963-III Barillas	71+	45+	Approx. 2.5km SE of El Campament	Oral information from local people	Unknown	Unknown	Not visited
No name (Pb, Zn)	?	1963-III Barillas	76+	44+	Approx. 1 km W of Finca Quilquil	"	"	"	"
No name (Pb, Zn)	?	1963-III Barillas	78+	46+	Approx. 700m SE of Tzicitón	"	"	"	"
Peña del Plata	Gash vein(?) of Pb-Zn	1963-III Barillas	77-9	43-1	Approx. 800m S of Finca El Edén	(1) UN, 1971 (2) UN, unpublished internal data	More than 60m of rat-hole drifts and shafts were driven in 3 levels from Sl 1380-1420m. These are lined in N40°W direction for about 80m.	Probably a gash vein type deposit, striking in N30°-40°W. Traced strike length is about 80m and level difference is 40m. Arithmetic mean of 16 channel samples taken from middle level tunnel by UN are: Ag 73.8g/T, Pb 8.13%, Zn 1.82%. Some galena pockets can be observed as well as cerussite	Upper 2 levels were investigated.
Saclecán (Pb, Zn)	Unknown	1963-3 Barillas	77+	45+	Approx. 3.5km SW of Barillas	(1) DGMH, unpublished internal report, 1977 (2) Our observation.	J. Rosenfeld of DGMH investigated short time in March 10, 1977	The showing comprises gossan floats that contain carbonates of Pb and Zn. Strongly limonitized ores are observed within a some 3^m by 4^m area. The arithmetic means of three handspecimens are as follow. Ag: 3.5g/T, Cu: 29.7ppm, Pb: 10.45% Zn: 2.0%, Fe: 49.34%, S: 0.06%	

Table-8 Summary of Known Prospects and Showings (cont'd)
(2) Area-F

Name of Prospect or Showing	Type of Deposit	Location: IGN Map	Location: UTM Co-Ord. X	Location: UTM Co-Ord. Y	Location: Nearest Village, etc.	Information Source	Old works and/or Production Records, etc	Brief Description of Local Geology	Remarks
Chupadero-I (Cr)	Chromite	1962-III	70+	97+		UN, 1966	Unknown	Unknown	*Not visited
Chupadeno-II (Mn)	Unknown	1962-III	70+	98+		"	"	"	"
Cata Santa María (Cr)	Massive chromite ore in serpentinized peridotite	1962-III	76-3	97-1	Approx. 1km WNW of La Barranca	Our obserbation		Several trenches are observed in a distance of about 100m in N75°W-S75°E direction. At least 2 lenses of massive chromite ore occur, striking N70-80W. Strike lengths are some 10m and widths are 1 to 2m respectively. RA-22 Cr_2O_3 48.1% RA-23 Cr_2O_3 46.3%	*Visited *Pentlandite and native Ni-Fe (awaruite) are observed in magnetite host.
Esmeralda (Pb, Zn, Ag)	Unknown	1962-III	76+	99+		UN, 1966	"	Unknown	* Not visited
Providencia (Pb, Zn, Ag)	"	1962-III	77+	99+		"	"	"	"
Guzanum (Cu)	Skarn	1961-I	87-8	95-1	Approx. 9km ESE of Aguacatán. And 2.3km WNW from NW CORNER OF 1/2000 mapped area by UN	(1) " (2) Our observation	"	3 outcrops are observed within a distance of 100m along creek with limonite gossan. A small amount of pyrite and hydrothermal magnetite is disseminated in epidotized quartz diorite, chlorite-epidote skarn, and epidote-chlorite-amphibole skarn	*Visted. *Various tests carried out for Samples No.RF-76 and 81. See: Appendix
Area-C (Llano del Coyote)	Skarn	1961-I	90 to 92-5	92-2 to 94-8	Approx. 9 to 12km ESE of Aguacatán	(1) UN, 1973 (2) MMAJ/JICA, 1967 (3) MMAJ/JICA, 1978 (4) MMAJ/JICA, 1979	*1/2000 Geological mapping, detailed geochemical sampling IP survey and 7 DDHs totaling about 680m were carried out by UN.	DDH MJ-9 intersected promising Zn-mineralization (12.76% Zn for 9.5m between 88.6 & 98.1m) in a skarn at boundary between Tactic F. & Chicol F. Rock-chip geochem. anom. delineated by 500ppm Zn well correlated to Z-order Zn-intersections (MJ-9, -1, UN-4). Zn-anom. has extent 3.6x 0.2km, & remained Unexplored, except 4 DDHs.	*DDHs carried out: UN: 7 DDHs 751.44m DGMH: 2 DDHs 189.70m MMAJ/JICA 10DDHs 1,233.70m *Further exploration is warranted & a intensive DDHs program is proposed. *cf. Phase-III Rept.
Llano del Coyote (asbestos)	Unknown	1961-1	95+	92+	Approx. 1.5km NW of Xetzajel	UN, 1966	Unknown	Unknown	*Not visited

Table-8 Summary of Known Prospects and Showings (cont'd)
(2) Area-B

Name of Prospect or Showing	Type of Minerali-zation	Location			Nearest village, etc	Informa-tion source	Old works and/or production records, etc	Brief description of Local geology	Remarks
		IGN map	UTM co-ord. X	UTM co-ord. Y					
South of La Abundancia (Erea B-2)	Skarn	1961-1 Sacapulas	99	94+	Approx. 1.5 to 2km S of La Abundancia	Our observa-tion	Unknown	Skarnized granitic rock crop out. A handspecimen of epidotized granite was assayed at: Ag30.6g/t Cu0.46%, Pb 0.35%, S 4.75%,	Visited in 1976.
No.1 Showing (Erea B-2)	Vein	1961-1 Sacapulas	96+	93+	Approx. 1.5km NW of Xetzaiel	"	"	20cm wide gossan occurs along a few quartz vein of 5cm wide in granite. The assay results of two samples are as follows: Ag (g/t) Cu (ppm) Pb (%) Zn (%) Fe (%) S (%) RE26 6.8 32 0.007 0.011 10.05 Tr RE27 2.4 28 0.001 0.009 65.34 Tr	Visited during this phase
No.2 Showing (Erea B-2)	Skarn	1961-1 Sacapulas	0.8	93+	Approx. 3.8km NW of Chacaya	"	"	Within a large stock of quartz porphyry, floats of epidote-garnet skarn and abundant gossan are observed for 250m on a ridge.	"
No.3 Showing (Erea B-2)	Vein	1961-1 Sacapulas	98+	91+	Approx. 1km SE of Xetzaiel	"	"	Gossan floats and a few barren quartz veinlets in EW to NE directions are observed. The assay result of a sample of the gossan is as follow Ag: 9 g/t, Cu: 66ppm, Pb:0.020% Zn: 0.018%, Fe: 19.27%, S:0.01%,	"
No.4 Showing (Erea B-2)	Unknown	1961-1 Sacapulas	03+	94+	Approx. 3.5km NNW of Sacapulas	"	"	A few floats of chloritized quartz porphyry weakly stained with green copper mineral are observed. The assay result of a float is as follow Ag:9.0g/t, Cu:66ppm, Pb:0.020%, Zn:0.018%, Fe:19.27%, S:0.01%,	"
No.5 Showing (Erea B-2)	Skarn	1961-1 Sacapulas	02+	92+	Approx. 1.5km NW of Chacaya	"	"	Floats of strongly silicified rock with epidote are scattered for 100m on a ridge. The floats are weakly disseminated with pyrite, and stained with hematite and limonite.	"
No.6 Showing (Erea B-2)		1961-1 Sacapulas	03+	91+	Approx. 0.5km NW of Chacaya	"	"	Limonite stained floats of pelitic schist are scattered within an area of 200m by 300m. A 30cm wide veinlet of massive pyrite occurs in the pelitic schist with a N65W strike.	"

The Pb-Zn mineralization in carbonate rocks includes Pechac, Laurita, Saclecan, Peña de Plata etc. We imagine that this type might hardly have an ore-reserve-potential exceeding say 10^4T, though it has the possibility of carrying high grade ores. The type has the great disadvantage both in exploration and exploitation of being ill located.

As to the chromite deposits, two occurrences are known in serpentinite lenses along Chixoy-Polochic fault zone, and new occurrences might possibly be discovered in future. However, we consider that the dimension of them would be too small (say 10^3T order per a single deposit) to undertake a systematic operation so that the deposit, if any, may be such one that can only be mined by local people as a side business when the market price rises.

Mineralization Type: The main mineralization types that occur within the project areas are as follows: Cu-(Bi-Ag) dissemination that may be of mesothermal range, Cu-quartz vein, Zn-(Cu) skarn, Pb-Zn-(Ag) mineralization in carbonate rocks, and chromite in ultrabasic rocks. All of these, except chromite mineralization, are seemingly related with acidic igneous intrusives genetically, and no deposit that can be of sedimentary origin is observed so far. Other than the above, some manganese occurrences are plotted in a UN map, on which no further information has been available so far. Geological setting of these types is schematically illustrated in Fig.12.

Brief descriptions on each type will be made below.

Cu-(Bi-Ag) disseminated mineralization: This occurs in the Cerro Bobí district in Area-A of the first phase (between A-1 and A-2 of the present phase). It occurs in green schist and recrystallized chert of the metamorphic basement. The main constituent mineral is chalcopyrite with a lesser amount of pyrite. Very small amounts of sphalerite and bismuthinite are also observed microcopically. Chalcopyrite and pyrite mostly occur as dissemination, but they also occur in quartz or calcite veinlets sometimes.

The surface extension of the mineralization has not yet been exactly delineated, however, the area of geochemical anomaly that was delineated by 100 ppm Cu of stream sediment collected by UN is 900m(E-W) by 700m (N-S).

A diamond drill (116.8m) was carried out by UN and DGMH, and weak dissemination of chalcopyrite and pyrite was intersected between 22 and 36m. However, the average Cu grade for the intersection might be of 0.0n% order. Two handspecimens collected locally from the outcrop near the drill site are assayed at 0.4 and 0.5% Cu with 28 and 30g/T Ag, respectively (RA-28 and RF-114 in 1976).

It can not be totally denied the possibility that the dissemination might locally be concentrated up to around 0.5% Cu and/or that high grade veins or veinlets might either occur within this mineralized zone. Nevertheless, we consider that there may be very little possibility that a minable deposit exist here, considering the physiographical conditions, access, and other infrastructures.

Cu-quartz vein: A chalcopyrite-quartz vein was discovered by UN near Yulatiz (in Area-A of 1976) and traced by trenching. It is described that there are two lenticular quartz veins 1 to 2m wide, with strike lengths of 6 and 10m (UN unpub.,1970?)

Zn-(Cu) skarn to hydrothermal replacement type: In the project area, this type of mineralization occurs only in the southern part of Area-B, in the southern side of the Chixoy-Polochic fault. The showings are observed in several places mostly in Area-C Llano del Coyote, and B-2 (PL-2). They are geologically situated in the proximinty of the contace zone between the early Cretaceous granitic batholith and the sedimentary and metamorphic rocks of the Paleozoic sequences. The mineralization is inferred to have occurred related with the later acidic intrusive phases of the later Cretaceous to Paleogene that intruded at the periphery of the batholith. Most of the showings except area-C are mainfested only by the limonitized skarn without any significant assay values of base metals. Only ones in which Cu is detected are South of La Abundancia (0.46% Cu, 0.35% Pb) and No.4 Showing (green copper stain), and the Sacapulas anomaly by UN(UN; 1969-70, & p.119-122 in the Phase-II report. Area-C Llano del Coyote is the most prominent showing among them.

The description on geology, mineralization, and exploration works in Area-C is made in more detail in the Phase-II, and -III reports. Therefore, only the results of our exploration works and conclusion are briefly described here:

Both the geochemical and geophysical anomalies that were detected in the phase-II are shown in Fig.23 in 5-3-4. Diamond drilling in the present program was concentrated only in this Area-C: 10 DDHs totaling 2,033.7m were carried out in the Phase-II and -III, in order to explore the geochemical and geophysical anomalies, and the extension of the subeconomic Zn mineralization intersected in DDH UN-4 by UN. Summary of DDHs is tabulated in Table-17 in 6-3, in which UN- and DGMH-drills are also listed so long as their data are available. The drill locations are shown in Fig.23 in 5-3-4. The assay results of the present drill program are summarized and tabulated in Table-18 in 6-3 together with those of UN and DGMH.

Llano del Coyote prospect:

Introduction:

DDH MJ-9 intersected a promising sulfide Zn-mineralization between 88.6m and 98.1m(12.76% Zn for 9.5m). The intersection is located in the proximity of those of MJ-1(oxide; 1.42% for 5.9m) and UN-4(sulfide; 2.96% Zn for 5.5m). These three intersections occur in skarns of the same horizon. In the same hole, secondary enrichment copper with chalcocite was intersected above the Zn intersection (3.80% Cu for 0.60m).

Primary mineralization:

Mineralization is cosidered to have occurred genetically related with granitic rocks of the early Cretaceous, and quartz porphyries-rhyolite of the Paleocene to Eocene. They intruded sedimentary and metamorphic rocks the Tactic and the Chicol Formations. At least, two phases of mineralization are inferred to have occurred, corresponding to the intrusive history. Major stage of useful minerals containing Cu,Zn,Pb and Ag probably belong to a later phase of the two, and may have been caused by post igneous action of the younger intrusives.

Alteration accompanied by the mineralization affected all the rocks of both the Tactic and Chicol, to form skarns in calcareous parts in the former and in limestone interlayers of the latter. Skarns so far confirmed can be grouped into three horizons, and the known "%-order Zn-mineralization" of the 3DDHs occurs in a skarn horizon that is situated at the boundary between the Tactic and Chicol.

Primary ore minerals that have so far been identified are a large amount of pyrite, a tolerable amount of magnetite, locally concentrated sphalerite and specularite, and minor amounts of chalcopyrite, galena, and native gold.

Mineralization in this area has such distinct natures in mineral assemblage as follow. A large amount of pyrite occurs pervasively with a toberable amount of magnetite. Shalerite is locally concentrated with pyrite and accompanies a smaller amount of copper, but practically no lead. This may be explained as follows: The mineralization occurred in an environment in which reduction did not advance very much and pH was comparatively low, as organic materials were lacking in the proximity, and the volume of calcareous rocks available was relatively smaller, being compared with that of ore fluid. The condition restrained Cu and Pb to precipitate

Mineralization in oxide zone:

On the surface, the mineralization-alteration zone extends for about 5.2km(WNW-ESE) with a breadth of 400 to 500m(NNE-SSW). Geochemical anomalies of soil samples and geophysical anomalies approximately coincide with this zone. However, the skarn horizon in which the mineralized intersection occurs rarely exposes on the surface due to stratigraphical and structural relations.

On the surface of the mineralization-alteration zone, bed rocks are poorly exposed, and they are almost always stained with limonite. Outcrops and floats of gossan and massive magnetite are scattered here and there. Stain of green copper is observed in several spots.

The oxide zone continues down to 50 to 100m from the surface, being judged from DDHs, and forms a leached capping for Cu and/or Fe sulfides though incomplete. Therefore, practically no primary sulfides minerals are observed in the zone except some residual pyrite. Zinc seems to remain in the zone to form local secondary enrichment with such secondary minerals as chalcophanite, and so forth.

Bottom of the oxide zone is nearly parallel to the present surface, and secondary enrichment of copper is often observed at the lowermost part of and/or directly below the oxide zone. For examples; (1) In MJ-9, supergene chalcocite is observed intersticially to pyrite grains in massive limonite gossan at the lowermost part of the oxide zone (82.3-82.9m 3.80% Cu for 0.60m). (2) In MJ-1, chalcocite coating reticular pyrite veinlets is observed just under the leached capping (90.6-91.6m 0.19% for 1.0m).

Secondary ore minerals that have been observed so far are; a large amount of goethite, a tolerable amount of maghemite, hematite, and manganese oxides such as psilomelane, and minor amounts of chalcocite, bornite, malachite, chrysocolla, and chalcopyanite.

Correlation between DDHs and anomalies:

Geochemical anomalies of rock-chip samples which were collected on the surface in Phase-III, well correlate to drill results: All the intersections of %-order Zn-mineralization(MJ-9, MJ-1, UN-4) are located just underneath the Zn-anomalies delineated by 500 ppm. Most of DDHs carried out within the Cu-anomalies delineated by 500 ppm intersected supergene chalcocite mineralization in the lower part of and/or just below the oxide zone (MJ-9,MJ-1,UN-1,UN-2,UN-4,UN-5; MMAJ/JICA,1979,UN,1973). This means that halos by primary dispersion of mineralization affected overlying rocks just above the mineralized loci up to the present surface. (PL-10 of Phase-III Report).

On the other hand, Geochemical anomalies of soil samples, which were collected in Phase-II, do not correlate very well to drill results (Fig.23); two of the three DDHs that intersected "%-order Zn-mineralization of sulfides(MJ-9,UN-4) are situated outside the anomalies of soil. This may be attributed to the facts that indicators in soil were dislocated to topographically lower position by supergene alteration and/or mechanical transportation of soil.

IP anomalies, especially those delineated by 3% FE, correlate very well to pyrite concentration underneath the leached capping: Almost all the DDHs that were carried out within the anomalies intersected semimassive to massive pyrite of several m thick with S grade of ten plus several % (Table-16). However, all the three intersections of "%-order Zn-mineralization" are outside the anomalies (Fig.23).

No conclusion can be made on applicablity of ground magnetic survey, as the most prominent inferred magnetic body between W4 and 0-lines has not been drilled as yet. However, there is a possibility that this is attributed to some magnetite concentration underground, as gossan with hematite occurs on the surface in this part. A weak but widely distributed inferred magnetic body that includes the prominent one mentioned above and approximately coincides with IP anomalies, may be due to magnetite that occurs in pyrite zone. The magnetite might be the unsulfidized residual of the 1st stage magnetite.

Exploration potential:

Exploration potential of this prospect is considered to be fairly great, because drill results correlate very well to geochemical anomalies (500 ppm Zn) of rock-chip samples and the most of the anomalies remain unexplored. The anomalies have an extent of 3.6km by 200m as a whole. If the expected ore bodies have a thickness of 9.5m(same to MJ-9), specific gravity of 4.0 and occur with a horizontal breadth of 100m, the reserves will be; (1) 3,420,000T, on the assumption that 1/4 of total strike-length of 3.6km are mineable, (2) about 1,500,000T, on the assumption that 1/4 of 1.6km ofthe central part(0-E16) are mineable, and (3) about 380,000T, on the assumption that strikelength of 100m around the intersection of MJ-9 are mineable.

A deposit of this size may be expoitable if Zn-grade is as high as that of MJ-9, as location of this prospect is quite favorable to minimize expenditures for infrastructures. Result of further exploration is hopefully expected.

Pb-Zn-(Ag) mineralization in carbonate rocks: Kesler et al (1973) studied the lead-zinc mineralization in carbonate rocks in the central Guatemala and conclusively mentioned that it exhibited characteristics of both Mississippi Valley type and magnatic hydrothermal deposits.

Within the present project areas, there are more than ten occurrences that may probably belong to this type; these are Pechac and Laurita in Area A-1, Saclecán and Peña de Plata in Area A-2, and other similar occurrences. All of these occur exclusively in the limestone-dolimitic limestone horizon that is stratigraphically situated at the uppermost of the Paleozoic Santa Rosa Group. No occurrence has been located in the Cretaceous Ixcoy Formation, as least during present program.

The occurrences that we could actually investigated are Saclecán and Peña de Plata, on which some description is made in the Phase-II report (p.82-87). On Pechac and Laurita, the description by UN is summarized in p.69 of that report, as we could not locate them.

There is no place where the occurrence of the primary mineralization of this type can be observed. For, Saclecán is a zone of gossan floats, and Peña de Plata is in the oxidized zone in which cerussite and smithsonite are principal ore minerals, and Pechac and Laurita are prospects for gravel-like sulfide ores in unconsolidated superficial deposits. Therefore, it is fairly difficult for us to discuss on the mineralization type and genesis. The nature that the mineralization accompanies copper minerals and barite, and the facts that there is no igneous rock in the directly adjacent areas and there is no conspicuous hydrothermal alteration around the mineralization suggest the affinity between this mineralization and the Mississippi Valley type. Nevertheless, no syngenetic character has been observed so far. On the contrary, the facts that the showings of this mineralization type are apparently situated in a Pb-Zn zone within a zonal arrangement system that centers acidic intrusive bodies, and that the mineralization is often controlled by fissures and fractures are suggestive of the magmatic origin of this mineralization.

The dimension of the mineralization of this type is very small as far as judged from the available data. We speculatively guess that the ore reserves per deposit would be around 10^4T at most, even if a deposit of "economic grade" were existed.

Infrastructure, as well as topographical and climatographical conditions, is one of the most serious difficulties both in exploring and exploiting the mineralization of this type. However, it is not realistic to construct infrastructures for the purpose of exploring these showings, as the expected reserves are too small. Therefore, we consider that it is important for DGMH to promote prospectors and give them tecnical assistance in order of facilitate exploration activities. For the exploration of the mineralization of this type, it is essentially necessary to confirm the occurrence of the very target at first, by any of the following methods that can directly reveal the occurrence; trenching, scraping, pitting, re-opening or cleaning the old tunnels (if any) etc. It cannot be recommended to commence drilling in a geochemical anomaly without the above-mentioned procedures, because the mineralization accompanies no alteration halo, has only small extension, and often dips steeply being controlled by fissures. Geophysical survey is also not recommendable for this particular mineralization, from the topographic and climatographical conditions.

We consider that there is still possibility that any of the known or unknown showings could be such a mine that could be mined by local people as a side business when the market prices of the metals rose and when the infrastructures had been improved.

Silver mineralization: Blount(1967) describes a few localities of pyrargyrite, several kilometers northwest of Aguacatán. According to him, the showings do not contain any other recognizable sulfide minerals. So far we have not been able to locate these showings. However, some Ag anomalies were located in B-1, which may cover the showings. These anomalies may reflect the showings themselves or unknown but similar ones. The fact that the correlation coefficients between silver and other three elements are considerably low in geochemical samples in B-1, may imply the existence of the mineralization mentioned above.

We consider that the mineralization has little economic significance, judging from the dimension and intensity of the anomalies.

Chromite ores in ultrabasic rocks: At least two chromite showings are known in Area B-1. These are Cata Santa María and Chupadero-I, and both occur in serpentinized peridotite. We investigated the former in 1976, and summarized the result in p.100-102 in the Phase-II report.

The chromite deposit observed in Cata Santa María comprises three irregular bodies of massive chromite ore. Each lenticular body is less than 10m long, and 1 to 2m wide.

We consider that there is possibility that new showings might be discovered in serpentinite bodies that occur intermittently in the fault zone of the Chixóy-Polochic fault. Nevertheless, we infer that the dimension of the deposit is small, because if a sizable deposit occurred near the surface, either outcrops or floats could have been discovered, as little vegetation is on the surface of the serpentinite exposures. We guess that the ore-reserve-potential per deposit, though it is of very speculative, would be the order of $n \times 10^3$T at most, and that the deposit would be the one which could be mined by local people as a side business when the market price rose.

Manágnese mineralization: A manganese locality is plotted in an unpublished UN map (1968). It is in the present Area B-1 (Chupadero-II). However, we could not locate it during the present project.

3-8-2 Non-metallic Minerals

Gypsum: Gypsum occurs locally in the shale of the Todos Santos Formation and in the travertine at its base. Small quarries have been intermittently operated in an area between Parraxtót and Pichiquí in Area-B. However, it can hardly be considered that these gypsum deposits will have any economic significance in near future, being taken account of the transportation and the market of natural gypsum. Therefore, no particular effort was made to study the deposits during the project. However it will be necessary for DGMH once to research on actual condition of the deposits.

Barite: Barite veinlets are observed in the Todos Santos Formation in the vicinity of the Laurita old prospect in Area-A-1. UN report(1971) describes that weathered barite also occurs in the Pechac old prospect. These occurrences are accompanied with Pb-Zn mineralization and are likely of hydrothermal origin (p.69 in the Phase-II report). However, no comment can be made here, as we did not investigated them.

Asbestos: Asbestos veinlets some 2 to 3 mm wide are observed in the fractures in an acidic dyke in Area B-2 (p.122 in Phase-II report). Another asbestos locality called Llano del Coyote is plotted near a small village Xetaziel in an unpublished UN map(1968). However, we could not locate this. This may probably be of the same occurrence as the former, because no serpentinite body has been found in the proximity of its suggested location as yet(p.122 in the Phase-II report).

3-9 Localization of metallic Mineralization

Most of the metallic mineralization that occur within the project areas are considered to belong to the category of the magmatic deposit. That is to say, almost all the mineralization that brought copper, lead, zinc, silver, pyrite, magnetite, specularite, barite etc. are considered to be genetically related with the acidic intrusives of the later Cretaceous to Paleogene ages. Chromite is closely related with sepentinite as well. Therefore, localization of the metallic mineralization is essentially controlled by following factors: (1) Presence of an intrusive body and the distance from it. (2) Premineralization faults as ore fluid parts (except for chromite deposits). (3) Types of the host rocks in which mineralization occurs. Further more, the post mineralization factors such as faults, folds, and levels of erosion surface are considered as the controlling factors that have brought the mineralized parts to expose on the present surface.

The relationship between mineralization types and geological factors in the project areas is schematically illustrated in Fig.12.

3-9-1 Localization of Metallic Minerals other than Chromite

(A) Relationship with acidic igneous rocks & zonal arrangement

The most important geological factor that controls the localization of the metallic minerals other than chromite is the acidic intrusives: In Area-A, copper mineralization (Cerro Bobí Prospect and Yulatíz) is observed in the Cerro Bobí area, where small stocks of acidic intrusives occur, while Pb-Zn showings (Pechac and Laurita in A-1, and Saclecan and Peña de Plata in A-2, etc) are distributed in the outer areas that surround the Cerro Bobí area, being located some 10 to 15km apart from the latter. This relation is obviously expressed in the distribution pattern of Pb/Cu in the rolling mean analysis of geochemical samples; the zone in which Cu is relatively high is located in the vicinity of the intrusive stocks, while the zone where Pb and Zn are relatively high concentrically surrounds the former (Fig.4).

In the Area-B, nearly the same tendency is observed in the southern part along the Chixoy-Polochic fault: The copper bearing showings and anomalies, such as the Llano del Coyote prospect, the Pichiquil Anomaly by UN(Cu,Mo), Sacapulas Anomaly by UN(Cu), the East of Estancia(Cu), and so forth, are located in an area in B-2, where dykes and sills of acidic hypabyssal rocks occur. On the other hand, the showings and anomalies of Pb, Zn, and/or Ag are observed in B-1 and B-3 that are located some 10km from the area mentioned above. In other words, a zonal arrangement is observed along the Chixoy-Polochic fault zone, in which the mineralization that accompanies some copper and/or molybdenum occurs at the center coinciding with intrusives, and the mineralization that accompanies Pb,Zn, and/or Ag is located at the both sides of the former(Fig.5, Pl-3 vs. Pl-6).

Neither showing nor geochemical anomaly has been observed so far in the terrain of the Cretaceous Ixcoy Formation where no acidic intrusive has been observed. The same situation is also recognized in the Paleozoic terrains such as in the southern half of Area-A and the northeastern part of Area-B, where there are little acidic intrusives.

(B) Ralationship with the Paleozoic distribution & rock types

It is obviously recognized that known shiwings are distributed at the periphery of the terrain of the Paleozoic sequence and metamorphic rocks (Fig.3 vs. Fig.13).

In addition, the following relations are recognized between the types of the mineralization and the types of the host rocks:
Disseminated Cu-(Bi) mineralization of mesothermal range is observed in green schist near the acidic intrusive stocks (Cerro Bobí). Skarn type (Cu)-Zn mineralization occurs in the calcareous horizons of the Paleozoic sequences, where these are in contact with granitic rocks and acidic hypabyssal rocks (Llano del Coyote and B-2). Pb-Zn-Ag mineralization of telethermal range is common in the Chochal limestone of the uppermost Paleozoic sequence (Pechac, Laurita, Saclecán, and Peña de Plata).

In the red beds of the Todos Santos Formation, mineralization (Laurita) and geochemical anomalies (B-4) are rarely observed. However, neither showings, nor geochemical anomaly has yet been localized in the limestone of the Ixcoy Formation.

(C) Relationship with faults

Most of the known showings are apparently distributed along the E-W trending Chixoy-Polochic fault and N60°-70°W trending faults. Some of the latter bifurcate from the former (Fig.3 in 3-4 vs. Fig.13).

The same tendency is observed in the patterns of the geochemical zoning revealed by the rolling mean analysis: In Area-A, an elongated pattern in the N60°-70°W direction is recognized, connecting Sebép, San Matéo Ixtatán, and Peña de Plata(Fig.4 in 3-4). In Area-B, the elongations in two directions are clearly observed. On^{E} is along the Chioxy-Polochic fault and another is that connecting Salquil, and Cunén, showing a N55°-60°W trend (Fig.5 in 3-4).

These tendencies may imply that faults played two roles in localizing the present distribution of mineralization: One is that faults provided the ore fluid paths, and another is that they lifted the mineralized Paleozoic rocks up to the present surface.

3-9-2 Localization of chromite mineralization

Chromite occurs in serpentinized peridotite without any exception. Peridotite is emplaced along structural lines, especially in or along the sheared zones of the Chixoy-Polochic fault system. However, no particular criteria have so far been established, to distinguish a peridotite body that is favorable for chromite concentration from the other.

4. Geochemical Survey

4-1 General Remarks

Geochemical survey was practiced in both the 1st and 2nd phases as the most important exploration tool to select prospective grounds.

In the 1st phase, a regional reconnaissance consisting of geochemical sampling of soil and stream sediments was carried out in both Area-A and B. The total area covered was about 2,000 sq·km. 2,352 samples were collected, and three elements Cu,Pb and Zn were analyzed as indicators by AAS technique. Six follow-up areas were selected around the major anomalies.

In the 2nd phase, geochemical soil sampling was performed in the six follow-up areas (297 sq·km) and in Area-C Llano del Coyote(14 sq·km). 1,671 samples were collected in the former, and 861 samples were collected on 100m by 200m grid in the latter. Four elements, Cu,Pb,Zn and Ag were analyzed as indicators. As a result of the follow-up geochemical survey, several anomalies were detected from the six areas. However, we could find no anomaly of these warrant positively further exploration, except "Peñasco-Pacumal Anomaly" in Area A-1, as most of them are small in extent and/or low in assay results. On the other hand, fairly extensive geochemical anomalies were located in Area-C. They occur in an area extended over 5.6 km in EW direction, approximately coinciding with geophysical anomalies. From these results, the exploration works in the 3rd phase were concentrated in Area-C.

Data processing and statistical analyses of assay results were performed by computer (NEAC 2200-250A), and the plot of the assay results and/or caluculated values were carried out by the combination of computer (CDC-6600) and plotter(XYNETICS).

Statistics of sampling in two phases is summarized in Table-9A and 9B.

Table-9A Statistics of geochemical sampling-1st phase

Area	Type of samples	Nos. of samples	Area (sq·km)	Routes (km)	Nos.per sq·km	sampling interval (m)	Remarks
A	Stream sediment	204					
	soil	695					
	Subtotal	899	650	375.0	1.38	4.17	
B	Stream sediment	581					
	soil	872					
	Subtotal	1,453	1,350	793.5	1.08	546	
Grandtotal		2,352	2,000	1,168.5	1.18	497	

Table-9B Statistics of geochemical sampling-2nd phase

	Nos.of Samples	Area (sq·km)	Routes (km)	Nos.per sq·km	Sampling Interval (m)	Remarks
A-1 Pechac-Laurita	262	36	83.0	7.28	317	
A-2 Peña de Plata	169	24	65.6	7.04	388	
B-1 La Barranca	266	36	75.8	7.39	285	
B-2 Río Blance	537	126	224.1	4.26	417	
B-3 Cunén	259	48	98.4	5.40	380	
B-4 Salquil	178	27	64.8	6.59	364	
Sub-Total	1,671	297	611.7	5.63	366	
C Llano del Coyote	861	14	(93) 88.1	61.5	100x200	Grid Sampling
Grand-Total	2,532	311	699,8	-	-	

4-2 Field Works, samples, preparation, and chemical analysis

Detailed description on field works, such as the organization of the field parties, sampling procedure, record of the samples, and sample preparation, are omitted here, as well as chemical analysis. These are to be referred to following pages listed below.

	1st phase report	2nd phase report
Organization of field parties	p-11 ,PL-75	p-9,10
Sampling procedure	p-53,54,PL-75	p-46,47
Sample number	p-54	p-47
Record of samples	p-54	p-47,48
Sample preparation	p-54	p-48
Chemical analysis	p-55,A-104	p-48,A-97

4-3 Assay result and its presentation

Assay results of individual samples, as well as their sample numbers and locations (Nos. of IGN quadrangle maps, and UTM coordinates), are tabulated in the appendix attached to the report of each phase. The assay results are also plotted in topographic maps element by element.

Details are to be referred to following tables and plates:

Results of the 1st phase(1st phase report)

Summary and assay results of geochemical samples ---------------------- Appendix 6-1(A-55 through 103)

Location Map of Geochemical Samples Area-A ----------------------------------- PL-19(1/50,000)

Geochemical Result:Area-A ---------------- PL-22 through 27 (1/50,000)

Location Map of Geochemical Samples Area-B ----------------------------------- PL-20 & 21 (1/50,000)

Geochemical Result:Area-B ---------------- PL-35 through 46(1/50,000)

Sample Location and Assay Results of Cerro Bobí-Quetzál Zone --------------- PL-61 Through 63(1/10,000)

Results of the 2nd phase (2nd phase report)

Summary and Assay Results of Geochemical Samples ------------------ Appendix 6-1(A-43 through 96)

Location Map of Geochemical Samples Area A-1 ------------------------------- PL-3 (1/20,000)

Geochemical Result:Area A-1 -------------- PL-4 through 7 (1/20,000)

Location Map of Geochemical Samples Area-A-2 ------------------------------- PL-12(1/20,000)

Geochemical Result:Area A-2 -------------- PL-13 through 16 (1/20,000)

Location Map of Geochemical Samples Area B-1 ------------------------------- PL-21(1/20,000

Geochemical Result:Area B-1 ---------------- PL-22 through 25(1/20,000)

Location Map of Geochemical Samples
Area B-2 ---------------------------------- PL-31 and 32 (1/20,000)

Geochemical Result:Area B-2 ---------------- PL-33 through 40 (1/20,000)

Location Map of Geochemical Samples
Area B-3 ---------------------------------- PL-47(1/20,000)

Geochemical Result: Area B-3 --------------- PL-48 through 51 (1/20,000)

Location Map of Geochemical Samples
Area B-4 ---------------------------------- PL-56(1/20,000)

Geochemical Result:Area B-4 ---------------- PL-57 through 60 (1/20,000)

Location Map of Geochemical Samples
Area C ------------------------------------ PL-67 in 2 sheets(1/10,000)

Geochemical Result:Area C ------------------ PL-68 through 71(1/10,000)

4-4 Statistical analysis of result

4-4-1 Selection of statistical technique

(A) Introduction: Interpretation of geochemical assay results can be said, in another word, A technique to distinguish a population reflecting mineralization as an "anomaly" from that of background, which usually includes various "noises". For this purpose, various statistical techniques have been developed and applied.

These are as follows : A classical technique in which the threshold value is mechanically defined as "mean + 2 standard deviations" of the assayed values. In this report this method is described as "statistical method" hereafter, in order to distinguish it from others. The method in which the threshold value is read graphically from the cumulative frequency curve of assay values, by interpreting the pattern of the curve(Lepeltier; 1969), which is to be described hereafter as"Lepeltier's method". Other than these two, followings are often applied : Trend Surface Analysis (Nichol, Garrett, and Webb;1969), Rolling Mean Analysis (Nichol, Garrett, and Webb; 1969), Factor Analysis (Dahlberg and Keith;1969, Dahlberg;1967, Gattett, and Nichol;1969), Multiple Regression (Dahlberg,1967,1969:Rose, Dahlberg and Keith;1970), Selective Simulation (Dahlberg;1968) and so forth. New and more sophisticated techniques are still being proposed every year.

All of these have both merits and demerits, and there is no technique that is absolutely or universally appropriate to all the possible cases. Therefore, it is necessary to select the most adequate one to the given case, taking following factors into consideration:

Purpose of the project, stage of the exploration, dimension or extent of the sampling area, sorts of samples, density and dispersion of the sample sites within the area, kinds and number of assayed chemical composition or elements, qualitity and quantity of available geological information (from both existing data and that from geological mapping to be carried on simultaneously), geological characteristics of the area, the nature of the soil, climate, tophography, hydrological factors and so forth. Another practically important factors, which must be taken into consideration on selecting the techniques, are cost and budget, time required to complete, objectivity, easiness, and so forth. On selecting the technique, it is also necessary for us to realize that some technique can be decided to apply prior to the field survey, but some others must be decided after the assay results return.

(B) Statistical techniques adopted in the present program: Taking the various factors mentioned in the previous section into consideration, we tried to apply the following three methods simultaneously in the 1st phase;"Statistical method";"Lepeltier's method", and "Rolling mean analysis". We likewise adopted "Statistical method" and "Lepeltier's method" in the 2nd phase. The reason why we tried plural methods in each phase is because we consider that a target area should be selected by integrating various "independent" methods, as there is no definitely correct statistical method in geochemical interpretation.

Threshold is a value by which an anomalous value is defined. Two methods were tried for the determination of the threshold value in each phase; by "Statistical method" and by "Lepertier's method". As a result, that by "Statistical method" was adopted in both phases, after the two having been compared. More detailed explanation will be made in the next section 4-4-2.

As criteria for comparison and evaluation of anomalies (or sometimes the areas that include anomalies), the extent and the average metal values of the anomaly were basically used. Moreover, the results of the "Rolling mean analysis" and "correlation analysis" were also taken into consideration in the 1st phase, when the target areas of the follow-up operation were selected from comparatively large areas. Also, the patterns of both the frequency distribution and cumulative frequency curves of the assayed values, "correlation analysis" of elements, and coefficient variances of elements were taken into account in the 2nd phase, when the smaller individual areas and/or anomalies within them were compared, and were evaluated. Furthermore, geological background were always taken into consideration throughout the two phases, as a most important factor on evaluating the anomalies.

In Area-C Llano del Coyote, where grid-sampling was carried out in the 2nd phase, maps showing isograde contour lines of each element were prepared. They were subsequently compared with geologic and geophysical maps for interpretation.

4-4-2 Determination of threshold values

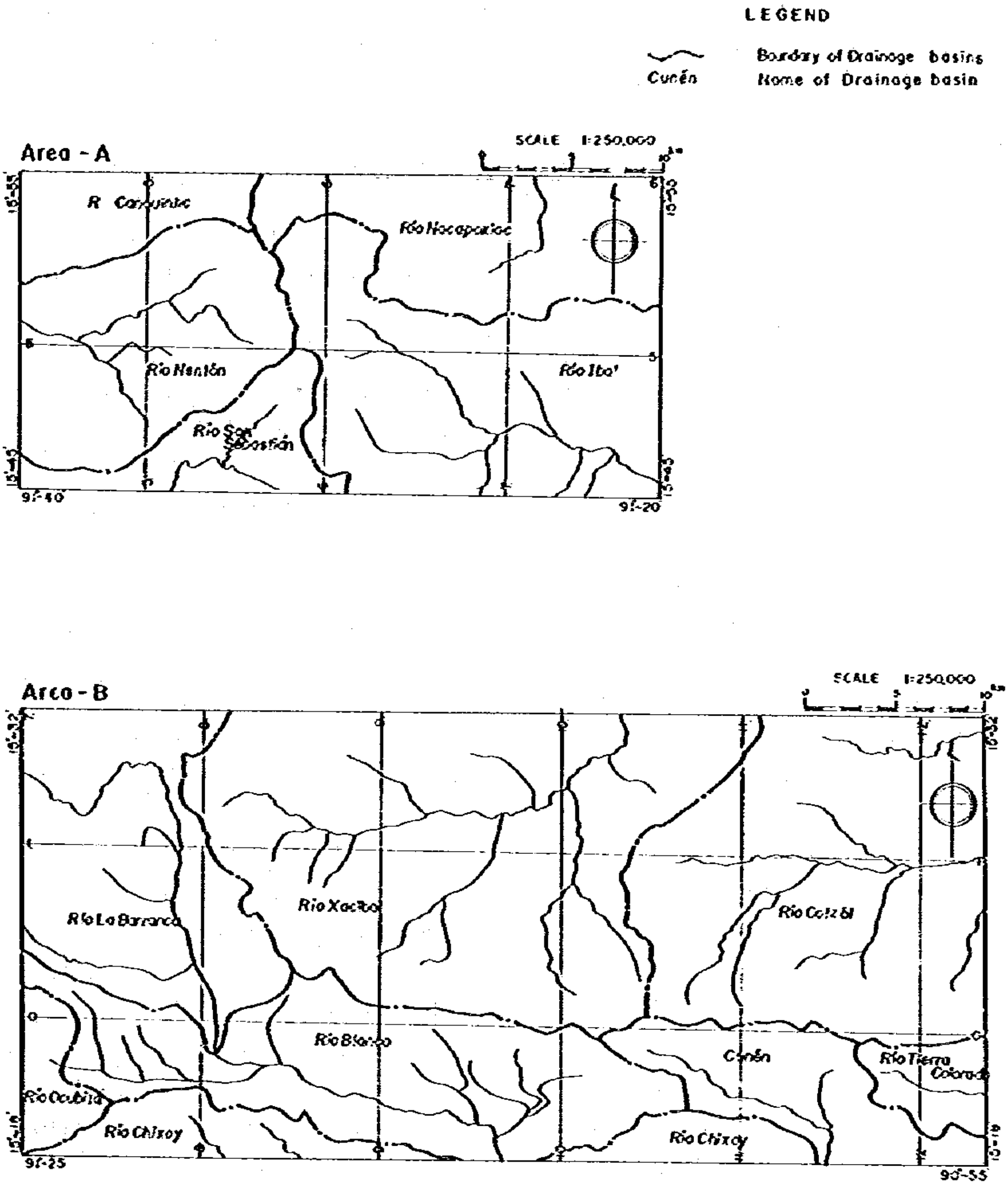
(A) Introduction

The greatest attention was paid in determining the threshold values, since it is the value by which a population that may represent mineralization is distinguished from populations reflecting background. As a result, "Mean + 2 standard deviations" calculated in the 1st phase for Area-A and -B by sample types was adopted as the threshold in the same phase. This was further used in the 2nd phase for Cu,Pb and Zn, whereas, for Ag in the 2nd phase "Mean + 1 standard deviation" calculated from all the 2,532 samples collected in the 2nd phase was adopted as the threshold, for no Ag assay had been made in the 1st phase. The reason why "1" standard deviation was adopted instead of "2" is, because there is little sample that exceeds "Mean + 2 standard deviations". This may be caused by the following reasons; there are many samples whose Ag values are "trace", which was mathematically treated as 0.04ppm for covenience' sake, so that apparently large standard deviation was obtained.

(B) 1st phase

Preparation: Before being statistically processed, all the geochemical data were calssified in the following way: First, all the samples were calssified by types of samples into two large groups "Stream sediments" and "Soil". Then, they were classified by areas into two groups "Area-A" and "Area-B", each of which is denoted hereafter as "All sample group" in this report. Samples were further classified into small groups by two categories "drainage basisn" and "geological units", each of which is called "Unit group" hereafter in this report. Details of the classification is described in p-56 through 58 in the 1st phase report.

Fig.14 Drainage Basins in Project Areas



First of all, "frequency distribution histograms" of assay values for all the groups were printed out by computer in both antilogarithmic and logarithmic scales. Then distribution patterns in two scales were compared. The logarithmic scale was decided to use, as the distribution patterns were confirmed to be more similar to lognormal. Therefore, in all the reports through three phases, logarithmic scale is used, unless there is any special note; consequently "mean" used here indicates "geometric average"

Statistical parameters & threshold by "Statistical method": Statistical parameters such as "mean", "standard deviation", "minimum", "maximum", and "range" of assay values were computed or selected as well as "correlation coefficient" between any two elements of the three. Threshold values by "Statistical method" (mean + 2 standard deviations) were also calculated. All these parameters were tabulated in eight tables (p59 through 66 in the 1st phase report). Four of the eight tables are attached to this report for reference (Table 10-A through -D); these are of the combinations "Stream sediments-Drainage baisins", and "Soil samples-Geological units".

To define the threshold value as "Mean + 2 standard deviations" is based on the assumption that the frequency distribution is not very much deviated from normal or lognormal distribution. However, generally speaking, it is very common in actual cases that a population comprises sub-populations which represent mineralization, various geological units that have different background levels, noises, and so on. Therefore, the frequency distribution histograms often show asymmetric(skew) or multi-peaked patterns. Nevertheless, in the threshold determination by "Statistical method", a threshold is only mechanically defined by calculation, regardless of distribution patterns. This is the greatest demerit of the "Statistical method". On the other hand, this method has such merits as follows; calculation is very easy (especially when computer is available), and there is no room for subjective interpretation of the person in charge. The demerit of the "Statistical method" cited above may, in some cases, be eliminated by grouping adequately the population.

In the 1st phase, threshold values from "Unit groups" were compared with those of "All sample groups". As a result, however, it was revealed that the threshold calculated from "All sample group" did not significantly differ from those calculated from subdivided "Unit groups", except very small "Unit groups" (Fig.15 -17).

Table 10-A Summary of Statistical Data of Geochemical Samples (Phase I)

(1) Area-A Stream Sediments, Drainage Basins

Formation	Elements	Average (PPM)	Standard Deviation	SD/Mean	Mean +1SD	Mean +2SD	Minimum	Maximum	Range	Correlation Analysis				
										Reliability		Correlation Coefficients		
										R(0.01)	R(0.05)	Cu	Pb	Zn
All samples n=204	Cu	1.3196 (20.9)	0.3076	0.2331	1.6272 (42.4)	1.9348 (86.1)	0.4771 (3.0)	3.082 (1207.8)	2.605			1.0000	0.1719*	0.4172**
	Pb	1.4648 (29.2)	0.3123	0.2132	1.7771 (59.9)	2.0894 (122.9)	0.9031 (8.0)	3.7269 (5332.1)	2.8239	0.1799	0.1376		1.0000	0.5923**
	Zn	1.799 (63.0)	0.2966	0.1649	2.0956 (124.6)	2.3922 (246.7)	0.9542 (9.0)	3.1248 (1332.9)	2.1706					1.0000
Río Nacapoxlac n=15	Cu	1.0281 (10.7)	0.2724	0.2650	1.3005 (20.0)	1.5729 (37.4)	0.6021	1.6532	1.0511			1.0000	-0.1574	0.6057*
	Pb	1.5599 (36.3)	0.0426	0.0273	1.6025 (40.0)	1.6451 (44.2)	1.4913	1.6532	0.1619	0.6411	0.5139		1.0000	0.2374
	Zn	1.5295 (33.8)	0.2558	0.1672	1.7853 (61.0)	2.0411 (109.9)	1.1461	2.3010	1.1549					1.0000
Río Ibac n=130	Cu	1.3561 (22.7)	0.3354	0.2473	1.6915 (49.1)	2.0269 (106.4)	0.4771	3.0820	2.6049			1.0000	0.2569**	0.3907**
	Pb	1.3839 (24.2)	0.2820	0.2038	1.6659 (46.3)	1.9479 (88.7)	0.9031	2.7649	1.8618	0.2251	0.1726		1.0000	0.5872**
	Zn	1.7430 (55.3)	0.2317	0.1329	1.9747 (94.3)	2.2064 (160.8)	0.9542	2.3979	1.4437					1.0000
Río Nenton n=35	Cu	1.3350 (21.6)	0.2017	0.1511	1.5367 (34.4)	1.7384 (54.8)	0.8451	1.8261	0.9810			1.0000	0.4331**	0.6423**
	Pb	1.6859 (48.5)	0.4105	0.2435	2.0964 (124.9)	2.5069 (321.3)	1.3424	3.7269	2.3845	0.4304	0.3345		1.0000	0.7478**
	Zn	2.1145 (130.2)	0.3340	0.1580	2.4485 (280.9)	2.7825 (606.0)	1.5563	3.1248	1.5685					1.0000
Río san Sebastian n=24	Cu	1.2816 (19.1)	0.1846	0.1440	1.4662 (29.3)	1.6508 (44.8)	0.6990	1.5798	0.8808			1.0000	-0.2730	0.6872**
	Pb	1.5211 (33.2)	0.2099	0.1380	1.731 (53.8)	1.9409 (87.3)	1.1461	2.0128	0.8667	0.5168	0.4060		1.0000	-0.0003
	Zn	1.8118 (64.8)	0.2315	0.1278	2.0433 (110.5)	2.2748 (188.3)	1.0414	2.2122	1.1708					1.0000

Table 10-B Summary of Statistical Data of Geochemical Samples (Phase I)

(2) Area-B, Stream Sediments, Drainage Basins

Formation	Elements	Mean (PPM)	Standard Deviation	SD/Mean	Mean +1SD	Mean +2SD	Minimum	Maximum	Range	Correlation Analysis: Reliability R(0.01)	Correlation Analysis: Reliability R(0.05)	Correlation Coefficients Cu	Correlation Coefficients Pb	Correlation Coefficients Zn
All samples n=581	Cu	1.2750 (18.8)	0.2222	0.1743	1.4972 (31.4)	1.7194 (52.4)	0.3010 (2.0)	1.9685 (93.0)	1.6674			1.0000	0.2152**	0.3593**
	Pb	1.4915 (31.0)	0.2167	0.1453	1.7082 (51.1)	1.9249 (84.1)	0.9031 (8.0)	2.2764 (189.0)	1.3734	0.1068	0.0814		1.0000	0.4989**
	Zn	1.9018 (79.8)	0.2409	0.1767	2.1427 (138.9)	2.3836 (241.9)	1.0414 (11.0)	3.2787 (1899.8)	2.2373					1.0000
Río Barranca n=40	Cu	1.3477 (22.3)	0.2507	0.7210	1.5984 (39.7)	1.8491 (70.6)	0.6990	1.9685	1.2695			1.0000	0.1373	0.5436**
	Pb	1.4066 (25.5)	0.2084	0.1482	1.615 (41.2)	1.8234 (66.6)	0.9031	1.8808	0.9777	0.4032	0.3125		1.0000	0.1768
	Zn	1.8130 (65.0)	0.1887	0.1041	2.0017 (100.4)	2.1904 (155.0)	1.3424	2.5563	1.2139					1.0000
Río Ocubila n=21	Cu	1.2466 (17.6)	0.1793	0.1438	1.4259 (26.7)	1.6052 (40.3)	0.7781	1.5441	0.7659			1.0000	0.4647*	0.7846**
	Pb	1.2243 (16.8)	0.1901	0.1553	1.4144 (26.0)	1.6045 (40.2)	1.0414	1.8388	0.7975	0.5487	0.4329		1.0000	0.7694**
	Zn	1.7103 (51.3)	0.1571	0.0919	1.8674 (73.7)	2.0245 (105.8)	1.4150	2.1038	0.6888					1.0000
Río Chixoy n=20	Cu	1.0857 (12.2)	0.3252	0.2995	1.4109 (25.8)	1.7361 (54.5)	0.6990	1.8633	1.1643			1.0000	0.3816	0.6619**
	Pb	1.1846 (15.3)	0.1588	0.1341	1.3434 (22.0)	1.5022 (31.8)	0.9031	1.6128	0.7097	0.5614	0.4438		1.0000	0.7336**
	Zn	1.7355 (56.7)	0.1942	0.1119	1.9297 (85.1)	2.1239 (133.0)	1.3424	2.0863	0.7439					1.0000
Río Blanco n=142	Cu	1.3274 (21.3)	0.2161	0.1628	1.5435 (35.0)	1.7596 (57.5)	0.6990	1.8633	1.1643			1.0000	0.4832**	0.5553**
	Pb	1.5151 (32.7)	0.2142	0.1414	1.7293 (53.6)	1.9435 (87.8)	0.9031	2.1931	1.2900	0.2154	0.1651		1.0000	0.6405**
	Zn	1.8740 (74.8)	0.2151	0.1148	2.0891 (122.8)	2.3042 (201.5)	1.1761	2.2718	1.0957					1.0000
Río Cotzal n=77	Cu	1.2209 (16.6)	0.1636	0.1340	1.3845 (24.2)	1.5481 (35.3)	0.8451	1.5315	0.6864			1.0000	0.0930	0.3196**
	Pb	1.4294 (26.9)	0.1520	0.1063	1.5814 (38.1)	1.7334 (54.1)	1.1139	1.7559	0.6419	0.2924	0.2245		1.0000	-0.0993
	Zn	1.8598 (72.4)	0.1566	0.0842	2.0164 (103.8)	2.173 (148.9)	1.4771	2.2227	0.7456					1.0000
Río Tierrcolorado n=26	Cu	1.2418 (17.5)	0.2002	0.1612	1.442 (27.7)	1.6422 (43.9)	0.6990	1.3979	0.6990			1.0000	0.2487	0.5332**
	Pb	1.6717 (47.0)	0.2788	0.1668	1.9505 (89.2)	2.2293 (169.6)	1.2041	2.1139	0.9098	0.4969	0.3893		1.0000	0.9000**
	Zn	1.9523 (89.6)	0.2252	0.1154	2.1775 (150.5)	2.4027 (252.8)	1.6721	2.3159	0.6439					1.0000
Río Xaclbal n=216	Cu	1.2796 (19.0)	0.2248	0.1757	1.5044 (31.9)	1.7292 (53.6)	0.3010	1.6902	1.3892			1.0000	0.0630	0.2438**
	Pb	1.5211 (33.2)	0.1821	0.1197	1.7032 (50.5)	1.8853 (76.8)	1.1139	2.2764	1.1625	0.1749	0.1337		1.0000	0.4076**
	Zn	1.9589 (91.0)	0.2643	0.1349	2.2232 (167.2)	2.4875 (307.3)	1.0414	2.9430	1.9016					1.0000
Cunen n=39	Cu	1.2247 (16.8)	0.1888	0.1542	1.4135 (25.9)	1.6023 (40.0)	0.6021	1.4913	0.8893			1.0000	-0.2456	0.3327*
	Pb	1.6332 (43.0)	0.1772	0.1085	1.8104 (64.6)	1.9876 (97.2)	1.2787	2.0334	0.7547	0.4082	0.3165		1.0000	0.3056
	Zn	2.0157 (103.7)	0.2914	0.1446	2.3071 (202.8)	2.5985 (396.7)	1.5185	3.2787	1.7602					1.0000

Table 10-C Summary of Statistical Data of Geochemical Samples (Phase I)

(3) Area-A, Soil, Formations

Drainage	Elements	Mean (PPM)	Standard Deviation	SD/Mean	Mean +1SD	Mean +2SD	Minimum	Maximum	Range	Correlation Analysis: Reliability R(0.01)	Correlation Analysis: Reliability R(0.05)	Correation Coefficients Cu	Correation Coefficients Pb	Correation Coefficients Zn
All samples n=695	Cu	1.3127 (20.5)	0.3056	0.2329	1.6183 (41.5)	1.9239 (83.9)	0.3010 (2.0)	2.5224 (333.0)	2.2214			1.0000	0.3374**	0.4480**
	Pb	1.4686 (29.4)	0.27521	0.1874	1.74381 (55.4)	2.01902 (104.5)	0.47712 (3.0)	2.5955 (394.0)	2.1184	0.0976	0.0744		1.0000	0.5564**
	Zn	1.6996 (50.1)	0.35974	0.2117	2.05934 (114.6)	2.41908 (262.5)	0.60205 (4.0)	3.7695 (5881.7)	3.1674					1.0000
Ixcoy Form n=227	Cu	1.3924 (24.7)	0.2330	0.1673	1.6254 (42.2)	1.8584 (72.2)	0.30103	1.8750	1.5740			1.0000	0.1168	0.6922**
	Pb	1.5860 (38.5)	0.1620	0.1021	1.748 (56.0)	1.91 (81.3)	1.0414	2.2355	1.1941	0.1706	0.1304		1.0000	0.1896**
	Zn	1.7703 (58.9)	0.2634	0.1488	2.0337 (108.1)	2.2971 (198.2)	0.6025	2.5798	1.9777					1.0000
Todos Santos Form n=204	Cu	1.1913 (15.5)	0.3561	0.2990	1.5474 (35.3)	1.9035 (80.1)	0.4771	2.3010	1.8239			1.0000	0.3851**	0.3966**
	Pb	1.3635 (23.1)	0.3369	0.2471	1.7004 (50.2)	2.0373 (109.0)	0.4771	2.3384	1.8613	0.1799	0.1376		1.0000	0.6168**
	Zn	1.6544 (45.1)	0.3632	0.2195	2.0176 (104.1)	2.3808 (240.3)	0.6025	2.7716	2.1695					1.0000
Santa Rosa Group n=238	Cu	1.4015 (25.2)	0.2874	0.2051	1.6889 (48.9)	1.9763 (94.7)	0.6021	2.5224	1.9204			1.0000	0.3503**	0.4408**
	Pb	1.4463 (27.9)	0.2504	0.7313	1.6967 (49.7)	1.9471 (88.5)	0.7781	2.3483	1.5701	0.1666	0.1273		1.0000	0.6489**
	Zn	1.6673 (46.5)	0.4204	0.2521	2.0877 (122.4)	2.5081 (322.2)	0.6025	3.7695	3.1674					1.0000
Granitic Rock n=3	Cu	1.4150 (26.0)	0.4277	0.3023	1.8427 (69.6)	2.2704 (186.4)	0.9542	1.7993	0.8451					
	Pb	1.1131 (13.0)	0.2096	0.1883	1.3227 (21.0)	1.5323 (34.1)	0.9031	1.3222	0.4191					
	Zn	1.3597 (22.9)	0.2190	0.1611	1.5787 (37.9)	1.7977 (62.8)	1.1761	1.6020	0.4260					
Unknown n=20	Cu	1.2890 (19.5)	0.2015	0.1563	1.4905 (30.9)	1.7095 (51.2)	0.7781	1.6812	0.9031			1.0000	0.3184	0.5412
	Pb	1.5747 (37.6)	0.3309	0.2101	1.9056 (80.4)	2.2365 (172.4)	1.0000	2.5955	1.5955	0.5614	0.4438		1.0000	0.4350
	Zn	1.8174 (65.7)	0.2899	0.1595	2.1073 (128.0)	2.3972 (249.6)	1.3802	2.4393	1.0591					1.0000
Others n=2	Cu	1.7297 (53.7)	0.1805	0.1043	1.9102 (81.3)	2.0907 (123.2)	1.6020	1.8573	0.2553					
	Pb	1.2644 (18.4)	0.2129	0.1684	1.4773 (30.0)	1.6902 (49.0)	1.1139	1.4150	0.3010					
	Zn	1.5773 (37.8)	1.1302	0.7165	2.7075 (509.9)	3.8377 (6881.8)	0.7761	2.3766	1.5964					

Table 10-D Summary of Statistical Data of Geochemical Samples (Phase I)

(4) Area-B, Soil, Formations

Drainage	Elements	Mean (log PPM)	Standard Deviation	SD/Mean	Mean +1SD	Mean +2SD	Minimum	Maximum	Range	Correlation Analysis: Reliability R(0.01)	Correlation Analysis: Reliability R(0.05)	Correlation Coefficients Cu	Correlation Coefficients Pb	Correlation Coefficients Zn
All samples n=872	Cu	1.3842 (24.2)	0.2409	0.1740	1.6251 (42.2)	1.866 (73.5)	0.3010 (2.0)	2.2253 (168.0)	1.9243			1.0000	0.4217	0.3873
	Pb	1.4657 (29.2)	0.2105	0.1436	1.6762 (47.4)	1.8867 (77.0)	0.6021 (4.0)	2.6989 (499.9)	2.0969	0.0872	0.0664		1.0000	0.4895
	Zn	1.7553 (56.9)	0.2989	0.1703	2.0542 (113.3)	2.3531 (225.5)	0.6021 (4.0)	3.012 (1028.0)	2.410					1.0000
Ash n=18	Cu	0.9155 (8.2)	0.3476	0.3797	1.2631 (18.3)	1.6107 (40.8)	0.3010	1.5051	1.2041			1.0000	0.6344**	0.8055**
	Pb	1.1530 (14.2)	0.2075	0.1800	1.3605 (22.9)	1.568 (37.0)	0.9031	1.5315	0.6284	0.5897	0.4683		1.0000	0.7245**
	Zn	1.4152 (26.0)	0.3740	0.2643	1.7892 (61.5)	2.1632 (145.6)	0.9031	2.0531	1.1500					1.0000
Alluvim n=12	Cu	1.4363 (27.3)	0.2257	0.1571	1.662 (45.9)	1.8877 (77.2)	0.9542	1.7559	0.8016			1.0000	0.4542	0.8092**
	Pb	1.4880 (30.8)	0.1282	0.0862	1.6162 (41.3)	1.7444 (55.5)	1.2304	1.7243	0.4938	0.7079	0.5760		1.0000	0.5911*
	Zn	1.6236 (42.0)	0.2830	0.1743	1.9066 (80.6)	2.1896 (154.7)	1.1139	2.1732	1.0592					1.0000
Ixcoy Form n=458	Cu	1.4360 (27.3)	0.2005	0.1396	1.6365 (43.3)	1.837 (68.7)	0.3010	2.2253	1.9243			1.0000	0.3272**	0.3542**
	Pb	1.4945 (31.2)	0.1619	0.1083	1.6564 (45.3)	1.8183 (65.8)	0.6021	2.3010	1.6990	0.1202	0.0917		1.0000	0.4674**
	Zn	1.7867 (61.2)	0.2374	0.6926	2.0241 (105.7)	2.2615 (182.6)	1.0000	3.0124	2.0124					1.0000
Todos Santos Form n=211	Cu	1.3808 (24.0)	0.2230	0.1615	1.6038 (40.2)	1.8268 (67.1)	0.4771	2.1072	1.6301			1.0000	0.3396**	0.1644*
	Pb	1.4388 (27.5)	0.2106	0.1464	1.6494 (44.6)	1.86 (72.4)	0.8451	2.3010	1.4559	0.1769	0.1353		1.0000	0.2920**
	Zn	1.7349 (54.3)	0.3050	0.1758	2.0399 (109.6)	2.3449 (221.3)	0.6990	2.6493	1.9503					1.0000
Santa Rosa Group n=122	Cu	1.3187 (20.8)	0.2259	0.1713	1.5446 (35.0)	1.7705 (59.0)	0.4771	1.8750	1.3979			1.0000	0.3661**	0.2859**
	Pb	1.5439 (35.0)	0.2559	0.1657	1.7998 (63.1)	2.0557 (113.7)	0.9542	2.6989	1.7447	0.2323	0.1782		1.0000	0.6387**
	Zn	1.7765 (59.8)	0.3993	0.2248	2.1758 (149.9)	2.5751 (375.9)	0.7781	3.0000	2.2218					1.0000
Granitic Rock n=40	Cu	1.1827 (15.2)	0.3683	0.3114	1.5465 (35.2)	1.9103 (81.3)	0.3010	2.0128	1.7118			1.0000	0.5763**	0.7778**
	Pb	1.1776 (15.1)	0.2306	0.1958	1.4082 (25.6)	1.6388 (43.5)	0.9031	1.8195	0.9164	0.4032	0.3125		1.0000	0.4777**
	Zn	1.6429 (43.9)	0.3812	0.2320	2.0241 (105.7)	2.4053 (254.3)	0.6021	2.4771	1.8750					1.0000
Unknown n=11	Cu	1.4607 (28.9)	0.1508	0.1032	1.6115 (40.9)	1.7623 (57.8)	1.2041	1.6812	0.4771	Test is not done		1.0000	-0.0034	0.5832
	Pb	1.4465 (28.0)	0.0588	0.0406	1.5053 (32.0)	1.5641 (36.7)	1.3222	1.5051	0.1829	because deg. of Freedom less			1.0000	0.2487
	Zn	1.7119 (51.5)	0.3011	0.1759	2.013 (103.0)	2.3141 (206.1)	1.2553	2.1461	0.8909	than 10.				1.0000

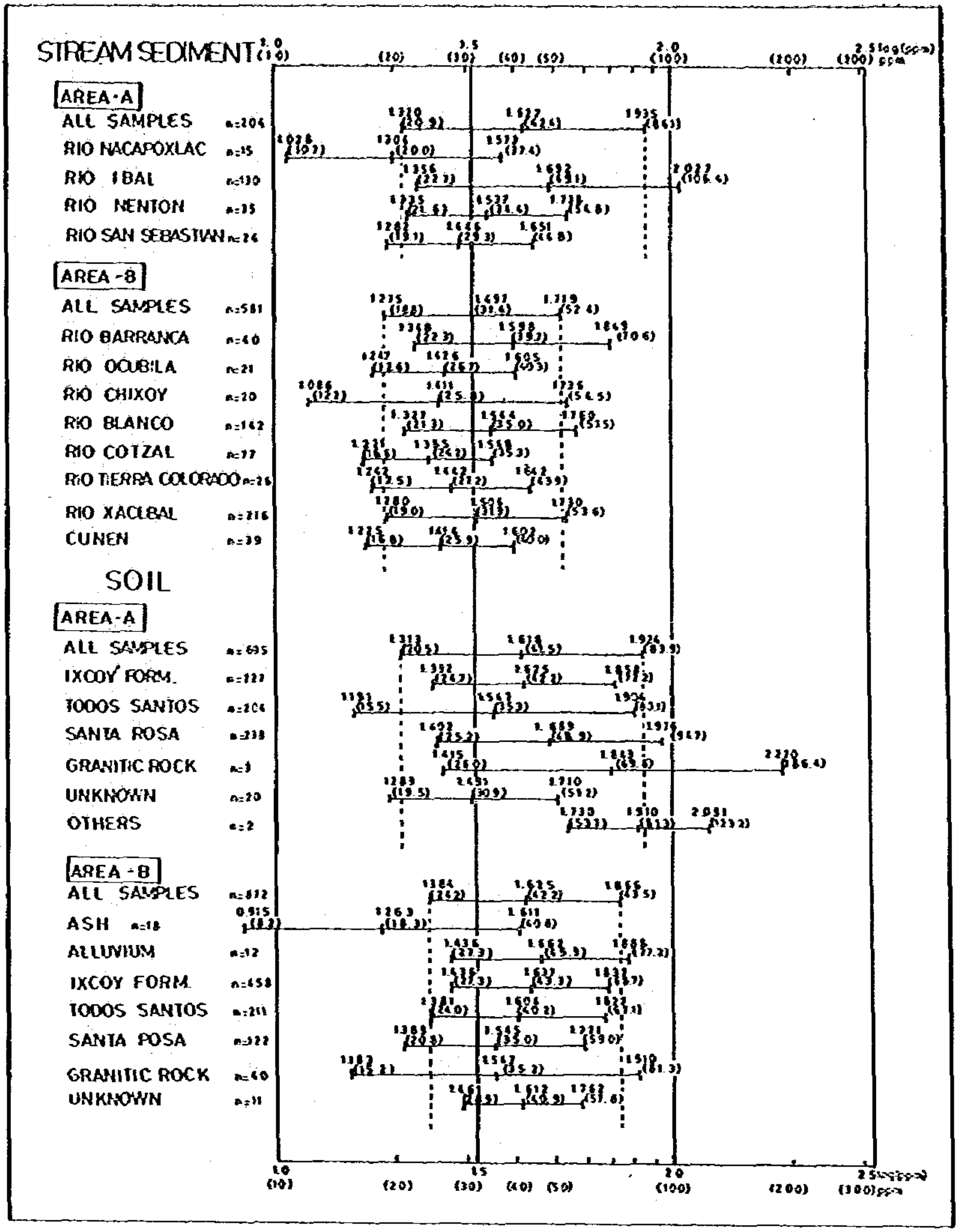


Fig.15 Means and standard deviations of Cu-content for individual drainage basins &/or geological units (Phase I)

The lowest values: mean. The second: mean + 1 standard deviation. The highest values: mean + 2 standard deviations.

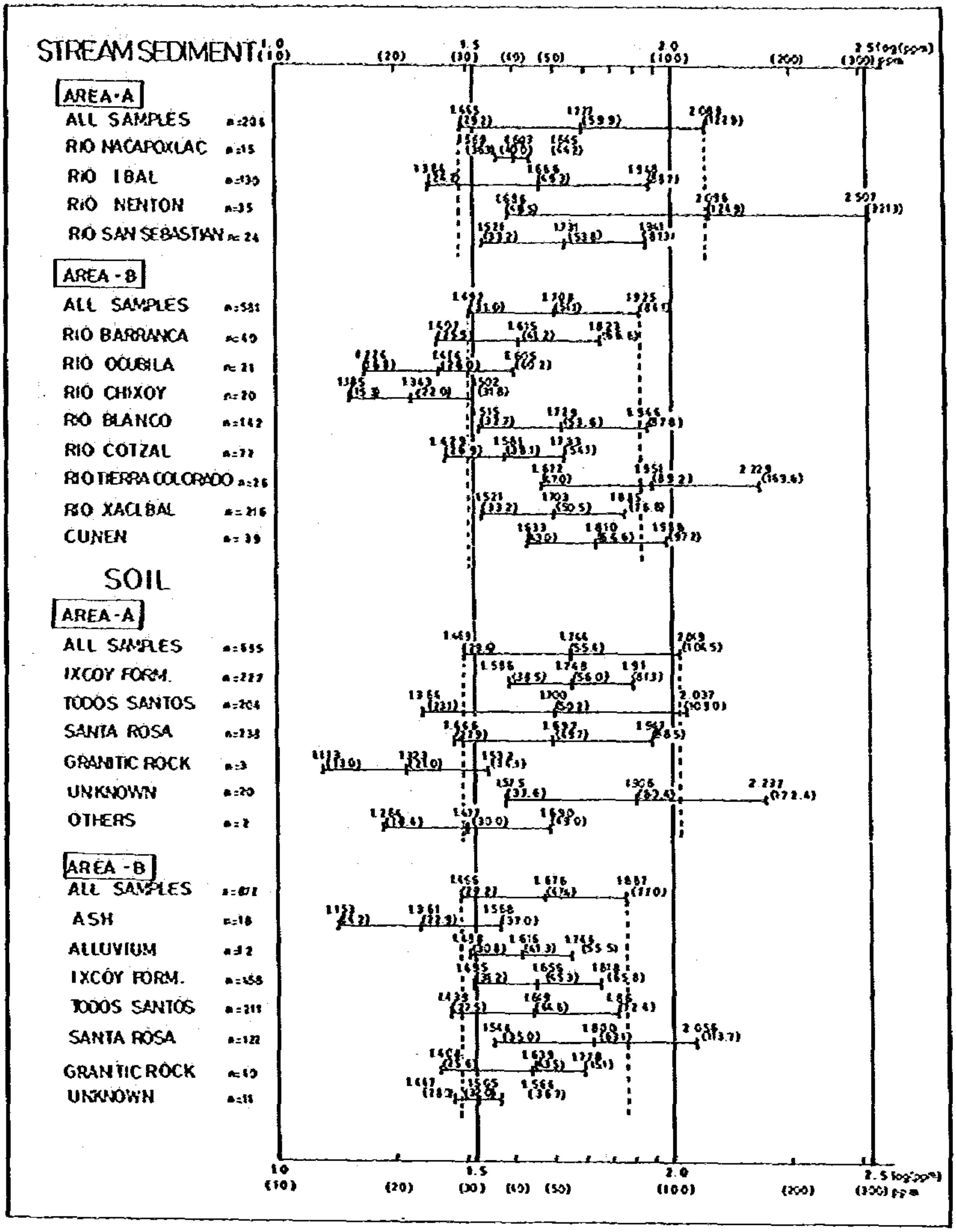


Fig.16 Means and standard deviations of Pb-content for individual drainage basins &/or geological units (Phase I)

The lowest values: mean. The second: mean+1 standard deviation. The highest values: mean+2 standard deviations.

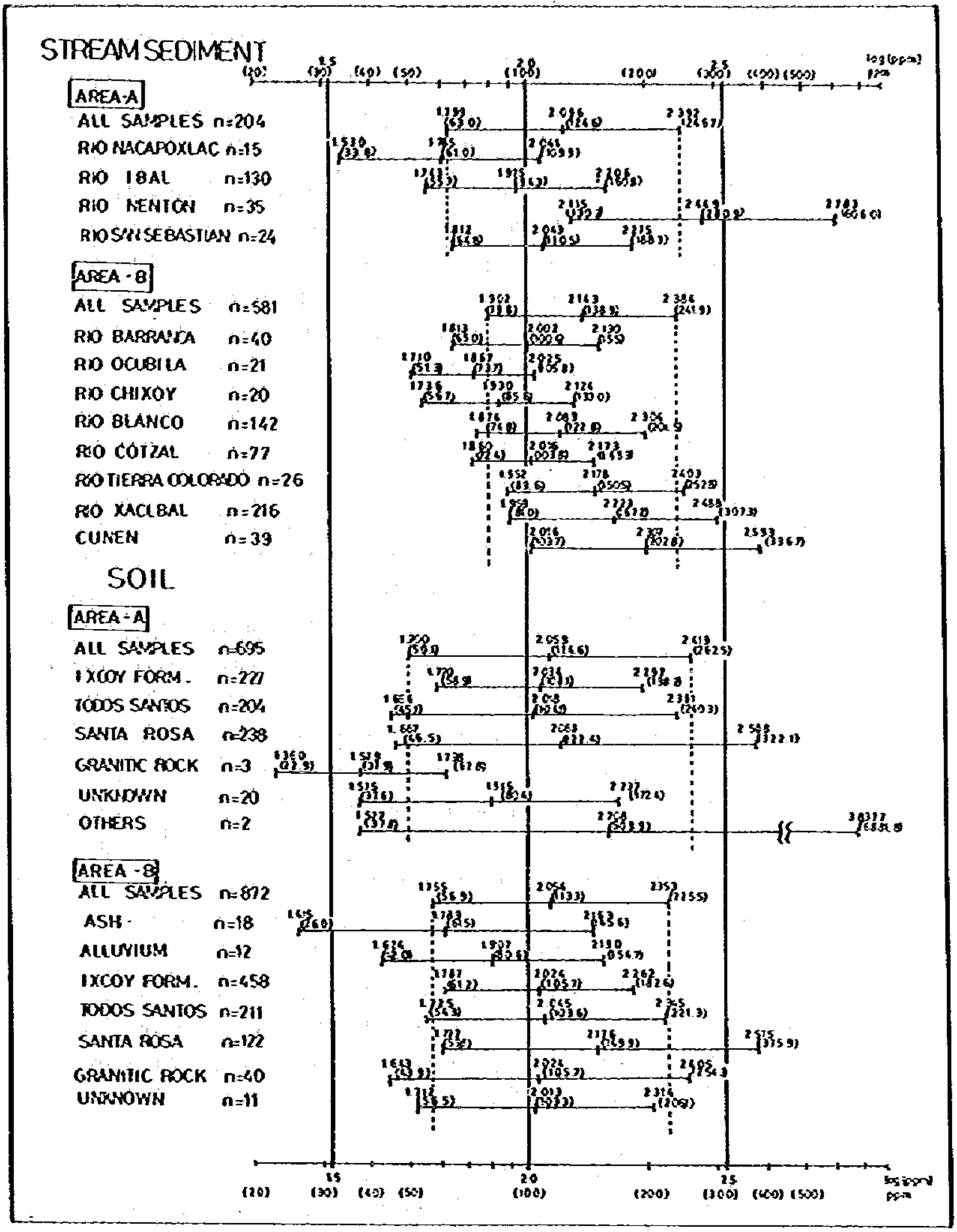


Fig.17 Means and standard deviations of Zn-content for individual drainage basins & for geological units.(Phase I)

The lowest values: mean. The second: mean±1standard deviation. The highest values: mean±2standard deviations.

Consequently, a threshold from "All samples" was adopted as the threshold common to that area, in order to simplify the later treatments.

Threshold by "Lepeltier's method" : "Lepeltier's method" is a method to distinguish populations of different natures by the difference in pattern of a frequency distribution curve. In practice, the threshold value is supposed to be determined by finding breaking points of regression lines drawn to the cumulative frequency curve. The method can be said more advanced than "Statistical method" as an idea, and is also convenient for a geologist to practice in the field where no computer is available.

In the 1st phase operation, the method was tried to apply simultaneously to the computation of statistical parameters and the thresholds by "Statistical method": Cumulative frequency curves were constructed for both "All sample groups" and "Unit groups", and "threshold values" were graphically read from all of these groups.

As a result, however, we did not use these threshold values for delineation of anomalies, because we found it fairly difficult to determine threshold values uniquely and objectively by this method: In a larger population "All sample group", several breaking points were observed on a single cumulative frecuency curve. This may probably imply that the population comprises various smaller populations of different natures. On the contrary, in certain smaller populations, which were subdivided from "All sample group" in order to eliminate the effect of the mixed population, we found it difficult to draw significant regression lines due to an extremely small number of samples. Another ambiguous nature of this method was caused by the use of "probability-log graph paprt". Only a slight difference in position of a regression line greatly affected the reading of the threshold value in antilogarithmic scale.

For reference, the cumulative frequency curves of "All sample Groups" are demonstrated in this report as Fig.18 and 19.

Threshold values finally adopted: After the threshold values by "Statistical method" and those by "Lepeltier's method" were compared, the former of "All Sample group" was finally adopted as the threshold values of that area.

For reference, these two different thresholds are summarized in Table-11, and Fig.18 & 19.

Table-11 Comparison of Threshold Values and Populations

by the Graphical and the Classical Methods.

Area	Type of Samples	Element		Graphical Method: Background	Graphical Method: Mixture	Graphical Method: Anomalous 2nd degree	Graphical Method: Anomalous 1st degree	Classical Method: $< \bar{x}$	Classical Method: $\bar{x} \leq < \bar{x}+1SD$	Classical Method: $\bar{x}+SD \leq < \bar{x}+2SD$	Classical Method: $\bar{x}+2SD \leq < \bar{x}+3SD$	Classical Method: $\bar{x}+3SD \leq$
A	Soil n=695	Cu	(ppm)	<20.0	20.0≦ <50.0	50.0≦ <80.0	80≦	<20.5	20.5≦ <41.5	41.5≦ <83.9	83.9≦ <169	169≦
			(%)	40.0	55.0	2.5	2.5	40.0	47.0	11.0	1.6	0.4
		Pb	(ppm)	<33.0	33.0≦ <51.0	51.0≦ < 115	115≦	<29.4	29.4≦ <55.4	55.4≦ < 104	104 ≦ <197	197≦
			(%)	50.0	32.0	15.5	2.5	46.0	40.0	10.8	2.6	0.6
		Zn	(ppm)	<20.0	20.0≦ < 142	142 ≦ < 300	300≦	<50.1	50.1≦ < 115	115 ≦ < 263	263 ≦ <609	609≦
			(%)	10.6	83.2	3.7	2.5	52.0	35.5	9.3	2.5	0.7
	Stream Sediment n=204	Cu	(ppm)	<16.5	16.5≦ <24.5	24.5≦ <72.0	72.0≦	<20.9	20.9≦ <42.4	42.4≦ <86.1	86.1≦ <175	175≦
			(%)	28.5	41.5	27.5	2.5	54.0	35.5	9.0	0.3	1.2
		Pb	(ppm)	<31.5	31.5≦ <50.0	50.0≦ < 145	145≦	<29.2	29.2≦ <59.9	59.9≦ < 123	123 ≦ <252	252≦
			(%)	58.0	29.0	10.5	2.5	52.5	37.8	6.7	1.7	1.3
		Zn	(ppm)	<66.0	66.0≦ <87.0	87.0≦ < 300	300≦	<63.0	63.0≦ < 125	125 ≦ < 247	247 ≦ <488	488≦
			(%)	45.0	37.0	15.5	2.5	44.0	45.0	7.3	2.4	1.3
B	Soil n=872	Cu	(ppm)	<19.0	19.0≦ <52.0	52.0≦ <56.0	56≦	<24.2	24.2≦ <42.2	42.2≦ <73.5	73.5≦ <128	128≦
			(%)	20.0	77.1	0.4	2.5	42.0	51.0	6.0	0.8	0.2
		Pb	(ppm)	<20.0	20.0≦ <50.0	50.0≦ <86.0	86≦	<29.2	29.2≦ <47.4	47.4≦ <77.0	77.0≦ <125	125≦
			(%)	15.0	77.6	4.9	2.5	52.0	39.5	5.7	1.8	1.0
		Zn	(ppm)	<76.0	76.0≦ < 125	125 ≦ <265	265≦	<56.9	56.9≦ < 113	113 ≦ < 226	226 ≦ <449	449≦
			(%)	61.0	30.0	6.5	2.5	48.0	39.0	9.5	2.7	0.8
	Stream Sediment n=581	Cu	(ppm)	<20.0	20.0≦ <51.0	–	51≦	<18.8	18.8≦ <31.4	31.4≦ <52.4	52.4≦ <87.4	87.4≦
			(%)	29.0	69.0		2.0	25.0	53.0	20.4	1.3	0.3
		Pb	(ppm)	<32.0	32.0≦ <63.0	63.0≦ <122	122≦	<31.0	31.0≦ <51.1	51.1≦ <84.1	84.1≦ <149	149≦
			(%)	29.0	58.5	10.0	2.5	27.5	45.5	20.0	5.9	1.1
		Zn	(ppm)	<50.0	50.0≦ < 275	–	275≦	<79.8	79.8≦ < 139	139 ≦ < 242	242 ≦ <421	421≦
			(%)	18.0	89.3		2.7	31.0	39.5	24.5	3.6	1.4

Fig.18 CUMULATIVE FREQUENCY DISTRIBUTION —AREA-A—