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VEN - 02 PROJECT

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"DEVELOPMENT OF TECHNIQUES TO SIMPLIFY THE PROCES OF INVESTIGATION AND ESTIMATE OF NATURAL RESOURCES IN REMOTE AND RELATIVELY UNEXPLORED AREAS (VENEZUELA)

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CARACAS 1976

"DEVELOPMENT OF TECHNIQUES TO SIMPLIFY THE PROCESS OF INVESTIGATION AND ESTIMATE OF NATURAL RESOURCES IN REMOTE AND RELATIVELY UNEXPLORED AREAS" (VENEZUELA)

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MINISTERIO DE OBRAS PUBLICAS

DIRECCION DE CARTOGRAFIA NACIONAL

EDIF. CAMEJO ESQ. CAMEJO

CARACAS 101

MAY 1974

FINAL REPORT

CORDIPLAN

PALACIO BLANCO

CARACAS 101

VENEZUELA

TABLE OF CONTENTS

	Page
Chapter 1 Introduction.	1-1
Chapter 2 GENERAL ASPECTS.	
Introduction.....	2-1
2.0. Objectives.....	2-3
2.1. Work Plan (Chronograms).....	2-4
2.2. Basic Information.....	2-9
2.2.1 Satellite images.....	2-9
2.2.2 Radar Images.....	2-9
2.2.3 Conventional Photography.....	2-17
2.2.4 Basic Cartography.....	2-17
2.3. Methodology.....	2-19
2.4. Results.....	2-25
Chapter 3. Geology.	
Introduction.....	3-1
3.1. Previous Work.....	3-2
3.2. Objectives of the Project.....	3-2
3.3. Interpretation Methods and chronology.....	3-3
3.3.1.Drainage.....	3-3
3.3.2.Tonal and textural differences.....	3-3
3.3.3.Structural Interpretation.....	3-3
3.3.4.Tonal and textural identification.....	3-4
3.3.5 Identification of geological units.....	3-4
3.4. Description of the units.....	3-5
3.4.1.A lluvium.....	3-5
3.4.2.Volcanics Rocks.....	3-5

3.4.3 Granitic Igneous Rocks..... 3-5

3.4.4 Granitic Igneous Roks..... 3-5

3.4.5 Roraima Unit..... 3-5

3.4.6 Igneous-metamorphic basement..... 3-6

3.4.7 Granitic Unit..... 3-7

3.4.8 Granitic Unit..... 3-7

3.4.9 Granitic Unit..... 3-7

3.4.10.Granitic Unit..... 3-7

3.4.11 Gneiss-Granitic Unit..... 3-7

3.4.12 Gneiss-Granitic Unit..... 3-8

3.5. Conclusions..... 3-8

3.5.1. Conventional aerial photographs..... 3-8

3.5.2. Side-looking airborie radar images..... 3-8

3.5.3. Satellite Images..... 3-9

3.6. Recomendations..... 3-9

3.7. Final results 3-10

Graph Comparing Interpretation Resuts..... 3-12

Textural Examples..... 3-31

Chapter 4 Forestry.

Introduction..... 4-1

4.1. Descriptiom of the zone..... 4-2

4.2. Available Material..... 4-5

4.3. Aspects of the photo-interpretation Methods..... 4-6

4.4. Results..... 4-9

4.5. Final Conclusions..... 4-36

Maps 4-37

Chapter 5 Cartography

Introduction 5-1

5.1. Characteristics of the ERTS-1 Images 5-2

5.2. Available Material 5-5

5.3. Cartographic Quality of the IMAGES 5-14

5.4. Conclusions 5-22

I N T R O D U C T I O N

During the ERTS-1 VEN-02 project, diverse efforts were consolidated, these have resulted in indicative conclusions as to the possibilities of evaluating natural resources through the use of remote perception techniques. For Venezuela, we believe that it has been an opportunity to form professionals in different scientific disciplines this type of activity was planned prior to the program iniciation; it has permitted a coordinated effort which will continue in the future study phases and permit us to take advantage of these facilities.

The personnel asigned to sack of the participating organizations was the following:

Directorate of National Cartography

Professional Personnel:	3	Geographers
Technical Personnel:	1	Draftman
	1	Secretary
	1	Photographer
	2	Asistent Photographers

Ministry of Mines and Hydrocarbons

Professional Personnel:	1	Geologist
	1	Photogeologist
	1	Photointerpreter
Technical Personnel:	2	Draftmen

1 Aerialcartographer

Ministry of Agriculture and Breeding

Professional Personnel: 2 Forestry engineers

3 Draftmen

The professional training phase was complemented during the work period with the attendance to the following scientific events related to the project:

VII and VIII Remote Sensing Symposium - Ann Arbor, Michigan - 1971-1974

Symposium on ERTS-1 Results- G.S.F.C. 1973

First Pan American Symposium on Remote Sensing - Panama - 1973.

IV Pannel of Remote Sensing, sponsored by U. N., Buenos Aires, Argentina, 1973.

Training courses:

Remote Sensing. Cartographic School I.A.G.S. - Canal Zone 1972.

Radar Image Interpretation

Aero Service Corporation. Philadelphia, U.S.A., 1971

Utilization of ERTS-1 and Sky Lab Data - Washington D. C. and Berkeley, California, U.S.A., 1973

Photointerpretation. I.T.C. - Bogotá, Colombia, 1972

The comparative analysis of Radar-Conventional photography and Satellite Images was very successful. The results of this investigation are presented in this report.

MINISTRY OF PUBLIC WORKS

DIRECTORATE OF NATIONAL CARTOGRAPHY

CHART DIVISION

REMOTE SENSING DEPARTMENT

"DEVELOPMENT OF TECHNIQUES TO SIMPLIFY THE PROCESS OF INVESTIGATION AND ESTIMATE OF NATURAL RESOURCES IN REMOTE AND RELATIVELY UNEXPLORED AREAS" (VENEZUELA).

NUMBER SR - 0120

GENERAL ASPECTS

By: Rafael LAIRET

Geographer

INTRODUCTION

During these last years research techniques of Renewable Natural Resources have gone through considerable transformations due to the use of the Radar and Satellite systems.

In our country, especifically in the Amazonas Territory, the efficiency of such systems has been proved in reconnaissance and semidetailed studies of the resources over extensive and little known areas.

The use of ERTS-1 images helps the scientist to obtain information which jointly with the Radar and conventional photography generates an overall view of the area and of the resources thereto existing, so that the efforts can be directed towards its rational exploitation.

Before the realization of such studies using the Radar system and the actual research programs with ERTS-1 images, the Amazonas was a practically unknown territory. This is clearly evidenced in the Report I presented by Codesur (page 9):

"Its potential and many resources are completely unknown distribution and quantity wise and the information on its demographic, natural and physical characteristics are scattered, incomplete and in many cases unreliable.

The scarcity and deficiency of the means of communication make difficult any verification action concerning available information as well as the realization of basic and disciplinary studies.

The lack of a penetration infrastructure and the limited action of the organizations in the region, in charge of developing specific programs

on a national level, leaves an emptiness in the field of execution of the most necessary works which are essential to carry out basic studies".

The Radar pictures constituted the first complete view of the Amazonas Territory, since due to its isolation and the problems derived from the heavy cloudiness, the conventional photographic system was unuseable. Thanks to the radar of the whole territory, the realization of regional studies as well as the establishment of priority areas for future studies was made possible.

Actually through the Radar and Satellite images, an ambitious program of studies has been established, which will permit knowledge of the reality of the natural resources in the Amazonas Territory within a relatively shorter time than the one required by the use of conventional methods.

2.0. OBJECTIVES

The goal established in the working plan, through the use of data and techniques of remote sensing, was to obtain a quick reconnaissance of the area under study, in order to establish priority areas for investigation.

The following objectives have been established:

1. Reconnaissance analysis of the area
2. Establishment of zones for semi-detailed and detailed studies using the radar and conventional photographic systems.

These objectives could be reached through the following steps:

A. Geology

a.- Structure

b.- Lithological changes

c.- Maps of alluvial areas

B. Cartography

Develop quick techniques for the elaboration of thematic maps such as Geology, Geomorphology, Vegetation, Hidrology, as well as topographic maps in scale of 1:250,000 to 1:000,000.

C. Vegetation

Study of large vegetational communities such as savannas, rain forests, etc.

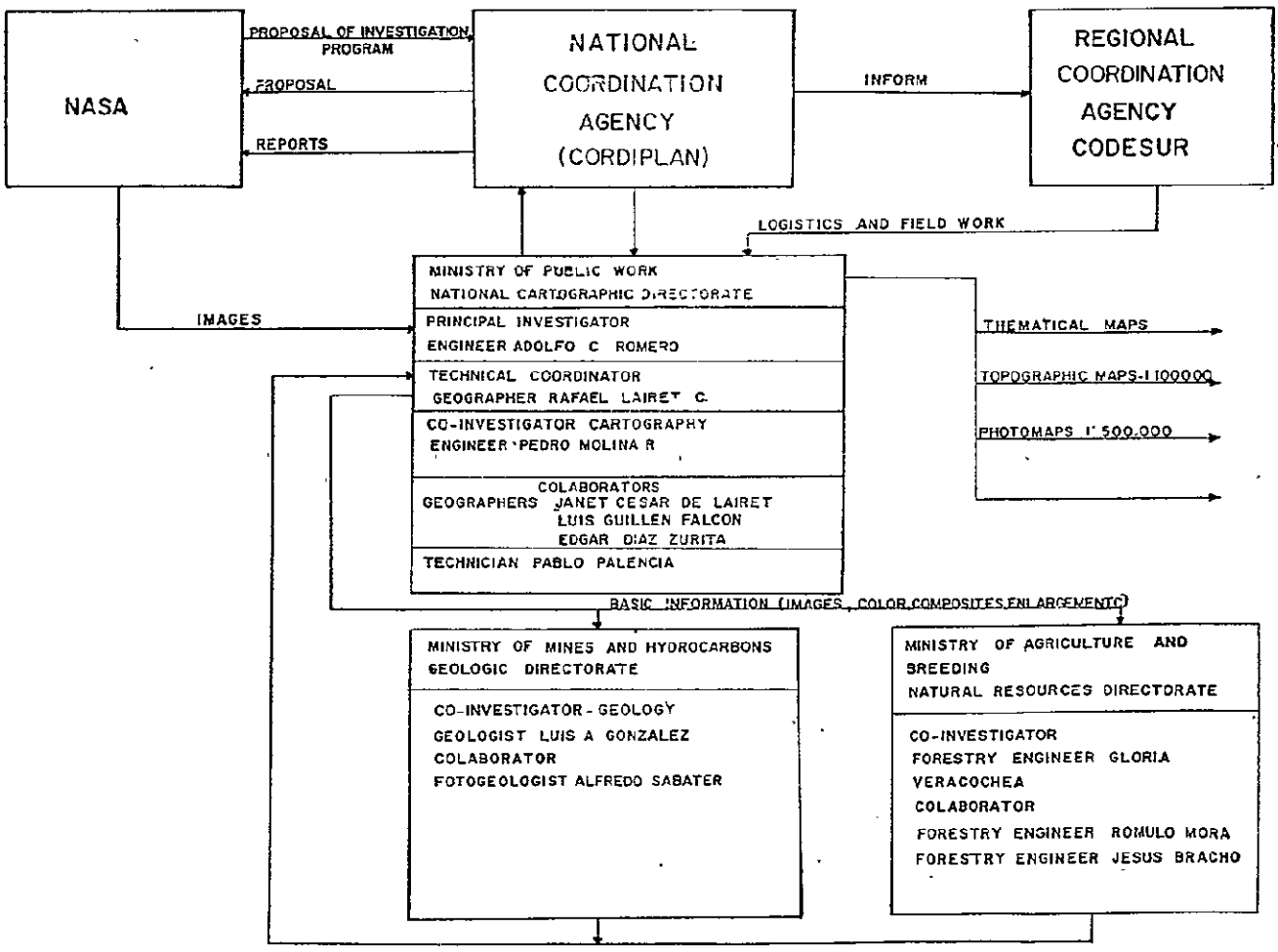
D. Hydrology

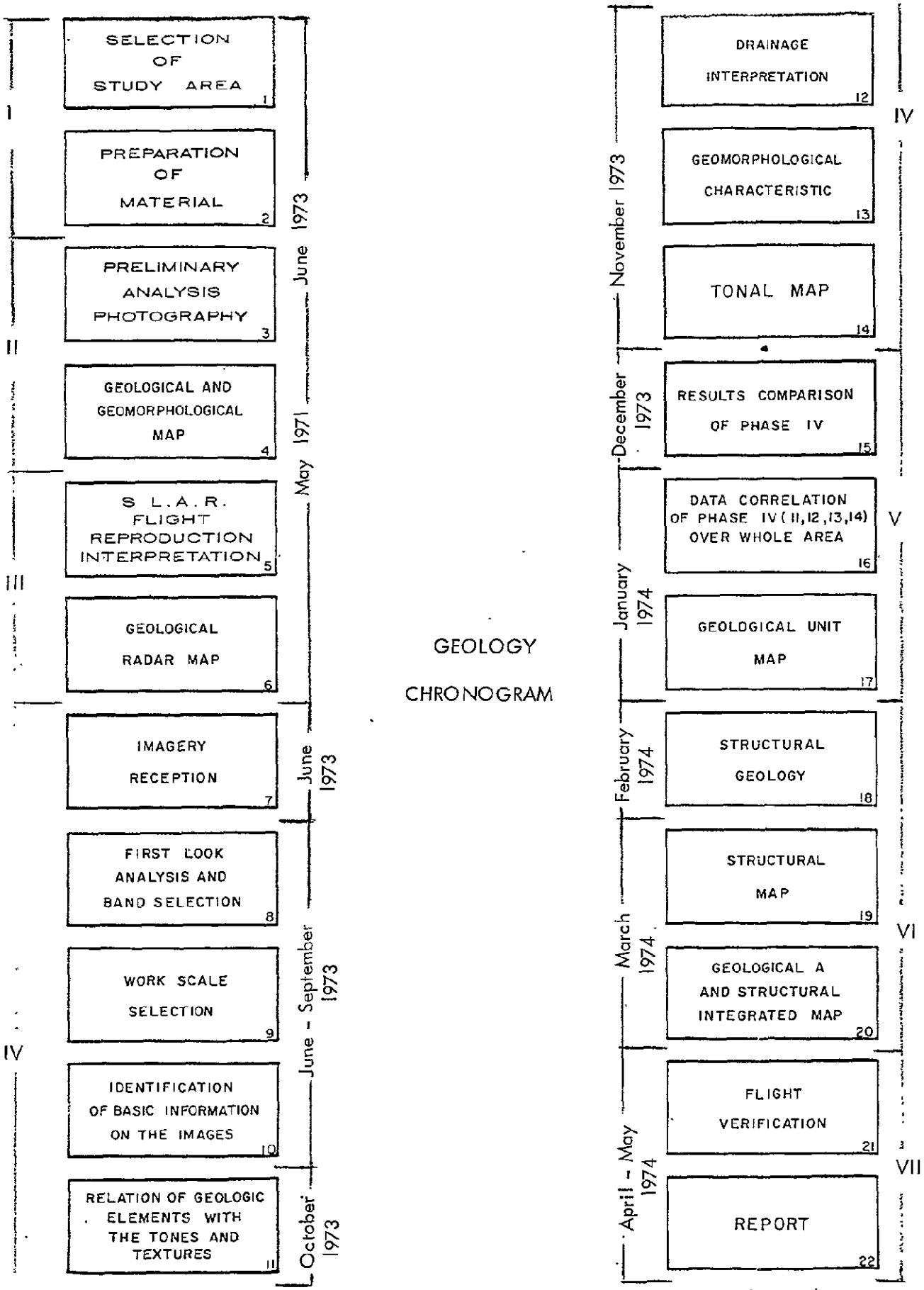
Study of river basins and regional drainage

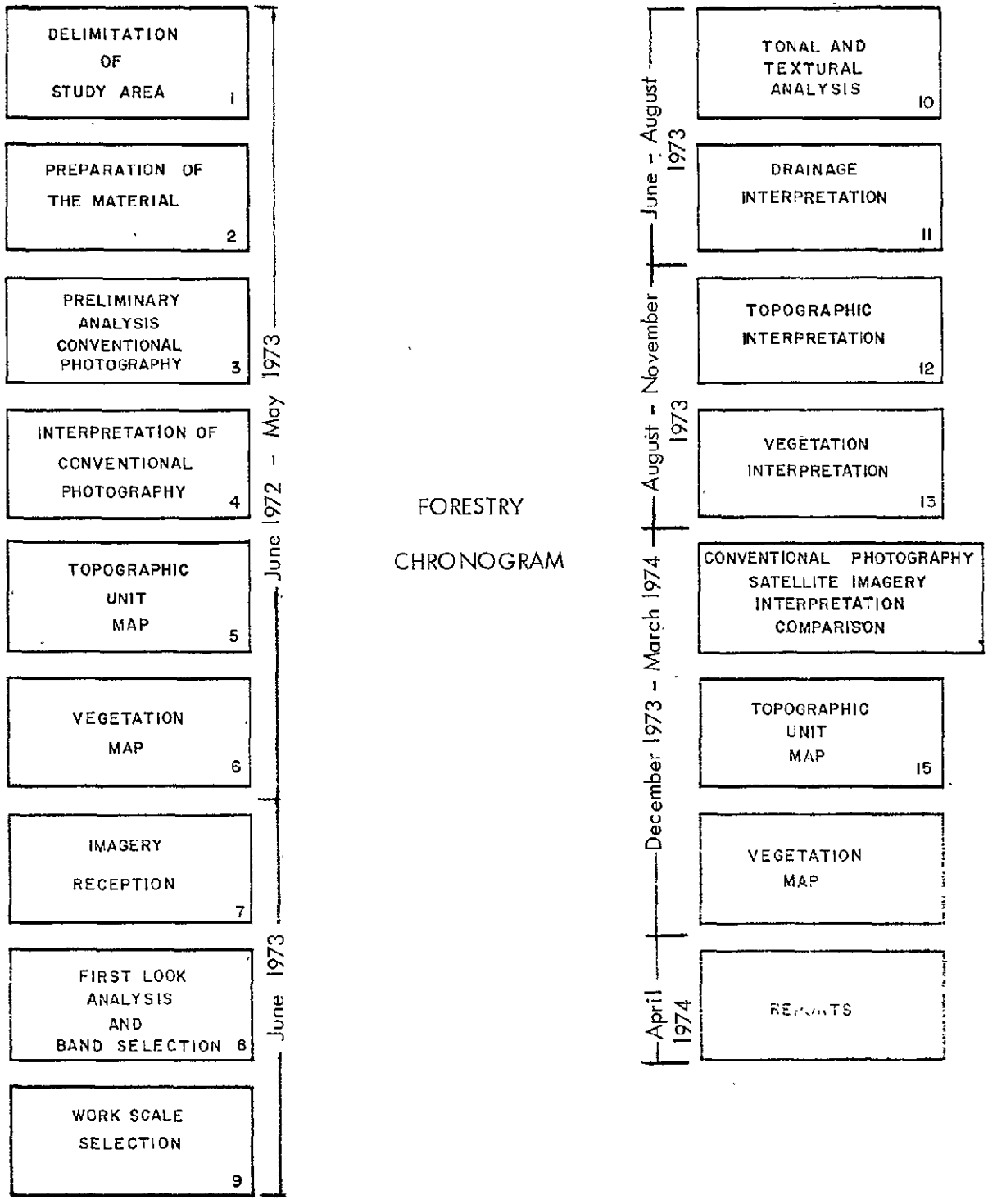
E. Techniques to accelerate the estimation and evaluation of the Natural Resources.

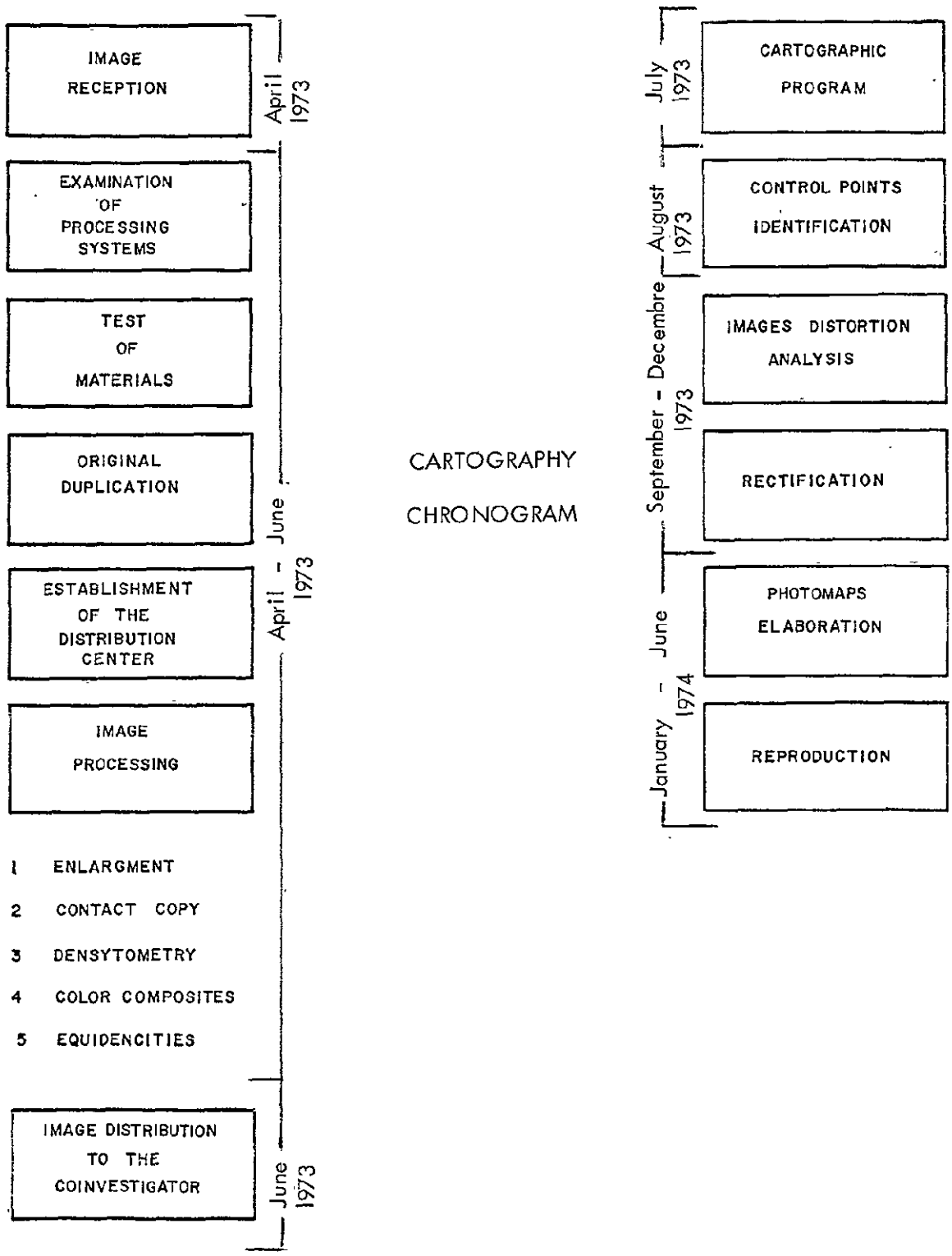
2.1. WORK PLAN (CHRONOGRAMS)

Hence forth are the cronograms of each one of the activities of each working group within the VEN-02 Proyect.




GEOLOGY
CHRONOGRAM
I
II
III
IV
V
VI
VII
SELECTION OF STUDY AREA 1
PREPARATION OF MATERIAL 2
PRELIMINARY ANALYSIS PHOTOGRAPHY 3
GEOLOGICAL AND GEOMORPHOLOGICAL MAP 4
S L.A.R. FLIGHT REPRODUCTION INTERPRETATION 5
GEOLOGICAL RADAR MAP 6
IMAGERY RECEPTION 7
FIRST LOOK ANALYSIS AND BAND SELECTION 8
WORK SCALE SELECTION 9
IDENTIFICATION OF BASIC INFORMATION ON THE IMAGES 10
RELATION OF GEOLOGIC ELEMENTS WITH THE TONES AND TEXTURES 11
DRAINAGE INTERPRETATION 12
GEOMORPHOLOGICAL CHARACTERISTIC 13
TONAL MAP 14
RESULTS COMPARISON OF PHASE IV 15
DATA CORRELATION OF PHASE IV (11,12,13,14) OVER WHOLE AREA 16
GEOLOGICAL UNIT MAP 17
STRUCTURAL GEOLOGY 18
STRUCTURAL MAP 19
GEOLOGICAL A AND STRUCTURAL INTEGRATED MAP 20
FLIGHT VERIFICATION 21
REPORT 22
May 1971 – June 1973
June 1973
June – September 1973
October 1973
November 1973
December 1973
January 1974
February 1974
March 1974
April – May 1974


DELIMITATION OF STUDY AREA 1
PREPARATION OF THE MATERIAL 2
PRELIMINARY ANALYSIS CONVENTIONAL PHOTOGRAPHY 3
INTERPRETATION OF CONVENTIONAL PHOTOGRAPHY 4
TOPOGRAPHIC UNIT MAP 5
VEGETATION MAP 6
IMAGERY RECEPTION 7
FIRST LOOK ANALYSIS AND BAND SELECTION 8
WORK SCALE SELECTION 9
June 1972 - May 1973
June 1973
FORESTRY
CHRONOGRAM
TONAL AND TEXTURAL ANALYSIS 10
DRAINAGE INTERPRETATION 11
TOPOGRAPHIC INTERPRETATION 12
VEGETATION INTERPRETATION 13
CONVENTIONAL PHOTOGRAPHY SATELLITE IMAGERY INTERPRETATION COMPARISON
TOPOGRAPHIC UNIT MAP 15
VEGETATION MAP
RESULTS
June - August 1973
August - November 1973
December 1973 - March 1974
April 1974


CARTOGRAPHY
CHRONOGRAM
IMAGE RECEPTION
April 1973
EXAMINATION OF PROCESSING SYSTEMS
TEST OF MATERIALS
ORIGINAL DUPLICATION
ESTABLISHMENT OF THE DISTRIBUTION CENTER
IMAGE PROCESSING
1 ENLARGMENT
2 CONTACT COPY
3 DENSYTOMETRY
4 COLOR COMPOSITES
5 EQUIDENCITIES
April - June 1973
IMAGE DISTRIBUTION TO THE COINVESTIGATOR
June 1973
CARTOGRAPHIC PROGRAM
July 1973
CONTROL POINTS IDENTIFICATION
August 1973
IMAGES DISTORTION ANALYSIS
RECTIFICATION
September - Decembre 1973
PHOTOMAPS ELABORATION
REPRODUCTION
January - June 1974

2.2. BASIC INFORMATION

The material used in the program was composed of:

A.- Satellite Images

B.- Radar Images

C.- Conventional Photography

D.- Basic Cartography

2.2.1 Satellite Images

MSS Images of ERTS-1 at a scale of 1:3,369,000 covering 100% of the study area.

N.A.S.A. supplied 16 images, eleven of which are useable, the remaining 5 having a cloud coverage of more than 70%. Of the 11 useable images, 6 cover 95% of the area.

The work suffered a considerable delay of 6 months, due to the late submittance of the images by Goddard Space Flight Center.

Due to this delay, it has been impossible to effect the field check during the period from November 1972 to March 1973.

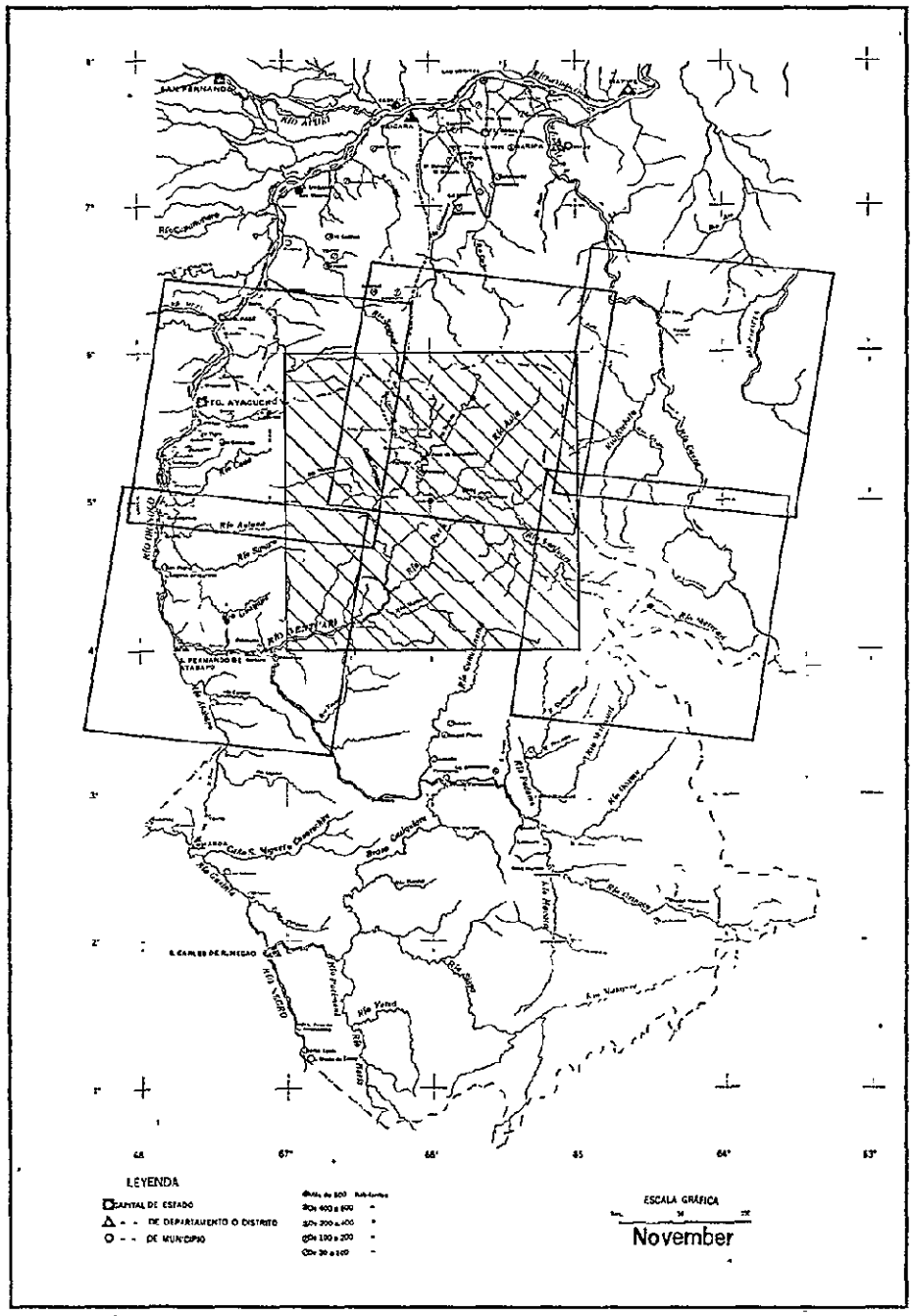
Part of the field check was performed between December 1973 and March 1974, the only period of time available before the coming of the rainy season.

2.2.2 Radar Images

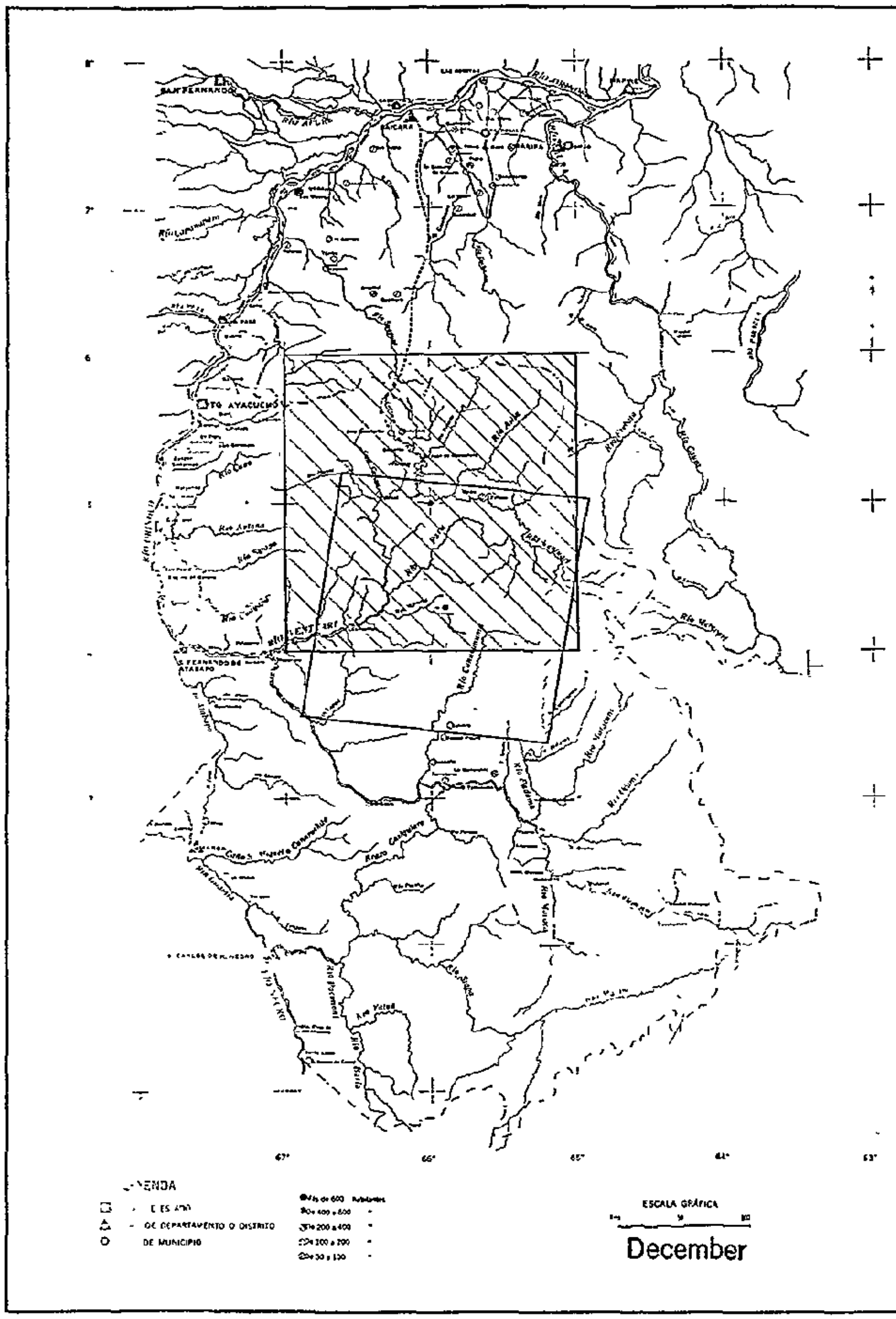
The Radar Images were obtained in April-May 1971 using the Goodyear APQ 102 system with a wave length of 3.12 cms., in a scale of 1:400,000 covering 100% of the area.

Noviembre				
5 Imágenes		Nubosidad		
1102-14090	11-02-72	70%	5.709 N	65.710 W
1103-14144	11-03-72	90%	5.680 N	67.131 W
1119-14032	11-19-72	70%	5.855 N	64.259 W
1119-14035	11-19-72	70%	4.399 N	64.597 W
1103-14151	11-03-72	90%	4.238 N	67.464 W
Diciembre				
1 Imágen				
1156-14092	12-26-72	20%	4.369 N	65.965 W
Enero				
2 Imágenes				
1174-14034	01-13-73	20%	5.704 N	65.551 W
1174-14091	01-13-73	10%	4.256 N	65.886 W
Febrero				
2 Imágenes				
1209-14033	02-17-73	10%	5.880 N	64.284 W
1209-14040	02-17-73	20%	4.438 N	64.626 W
Marzo				
6 Imágenes				
1227-14034	03-07-73	40%	5.868 N	64.336 W
1229-14151	03-09-73	20%	5.941 N	67.190 W
1229-14154	03-09-73	10%	4.510 N	67.533 W
1245-14041	03-25-73	20%	4.462 N	64.719 W
1247-14152	03-27-73	10%	5.910 N	67.232 W
1247-14154	03-27-73	20%	4.451 N	67.564 W

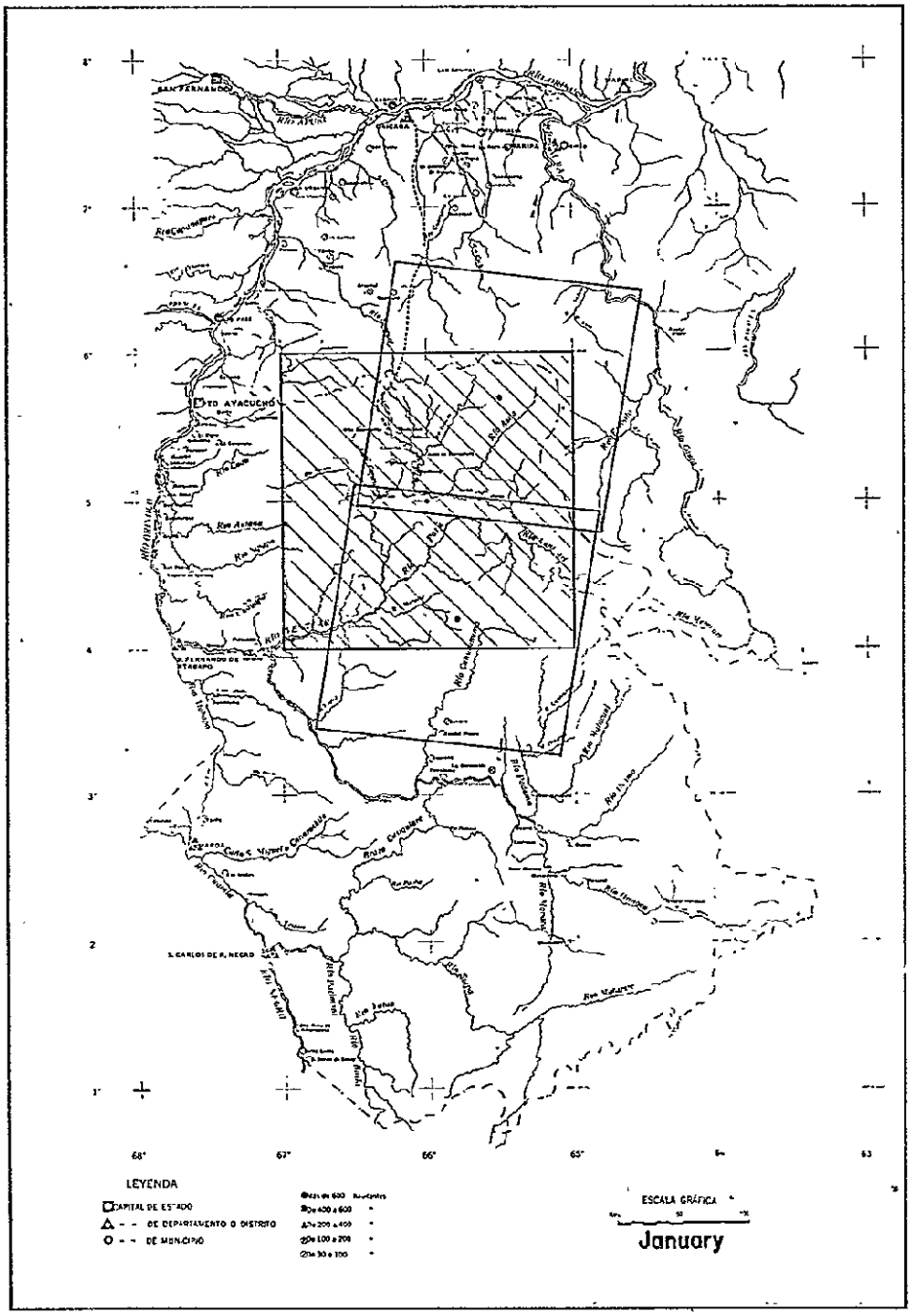
4-REGIÓN DE ESTUDIO-CODESUR



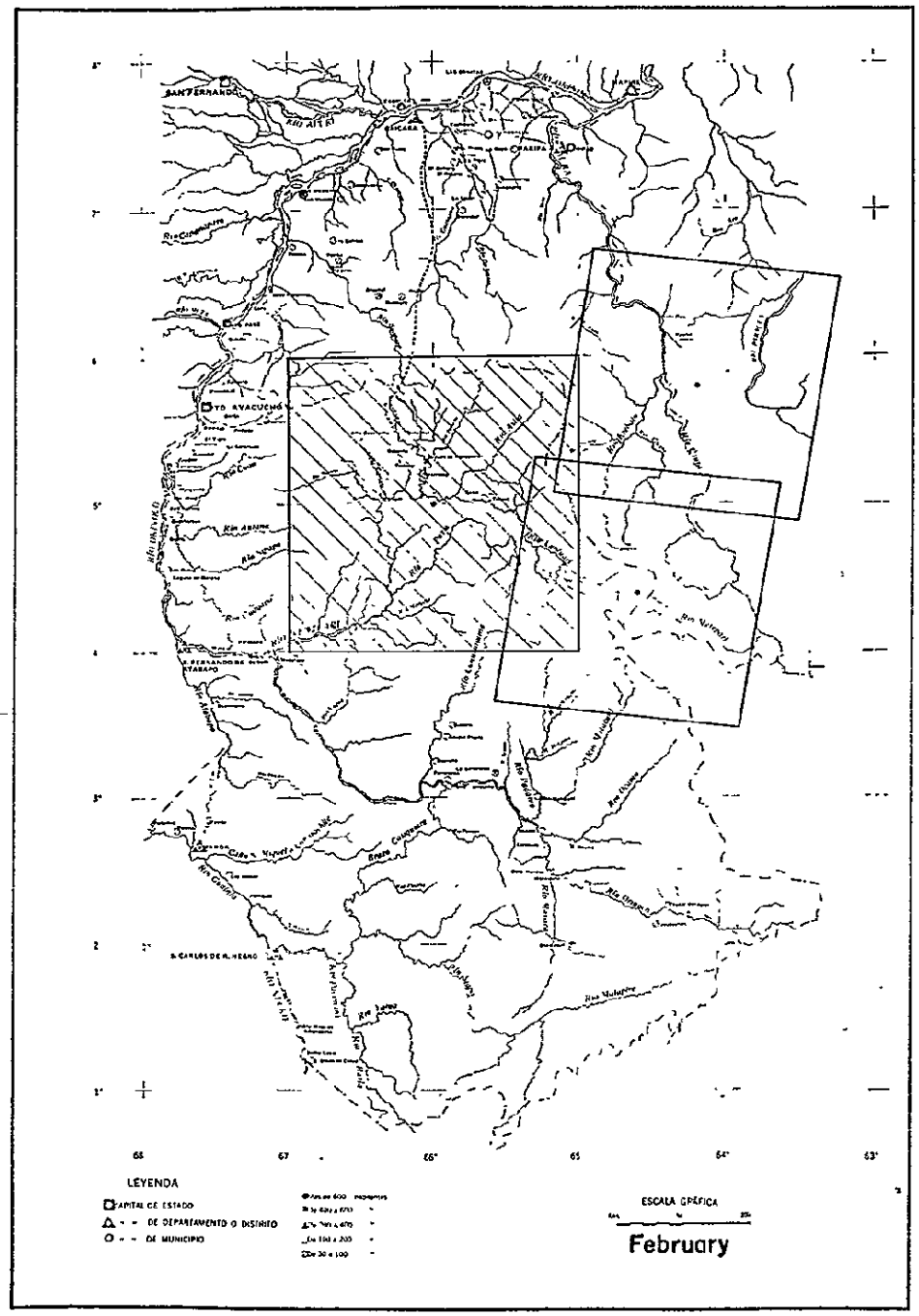
4-REGIÓN DE ESTUDIO-CODESUR



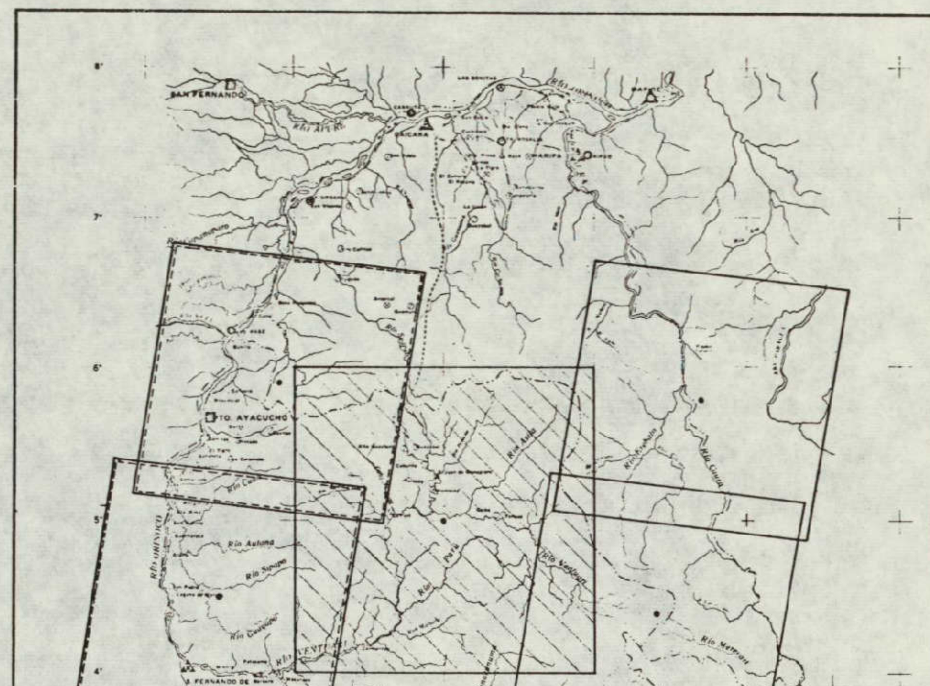
4-REGIÓN DE ESTUDIO-CODESUR

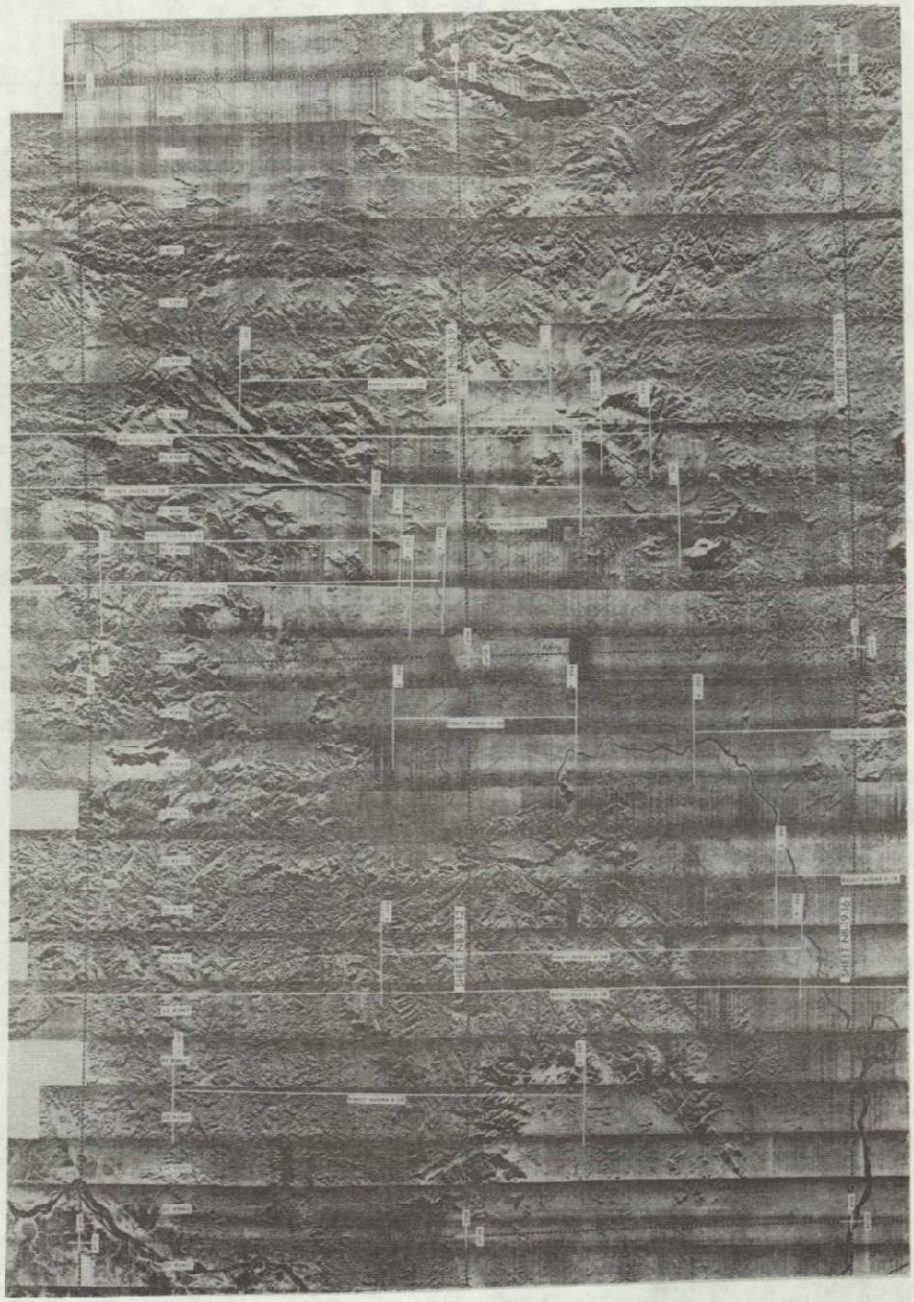


4-REGIÓN DE ESTUDIO-CODESUR



4-REGION DE ESTUDIO-CODESUR





2.2.3 Conventional Photography

Black and White and Black and White IR. photos were obtained in a scale of 1:50,000 covering 90% and 15% respectively.

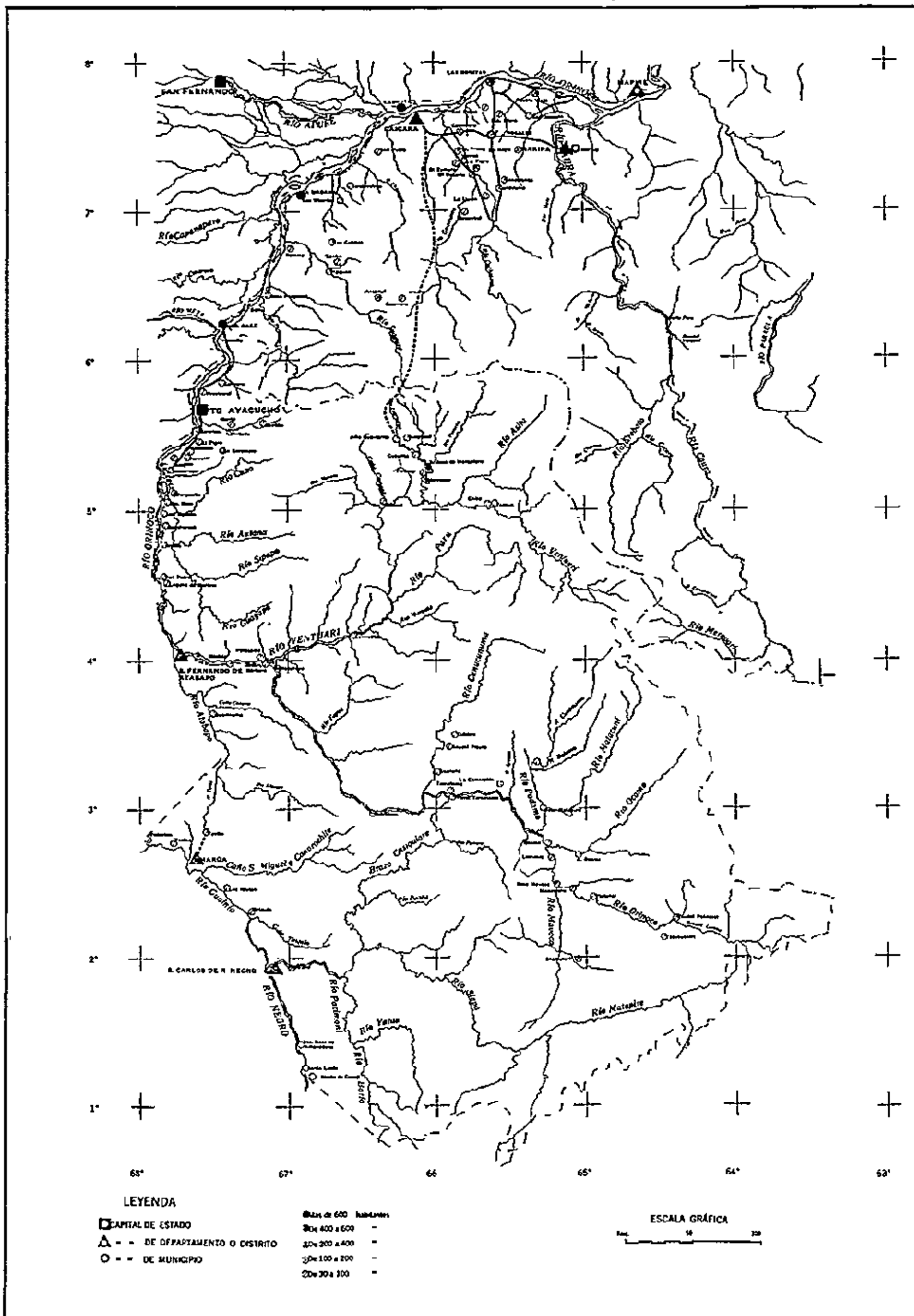
2.2.4 Basic Cartography

The cartographic material was composed of 1:100,000 scale maps. It was made employing a monocular restitution system (sketch-master) using the Black and White photographs of scale 1:50,000.

Using the satellite images, maps were elaborated at scale of 1:250,000 and 1:500,000.

The following sketch shows the coverage of the idfferent types of maps made.

4-REGIÓN DE ESTUDIO-CODESUR

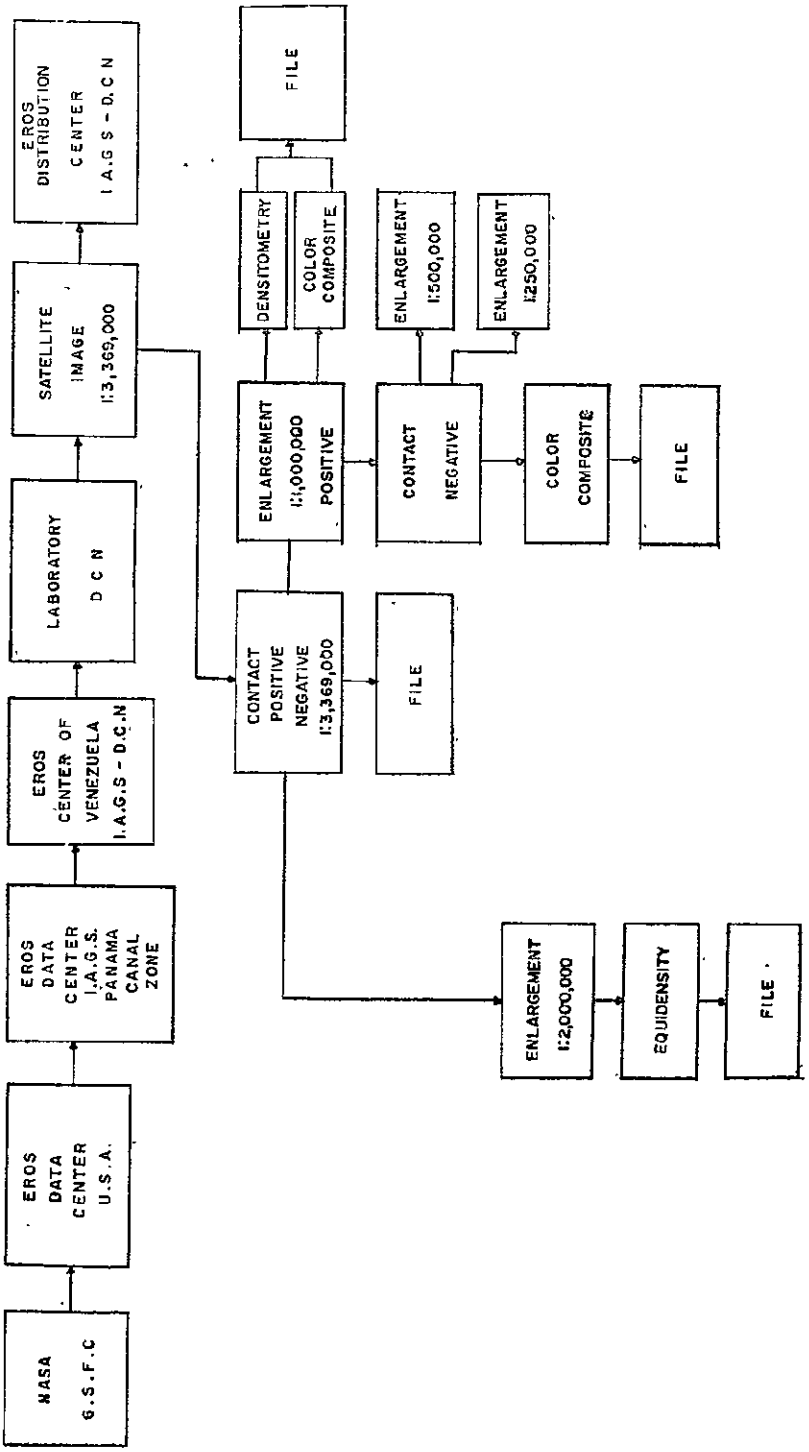


2.3. METHODOLOGY

As established in the proposal submitted to N.A.S.A., conventional systems have been applied in the first stage working program. Nevertheless, the training cycle of the professional and technical staff has permitted the application of non-conventional techniques in the study of natural resources.

Among the new techniques that should be mentioned are: Densitometry, color composites, and photographic equidensities.

The following flow diagrams show the steps followed during the application of each of the techniques.



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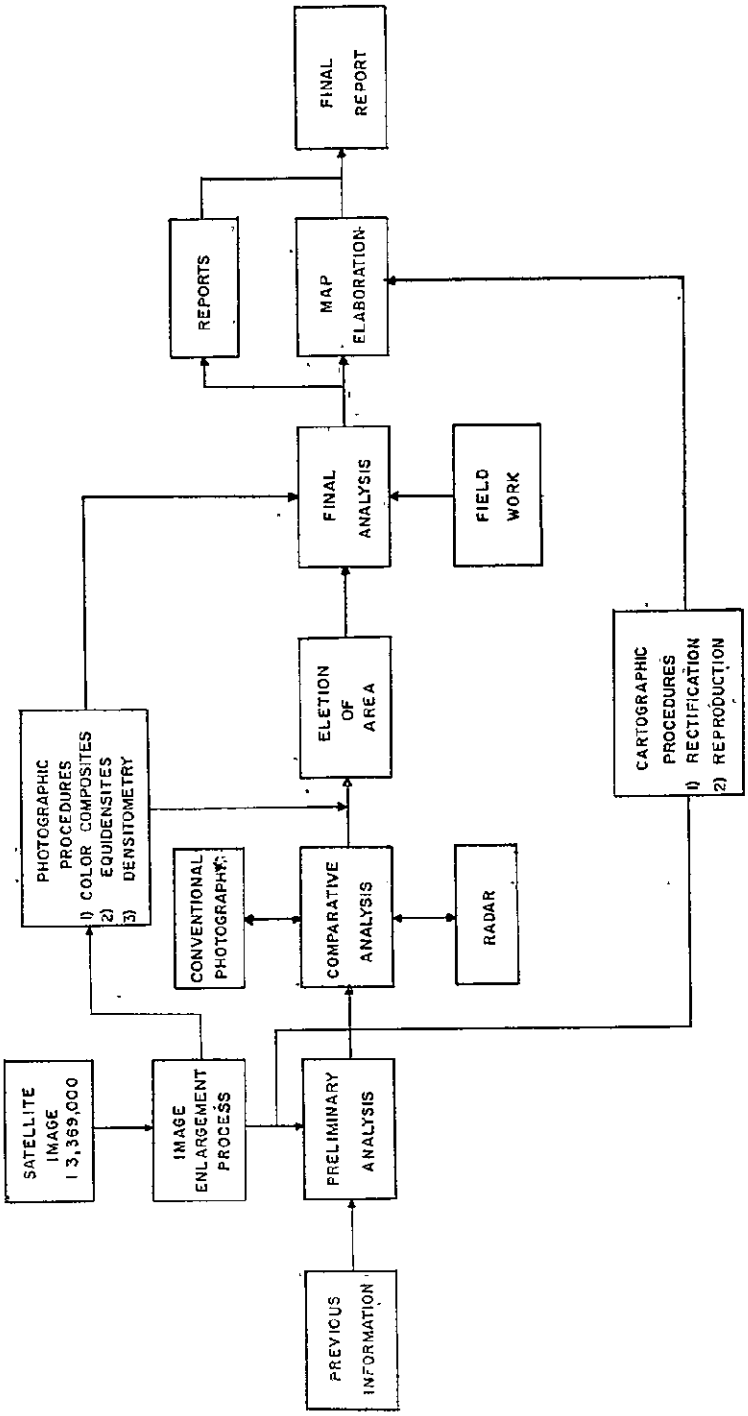
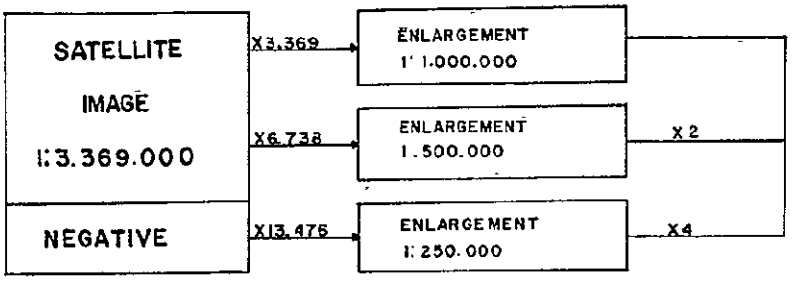
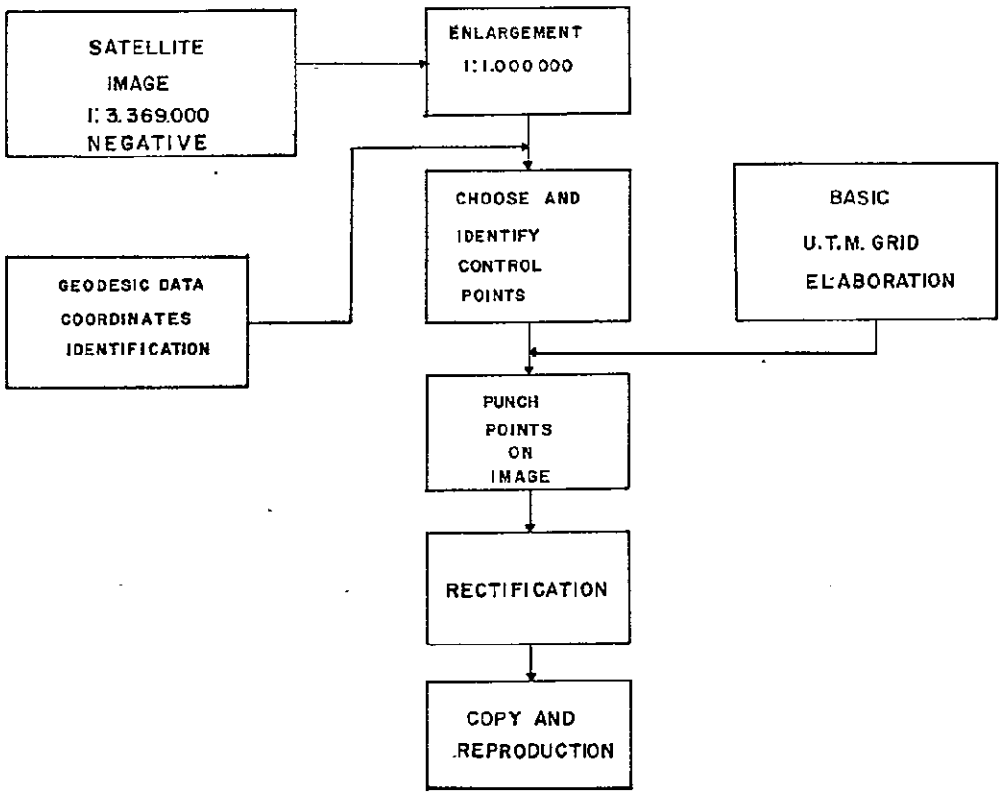


ENLARGEMENT
CROMEGA AMPLIFIER



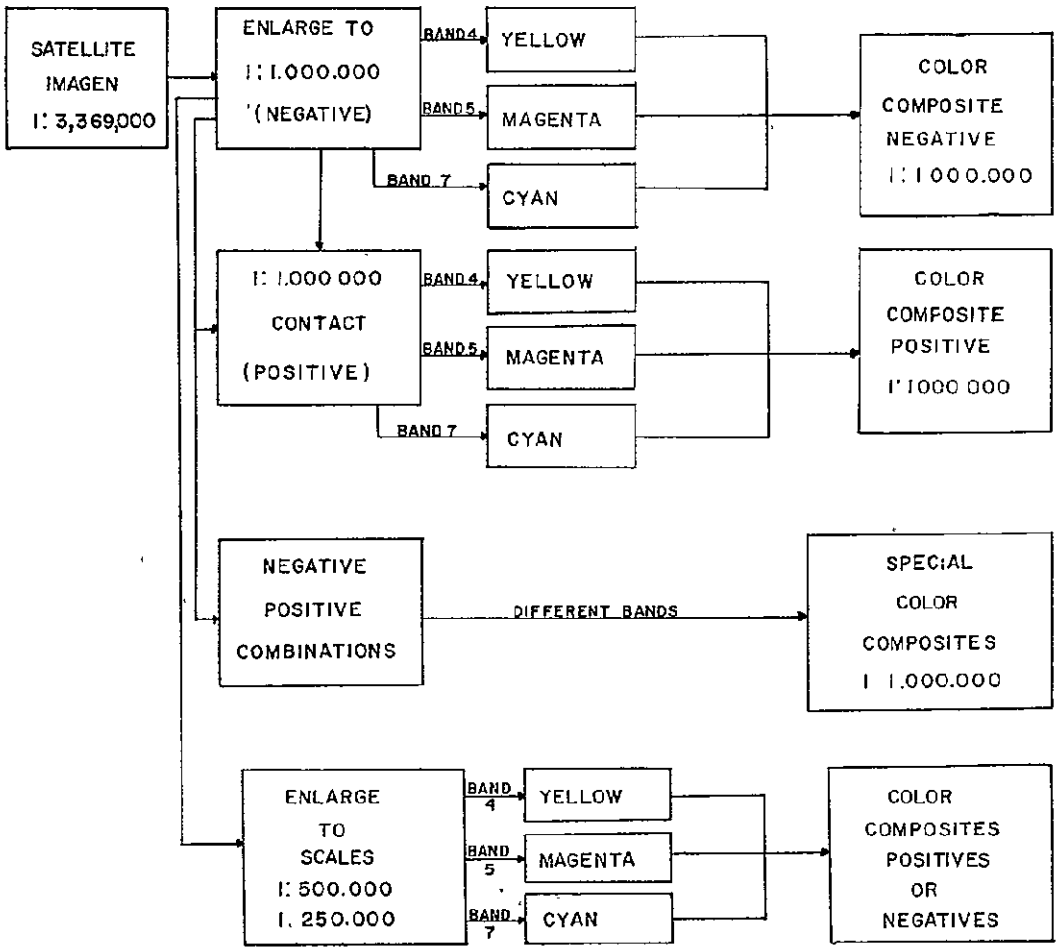
RECTIFICATION



COLOR COMPOSITE

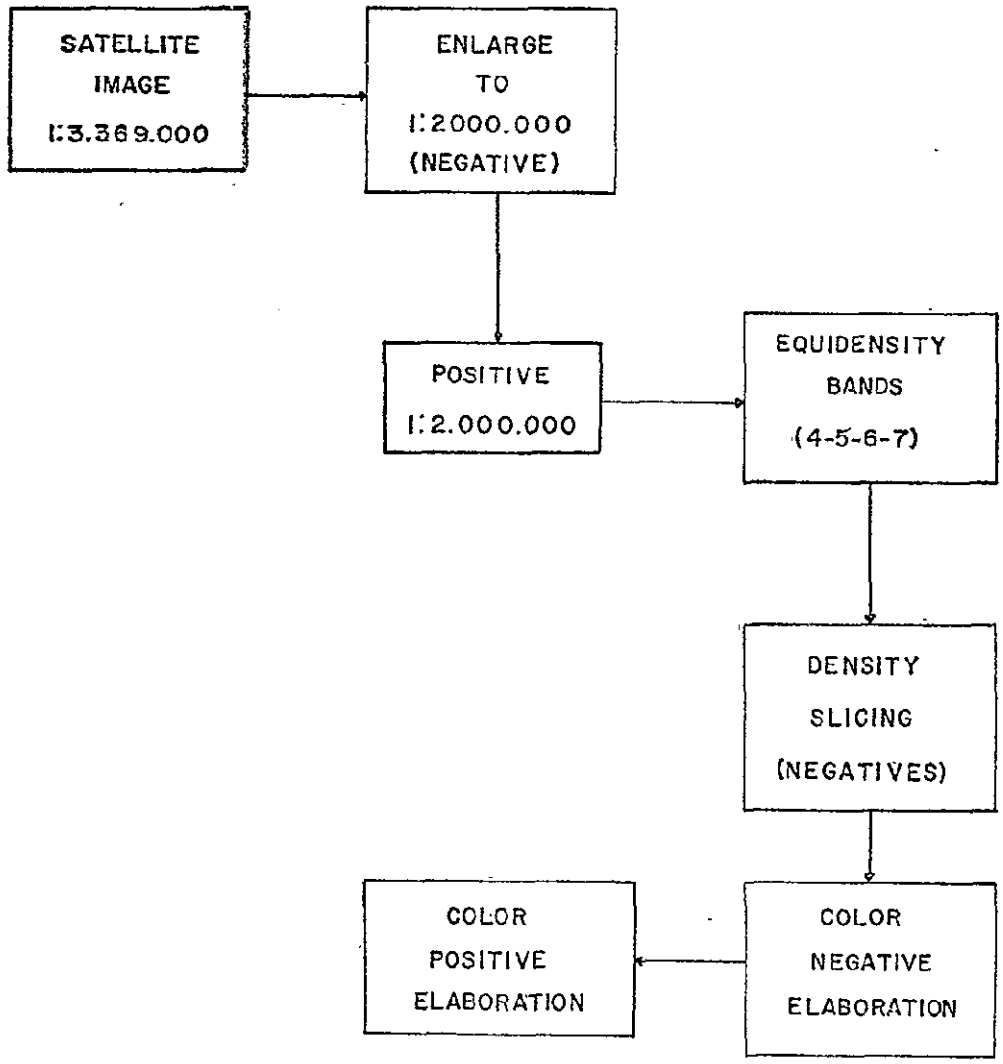
DYAZO SYSTEM

(SUBSTRACTIVE)



PHOTOGRAPHIC

EQUIDENSITIES



2.4. RESULTS

Although they are not definite, the following results show the possibilities of using Remote Sensing Techniques in the elaboration of reconnaissance and semi-detailed level investigations of Natural Resources.

The main goal of the ERTS-1 Proyect in the northern part of the Amazonas Territory was the evaluation of the information obtained using remote sensing data (satellite, radar and conventional photography), by comparing it, with the previously existing information.

In each of the sections of the report examples are included which clearly show the qualitative differences between the three types of information used.

GEOLOGY

Maps of 1:500,000 scale were elaborated covering different aspects of the study area showing the following: structure, lithological changes, regional drainage, alluvial areas and po-sible mineralization zones. Said maps were elaborated using radar imagery taken in the year 1971. The conventional photography was used as comparative material in the test areas.

After the reception of the ERTS-1 imagery, various maps were compiled based upon the data. As can be seen in the section on geology, the three basic types of information were compared as to: man/hours of work, surface coverage, time, costs and detail in order to evaluate separately the potential benefits which can be obtained from each form.

CARTOGRAPHY

A program was developed for the elaboration of semi-controlled photomaps with an acceptable precision for the scale, at scales of 1:500,000 and 1:1,000,000 for the entire area (80,000 Km^2). Planimetric and thematic information extracted from satellite images was added to these photomaps for later elaboration of thematic photomaps. Due to the quality of the trial photomaps, in spite of sufficient control, the area was increased towards the northern and western sectors, in which reliable cartographic information existed, because the possibility of producing excellent material was seen.

As to the Geodetic aspect supporting the cartographic program with radar and satellite imagery, the measurement of first order astronomic points were obtained using the doppler system.

FORESTRY

The Sipapo Forest Reserve was chosen as the study area because it was completely covered by conventional photography ( ) at scale of 1:50,000 and ERTS-1 imagery.

Using the conventional photography, vegetation maps at scales of 1:250,000 and 1:500,000 were made, at previous reconnaissance study levels.

Vegetation maps were also made using the satellite images.

In defined sectors of the reserve the conventional photography was used to check the quality of the interpretation of ERTS-1 images.

HIDROLOGY

The Ventuari River Basin and the Puerto Páez-Urbana sector of the Orinoco River were studied in different images in order to obtain a dynamic analysis of the hydrological aspects of the area. This was accomplished by comparison of the generated information of the interpretation with the data obtained from ground stations (climatic and hydrographic).

INTERPRETATION TECHNIQUES

Another important aspect was the one relating to the photographic interpretation techniques, the systems used were:

conventional interpretation and

non-conventional such as:

Color composites

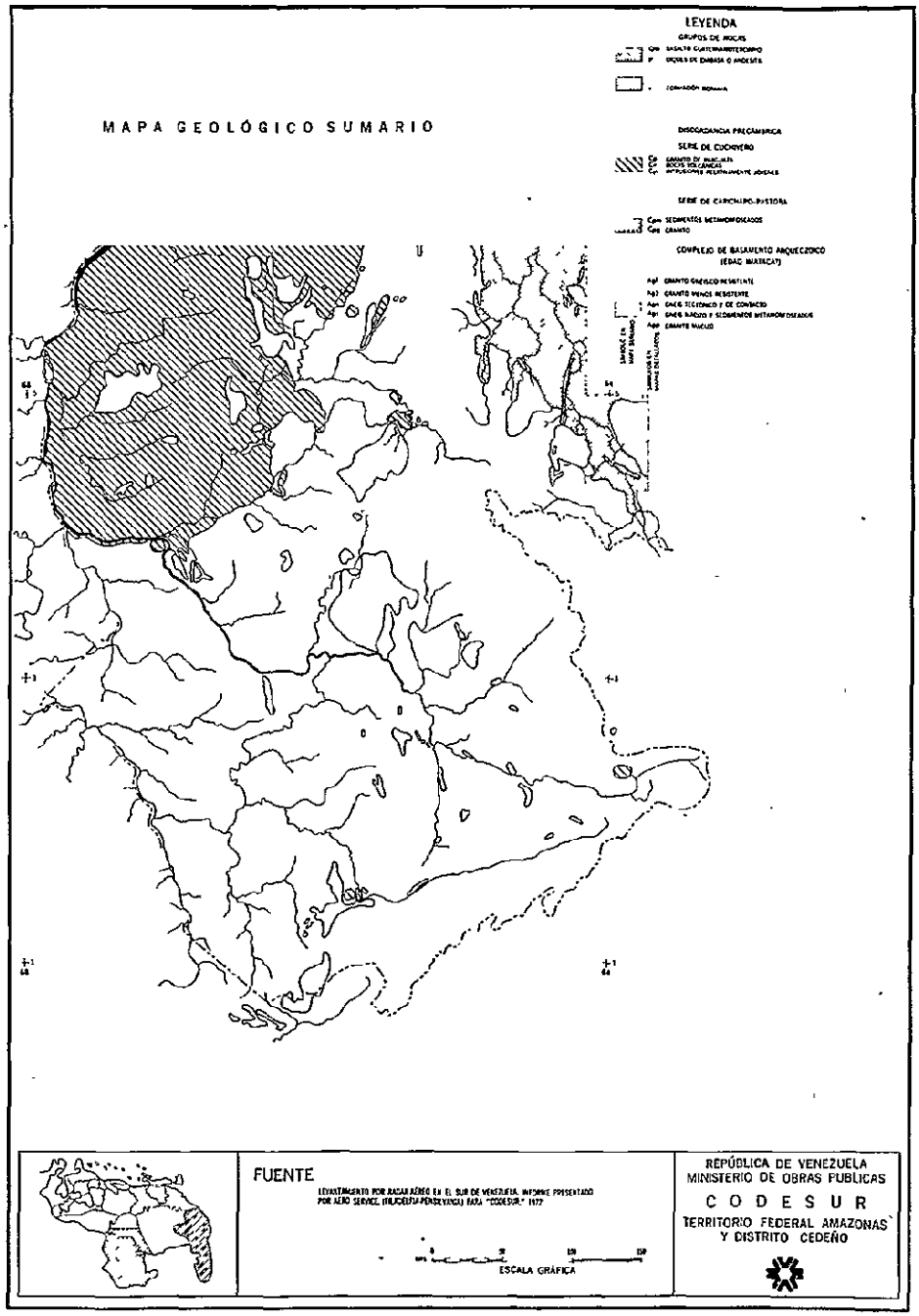
Densitometry

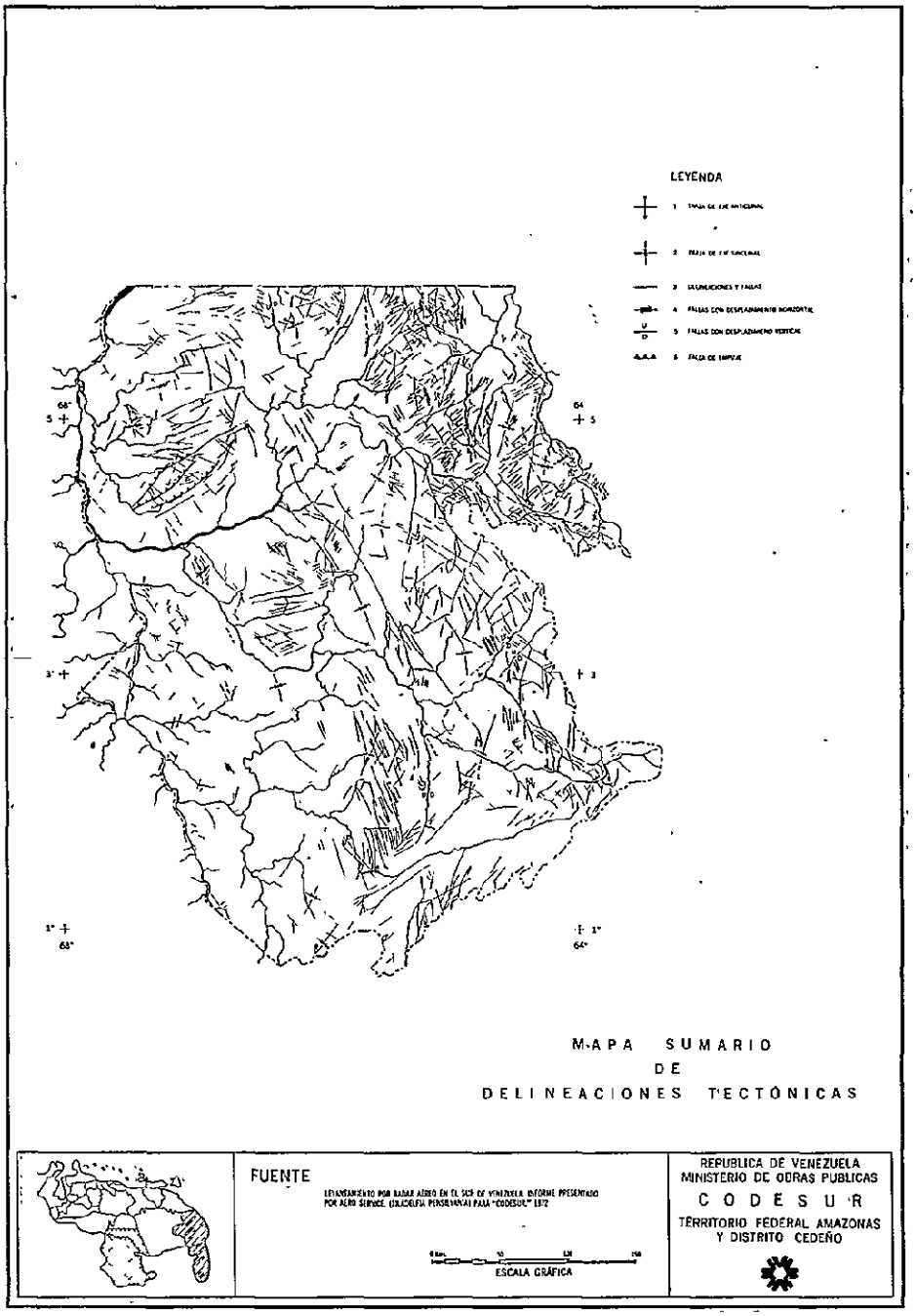
Equidensities

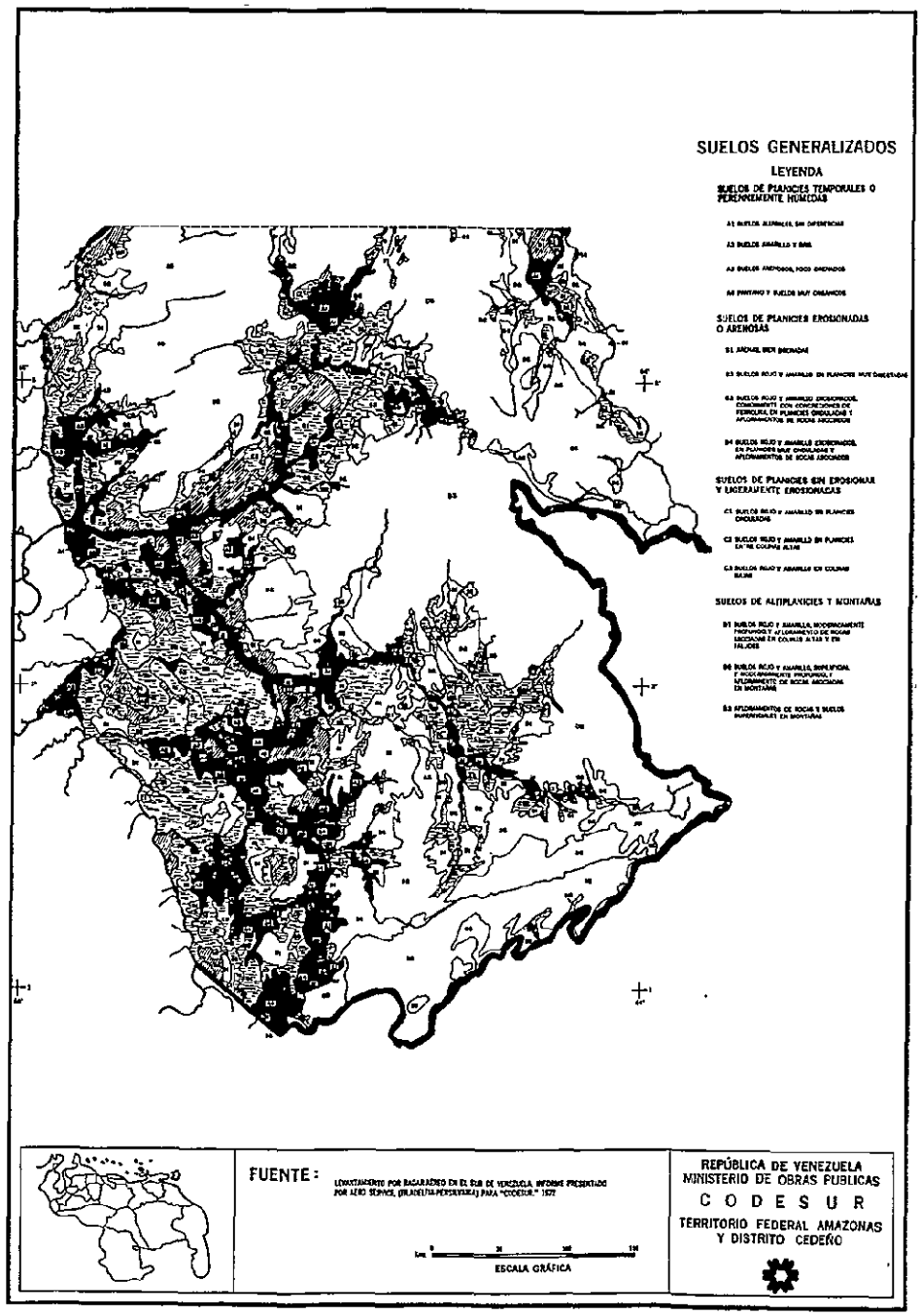
and Image Enhancement.

In the following maps the information obtained in the Radar and Satellite program can be compared with the previously existing information.

The following chapters deal with the use made of the satellite images.


MAPA GEOLÓGICO SUMARIO
LEYENDA
FUENTE
ESCALA GRÁFICA
REPÚBLICA DE VENEZUELA
MINISTERIO DE OBRAS PUBLICAS
C O D E S U R
TERRITORIO FEDERAL AMAZONAS
Y DISTRITO CEDEÑO




SUELOS GENERALIZADOS
LEYENDA
SUELOS DE PLANICIES TEMPORALES O PERENNEMENTE HUMEDAS
SUELOS DE PLANICIES EROSIONADAS O ARENOSAS
SUELOS DE PLANICIES SIN EROSIONAR Y LIGERAMENTE EROSIONADAS
SUELOS DE ALTIPLANICIES Y MONTAÑAS
FUENTE :
ESCALA GRÁFICA
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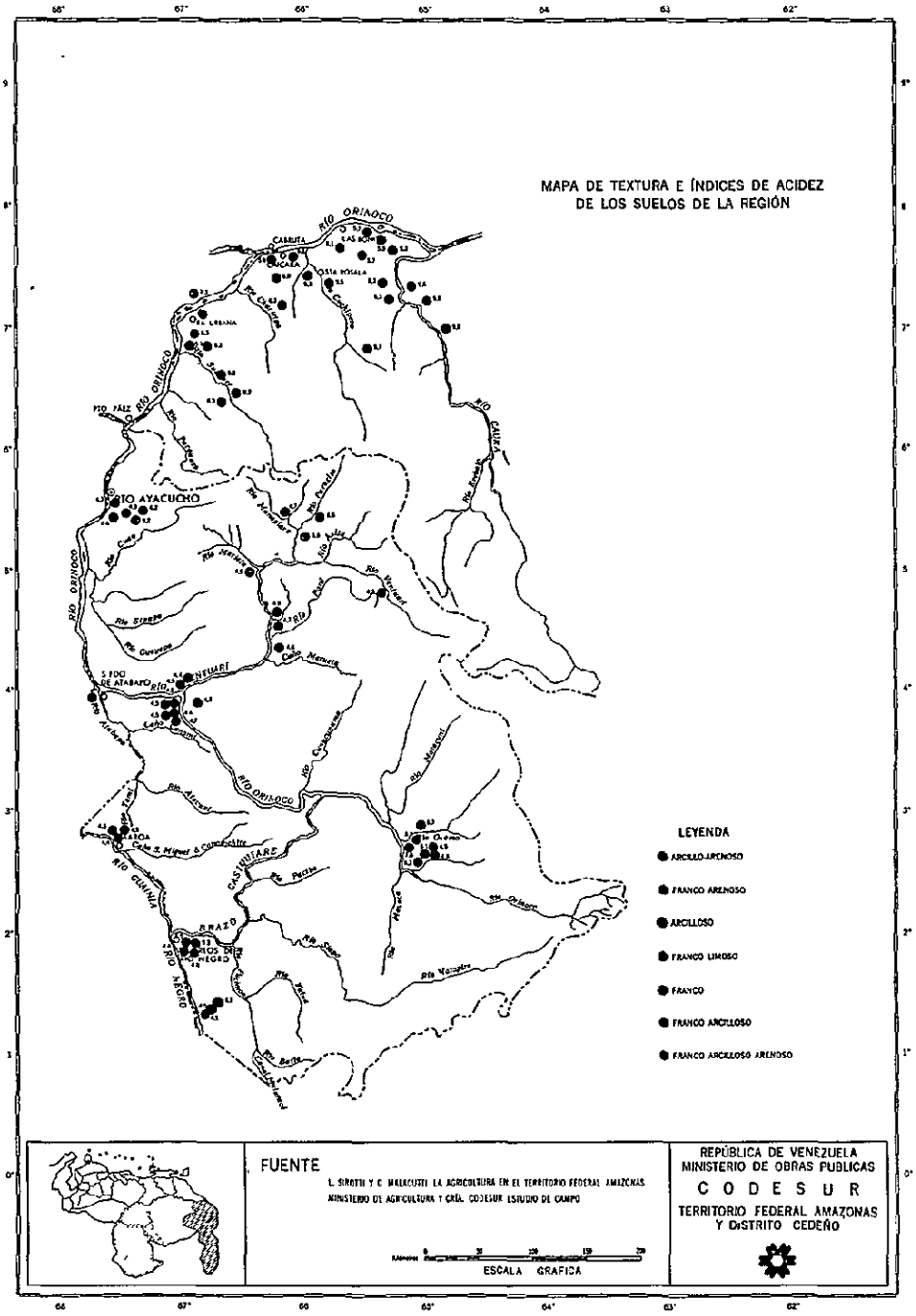
MINISTERIO DE OBRAS PUBLICAS
C O D E S U R
TERRITORIO FEDERAL AMAZONAS
Y DISTRITO CEDEÑO



MINISTRY OF MINE AND HYDROCARBONS

DIRECTORATE OF GEOLOGY

REMOTE SENSING DEPARTMENT

"DEVELOPMENT OF TECHNIQUES TO SIMPLIFY THE PROCESS OF INVESTIGATION AND ESTIMATE OF NATURAL RESOURCES IN REMOTE AND RELATIVELY UNEXPLORED AREAS" (VENEZUELA).

NUMBER SR - 0120

GEOLOGY

GEOLOGICAL AND STRUCTURAL INVESTIGATION OF A SECTION OF TERRITORIO FEDERAL AMAZONAS BETWEEN 4° TO 6° NORTH LATITUDE AND 65° TO 67° WEST LONGITUD.

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Geologist

Alfredo SABATER DELGADO
Photo-Geologist

INTRODUCTION

The present investigation is part of a general project being carried out by the Ministry of Mines and Hydrocarbons which aims at the interpretation of the entire Amazonas Federal Territory by Satellite images supplied by the National Agency of Space Administration (N.A.S.A.). The images in reference, N° 1174-14084 and 1174-14091 were taken by Satellite ERTS-1 on January 13, 1973.

Images corresponding to bands 6 and 7 were used because geological features showed up most clearly in these. The imagery was processed and supplied by the National Cartographic Directorate (Dirección de Cartografía Nacional); the name Parú-Duida was selected, after the most significant topographic features of the region in question.

It should be emphasized that during the work none of the other interpretations which were being carried out simultaneously were consulted. Therefore, the results of each have not been influenced by previous knowledge. The similarities in the final results thus demonstrates the efficiency of the applied methods.

3.1. PREVIOUS WORK

The only previous work available is a geological section along the Ventuari River, and the interpretation of radar images and conventional aerial photographs was carried out by specialists working for the Remote Sensors Department of the Ministry of Mines and Hydrocarbons.

3.2. OBJECTIVES OF THE PROJECT

The main purpose of this work is the evaluation and development of remote sensing techniques based on images supplied by Satellite ERTS-1 over relatively unexplored, mostly inaccessible areas, where little or no preliminary work in connection with prospecting of natural resources has been done.

Several disciplines directly related to earth resources were included in the project; the Ministry of Mines took charge of the investigation of the geology and mineral resources for purposes of choosing priority areas where preliminary field work is to be done.

The project applied conventional aerial photographs, radar and satellite images. Qualitative and quantitative analysis were done for purposes of comparing the advantages and limitations of these types of sensors.

The original project area presented to N.A.S.A. is located between 4°00-6°00 N latitude and 65°00-67°00 W longitude and covers aproximately 72.600 Km^2 in the northern part of the Amazonas Federal Territory (see Fig. 1, Location Map).

3.3. INTERPRETATION METHODS AND CHRONOLOGY

3.3.1. Drainage

Even very small streams can be clearly recognized on Satellite images, although resolution (MSS) of ERTS-1 is approximately 80 meters.

3.3.2. Tonal and textural differences (tonal-textural map)

The tonal map was drafted with the aim of obtaining a series of areas which show the same tonal values, to be grouped as a whole representing average textures, tones, apparent relief and structural features. The boundaries of these new groups were checked and analysed by means of magnifying lenses (4X) for detecting the image's physical characters corresponding to units having similar shapes and textures, which are functions of the rock type.

3.3.3. Structural interpretation

The ERTS-1 Satellite images cover 64.800 Km^2 and allow a quick synoptic view of the structural framework. This relates very well with the dominant drainage pattern; if no structural alignments are found in the existing outcrops, they may be inferred by means of the stream beds which follow an established structural model. Two main fault systems are recognizable: one is clearly marked, trending NE, and the other consists of several important faults trending mainly NW almost normal to the former. Several faults were identified in the first system; the largest was named the El Parú Fault and separates post-Roraima granitic units from the remaining pre-Roraima units; this is one of the oldest faults in the

The remaining NE-trending faults are less important.

The secondary system trending mainly NW, consists of several large faults, such as the Duida, San Juan de Manapiare and Ventuari River faults. The oldest of these is thought to be the El Duida fault which displaces the Parú fault at the confluence of the Parú and Ventuari rivers; the system is offset by minor transverse faults.

Other minor fracture systems and alignments do not show a definite distribution or trend.

3.3.4. Tonal and textural identification

Careful study of the different tones and textures of the images shows up differences which permit the determination of rock types, since these different tones and textures correlate directly with the physical characteristics of the rocks.

3.3.5. Identification of geological units

Eleven major units were recognized which include secondary groups. The observed tonal differences are probably due to the different degrees of weathering which characterize rocks exposed in the Venezuelan Guayana Shield. These eleven major units have been regrouped according to rock types: (1) Alluvium, (2) Volcanic rocks, (3) and (4) Granitic igneous rocks, (5) Roraima unit. (6), (7), (8), (9), (10) and (11) Igneous-metamorphic basement. These have been correlated with similar formations exposed in the eastern portion of the Guayana Shield (some 500 Km distant), where radiometric age determinations range as follows: 1.500 - 2.100 m.y. (Rb/Sr); (McDOUGAL et al., 1969); 1.600 - 2.100 m.y. (MARTIN-BELLIZZIA, 1969); 1.500 - 1.700 m.y. (Rb/Sr). Based on these correlations the following classification is

suggested:

Units	(1), (2), (3) and (4):	Post-Roraima
Unit	(5):	Roraima
Units	(6), (7), (8), (9), (10) and (11):	Pre- Roraima

3.4. DESCRIPTION OF THE UNITS:

This is based on features observed in the images and used in classifying the geological units:

3.4.1. Alluvium

Located along the main rivers, shows uniform tone and texture.

3.4.2. Volcanic rocks

Fine-textured, elongated mountain forms and shows differential resistance to erosion.

3.4.3. Granitic Igneous Rocks

This unit is exposed mainly west of the Ventuari River Bed and is medium-textured. This probably intrusive rock stands out from the other surrounding units due to its textural features.

3.4.4. Granitic Igneous Rocks

This unit shows medium texture, advanced differential erosion and crops out mainly west of the Ventuari River.

3.4.5. Roraima Unit

This is very well defined by texture, morphology and relief characteristics. It forms plateaus at different levels, three of which have been defined. The beds exposed on the tops of these hills or "TEPUIS" dip towards the center with very low angles forming very gentle synclines. The

unit shows different types of joints whose magnitude and direction depend on their position within the stratigraphic section. Lithology: The unit consists of a series of Quartz conglomerates, mixed conglomerates, Quartzitic feldspathic rose colored sandstone, with very dense, quartzitic sandstones, red shales, and jasper, interbed-bed with the arenaceous section. BELLIZZIA considered the green and red jasper horizon as metamorphosed mudstones, and AGUERREVERE and ZULOAGA (1939), as metamorphosed volcanic ashes, this leads to assume a longer period for the volcanic cycle of the Pastora Group which underlies this formation. In the Gran Sabana Region, the section has been intruded large diabase masses in the form of silis and dykes. (BELLIZZIA, 1957); the age of these intrusion has been established as 1.800 m.y.. (More recently (1972) known as the Roraima Group). Thick (over 3000m) extensive, geomorphologically characteristic ("Mesas or Tepuis"), Early Proterozoic (± 1.800 m.y.) sedimentary sequence representing the final Precambrian deposition in the Venezuelan Guayana Shield (Gran Sabana area): basal fluvial conglomerates and sandstones (Uairén Fm) overlying weathered eroded volcanic surface; followed by fissile shale - (Kukenán Fm), cherts, siltstones and red arkose (Uaimapue) and sandstones (Mataui Fm); abundant quartz veins; diabase siliceous intrusions at different levels and periods (1500-1650 and 1750 m.y.).

3.4.6. Igneous-metamorphic basement (general features)

All the units show different textures, tones, fractures and alignments which were carefully analysed and integrated into a group with the characteristics of the igneous-metamorphic basement. Six (6) geological units were separated.

3.4.7. Granitic unit

This unit is exposed mainly south and west of the Ventuari River and shows different textures and tones although the fine texture is dominant; some alignments are also visible. Medium-textured zones are also distinguished which probably indicate different degrees of weathering.

3.4.8. Granitic unit

This is exposed in the northern and central portion of the area covered by the images. Part of the unit is fractured and faulted, especially at the contact zone with the Roraima unit west of Cerro Parú. Two faults: E-W and NE, and minor alignments are visible. The difference in the faulted and fractured zones may be due to the physical composition of this type of rock.

3.4.9. Granitic unit

This unit crops out in the central and southern part of the area covered by Image southeast of the Ventuari River. Texture and tones are quite uniform, excepting a small sector in the southwestern part of the area. The unit shows definite fractures, and NE-trending transverse faulting.

3.4.10. Granitic unit

Appears northeast of Cerro Parú and stands out due to its coarse texture and sharp relief, which leads to infer that the rocks are very resistant.

3.4.11. Gneiss-granitic unit

This unit shows a good generally N-S orientation and an E-W structural alignment; very well defined joint systems form rectangular patterns; longitudinal N-S trending faults are also present. The observed texture has

been classified as medium to coarse.

3.4.12. Gneiss-granitic unit

This igneous-metamorphic unit included within the basement is well defined, with features trending mainly NE, very fractured and jointed and crossed by several faults; the principal faults are the Ventuari and another large curved fault striking NW-N. The texture varies from fine to coarse depending on the composition and degree of weathering of the unit.

3.5. CONCLUSIONS

From the analysis of the different methods (black-and-white aerial photographs, radar and satellite images) the following conclusions may be reached:

3.5.1. Conventional air photographs

This type of sensor allows the analysis of important variables. None of the conventional analytical criteria is strictly geological, since the interpretation of the geology is based on different features of the earth's surface which are reproduced with certain characteristics on aerial photographs (topographic, geomorphological, tone and textural features). For the specific work done in this area, concentional photographs have the problems and limitations inherent to the method, such as: dependence on good atmospheric and climatic conditions, variable illumination and the large volume of material which makes the interpretation and compilation of data and results a laborious process envolving numerous specialists in order to complete the process within a given period thus leading to higher costs.

3.5.2. Side-looking airbone radar images

Radar images permit the study of areas where climatic conditions

restrict the use of conventional airphotographs. Geological structures show up very clearly, as well as minor structural patterns, thus allowing detailed structural analysis of structures and fault systems and the detection of conditions probably favorable to mineral accumulation. Radar images supply not only a first approximation for the selection of prospective zones, but also specific priority areas in the planing of field work.

3.5.3. Satellite Images

The study of these images evidences their applicability to extensive exploration projects in which a preliminary evaluation of mineral resources is aimed at under restricted economic and time conditions.

In the geological aspect these images have been used for the preliminary synoptic interpretation of vast areas where no information was available, owing to their capacity of covering 32.400 Km^2 at a time.

It is possible to study relations between shapes and textures, which are basic interpretative criteria in these images, and thus detect shear and fracture zones, fault intersections, fault systems and igneous structures.

3.6. RECOMMENDATIONS

After exhaustive analysis of the described methods, the conclusion was reached that extensive exploratory programs difficult to carry out by conventional methods require the maximum possible application of all three methods; the selection of techniques to be applied in specific problems will depend on the characteristics, specifications, physical conditions of the area and objectives of the project.

3.7. FINAL RESULTS

Upon completion of the investigations and analysis of the imagery that covers the area of the Amazon Project "VEN 002", the Direction of Geology of the Ministry of Mines and Hydrocarbons began the instrumentation of an Airborne Geophysical Investigation.

Based upon the results obtained by both interpretations, "Radar and Satellite", highly fractured zones were outlined and checked against geologic rock samples. These were collected during the Radar Project, to be used as ground truth. Most of these rock samples were collected along the Ventuari River that crosses most of the Project Area from NE to SE. The Radar Geologic Interpretation and Fracture Analysis were the basic information used to contract the Airborne Magnetic and Madiometric flight of the area.

The structural orientation and fracture patterns were taken into consideration during the planning of flight lines, also the magnetic declination of the area. Most of the flight lines were oriented N 30° W across known structural trends; the altitude above ground was 450 feet, and the distance between lines was 3000 feet. All airborne data was analytical and digitally registered.

The Fig. 14 shows the results, utilizing these two methodologies, and also indicates the exact location of some of the major anomalies, both Magnetic and Radiometric.

Following the first phase of the program, a second phase is being carried out, starting with geochemical work and following with a drilling program towards the vicinity of Cerro Impacto, N 5° 55' North latitude, and 65° 13' longitud West of Greenwich.

An attempt is being made to evaluate some of these anomalies in the field for their economic potentials. Mainly there are two types of anomalies: basic metals and radiometric metals.

Types of Airborne Equipment used:

(1) Spectrometer NE 8424 MK - 15 (Nuclear Interprise)

(2) Digital Serial Magnetometer GVLF MK III

(3) Ground Magnetometer Gulf Fluxgate.

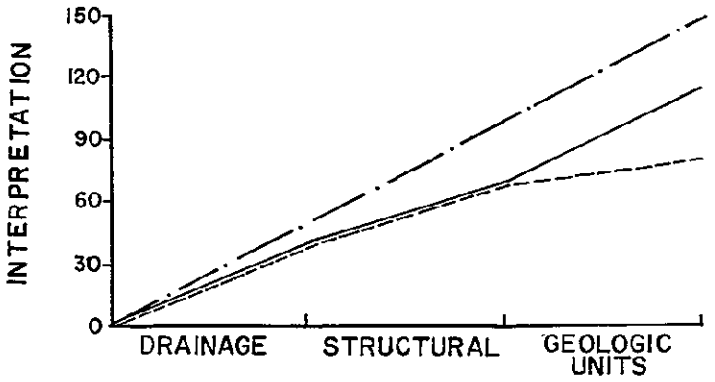
(4) Radio Altimeter (Radar) STR 54 B

(5) Photographic Camera VINTEN MK-2

(6) Navegation System Doppler MANONI AD-560

COMPARATIVE ANALYSIS OF THE INTERPRETATION

	DRAINAGE			STRUCTURAL			GEOLOGIC UNITS			TOTAL
	E	G	F	E	G	F	E	G	F	
RADAR	0			0			0			150
SATELLITE		0			0		0			116
AERIAL PHOTOS		0			0				0	82



EXCELLENT 33-50

GOOD 16 - 33

FAIR 0 - 16

SYMBOLS

RADAR

SATELLITE

AERIAL PHOTOS

FIG. 1

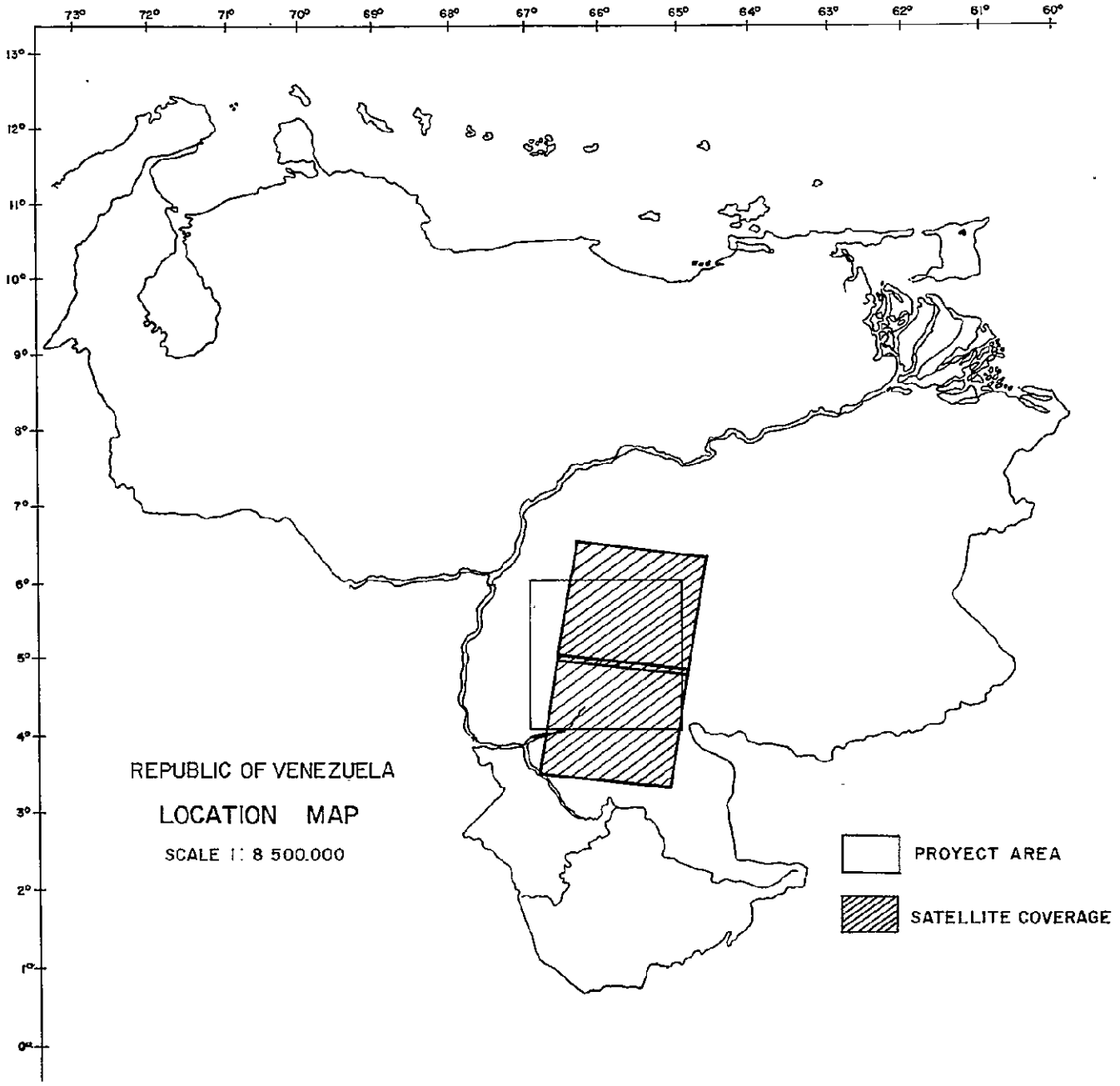
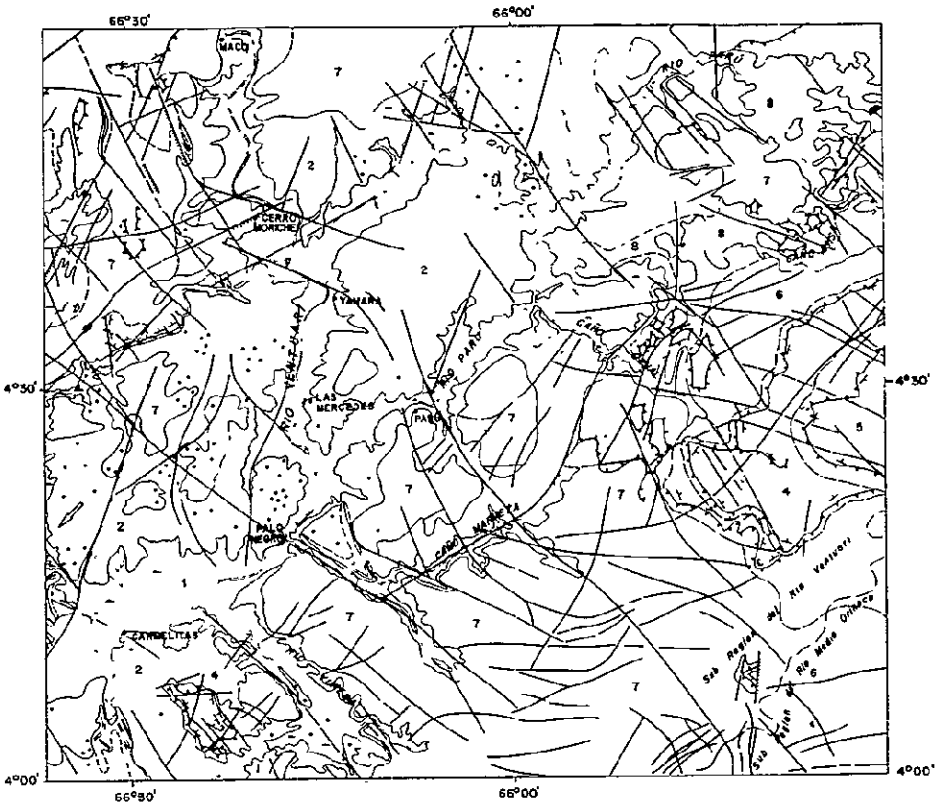

73°
72°
71°
70°
69°
68°
67°
66°
65°
64°
63°
62°
61°
60°
13°
12°
11°
10°
9°
8°
7°
6°
5°
4°
3°
2°
1°
0°
REPUBLIC OF VENEZUELA
LOCATION MAP
SCALE 1: 8 500.000
PROYECT AREA
SATELLITE COVERAGE

FIGURE 2

STRUCTURAL GEOLOGY INTERPRETATION
USING CONVENTIONAL PHOTOGRAPHY



LEGEND

0 50 100 KM.

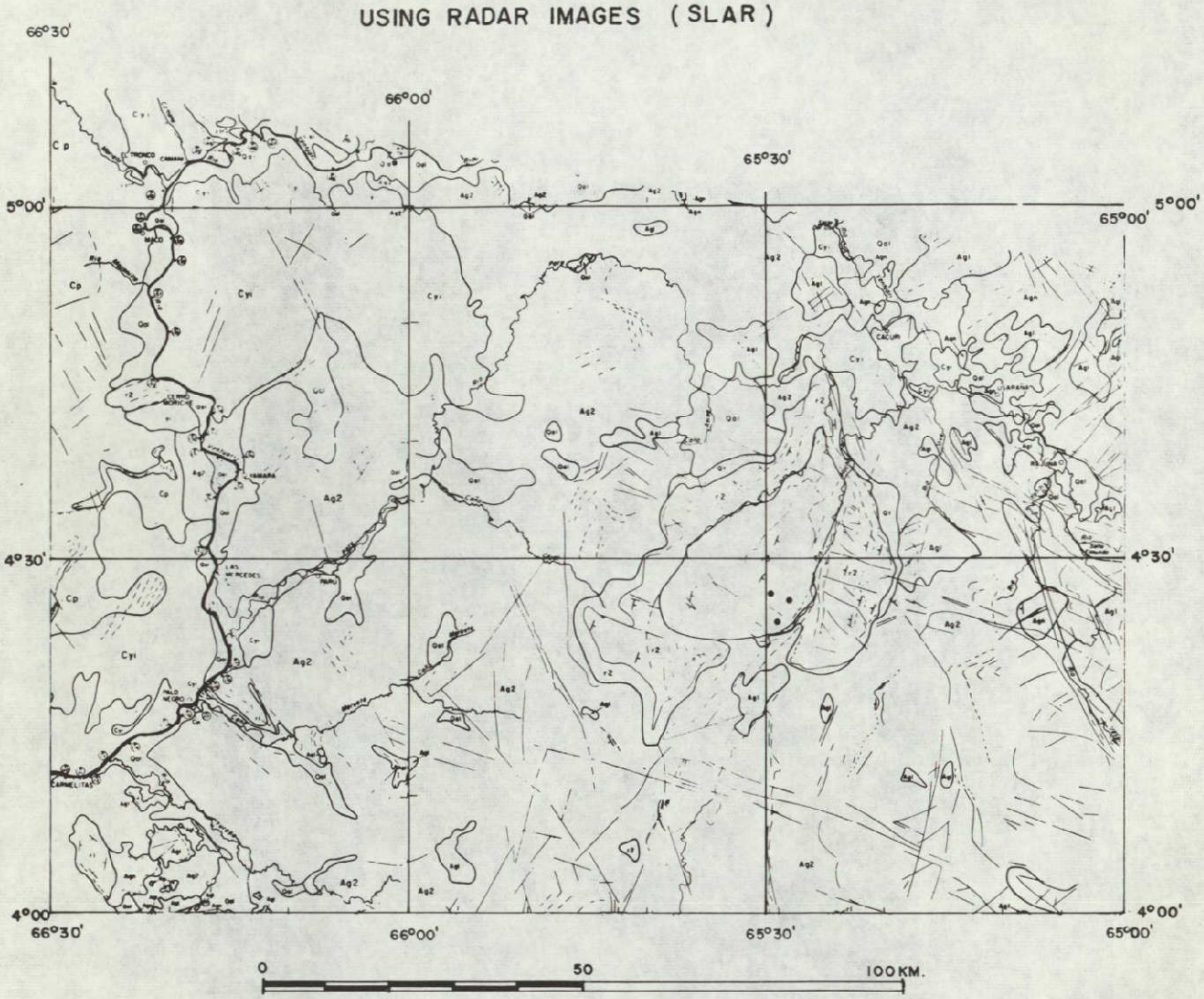
1 ALLUVIUM	PHOTO LINEATIONS
2 QUARZITIC SAND-STONE	SHEARS
3 SAND-STONE	FAULTS
4 INTERMEDIATE, SAND-STONE	EDGE OF RELIEF
5 LOWER, SAND-STONE	MONOCLINES STRUCTORES
6 BASAL, SAND-STONE	VERTICAL DIRECTION OF TECTONIC INCLINATION
7 CRISTALLINE BASEMENT GRANITES AND GNEISSES	SWAMPS
8 CRISTALLINE BASEMENT GRANITE GNEISS	INSELBERGS AND TORS GRANITICS

RADAR MOSAIC
PROJECT VEN-02
ERTS-1

SCALE: 1:2000.000

FIG.3

STRUCTURAL GEOLOGY INTERPRETATION USING RADAR IMAGES (SLAR)



LEGEND

- Qal — QUATERNARY-ALLUVIUM AND COLLUVIUM
- Qt — QUATERNARY TALUS
- r1 — RORAIMA Fm
- r2 — RORAIMA Fm
- r3 — RORAIMA Fm

CUCHIVERO SERIES

- Cy1 — YOUNGER INTRUSIVES
- Cp — PARGUAZA GRANITE

SAMPLE SITE

CARICHAPO PASTORA SERIES

- CPm — METAMORPHIC SEDIMENTS
- CPg — GRANITE

ARQUEAN BASAL COMPLEY

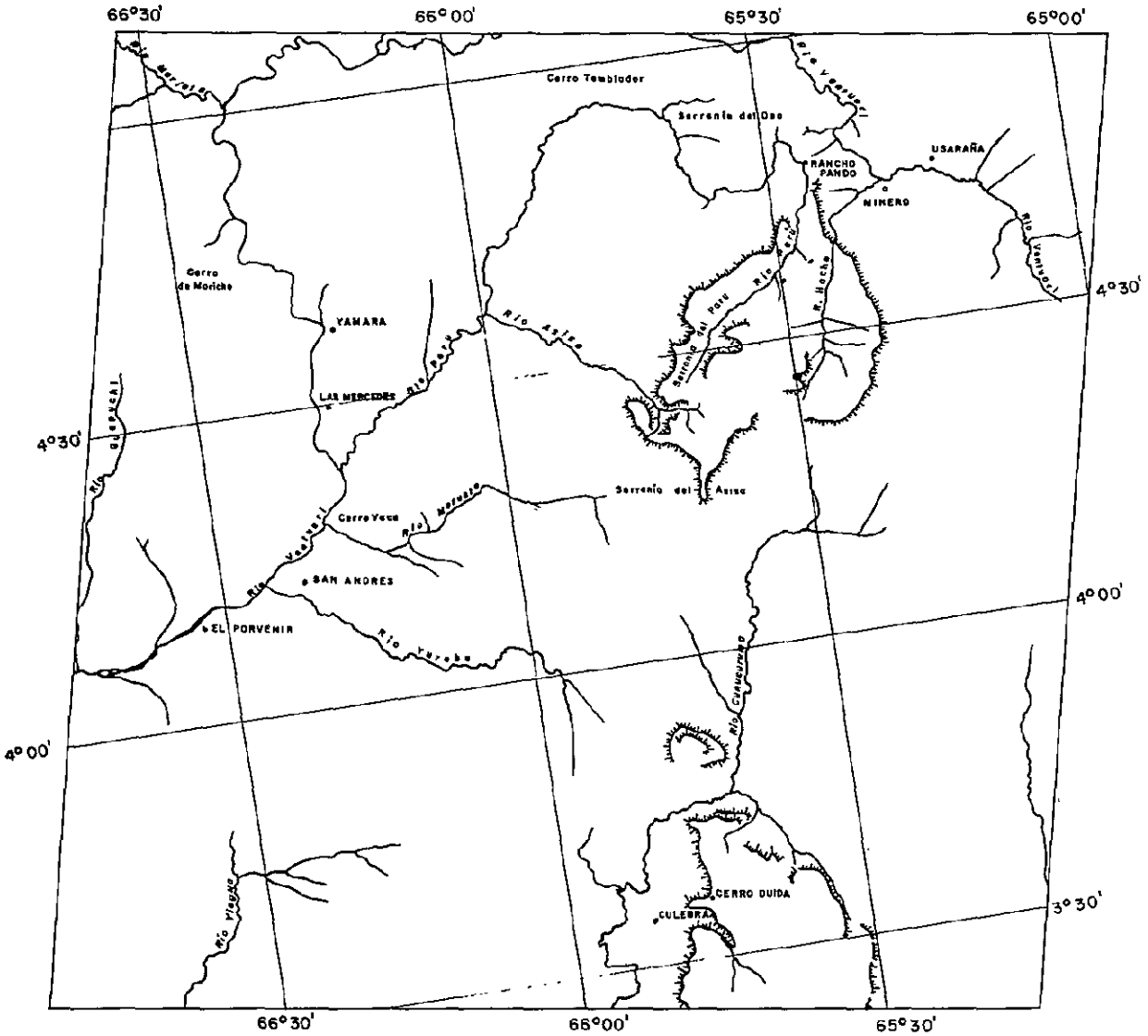
- AG 1 — GRANITE GNEISS (RESISTENT)
- AG 2 — GRANITE (NON RESISTENT)
- AG 3 — CONTACT GNEISS

- ANTICLINE AXIS
- SYNCLINE AXIS
- ANTICLINE OVERTURNED
- SYNCLINE OVERTURNED
- STRIKE AND DIP OF BEDDING
- STRIKE AND DIP OF FOLIATION
- FRACTURE FAULT
- STRUCTURAL LINEAMENT

FIG.4

MINISTERY OF MINES AND HYDROCARBONS
DIRECTORATE OF GEOLOGY
DIVITION OF GEOLOGIC EXPLORATION
REMOTE SENSING DEPARTAMENT

ERTS RESOURCES TECNOLOGY SATELLITE
(ERTS. NASA)



PARU-DUIDA AREA

DATE OF IMAGE JAN-13-1973 E-1174-14091PC N-04-13/W065-49M.S.S..
DRAINAGE AND TOPOGRAPHY INTERPRETATION

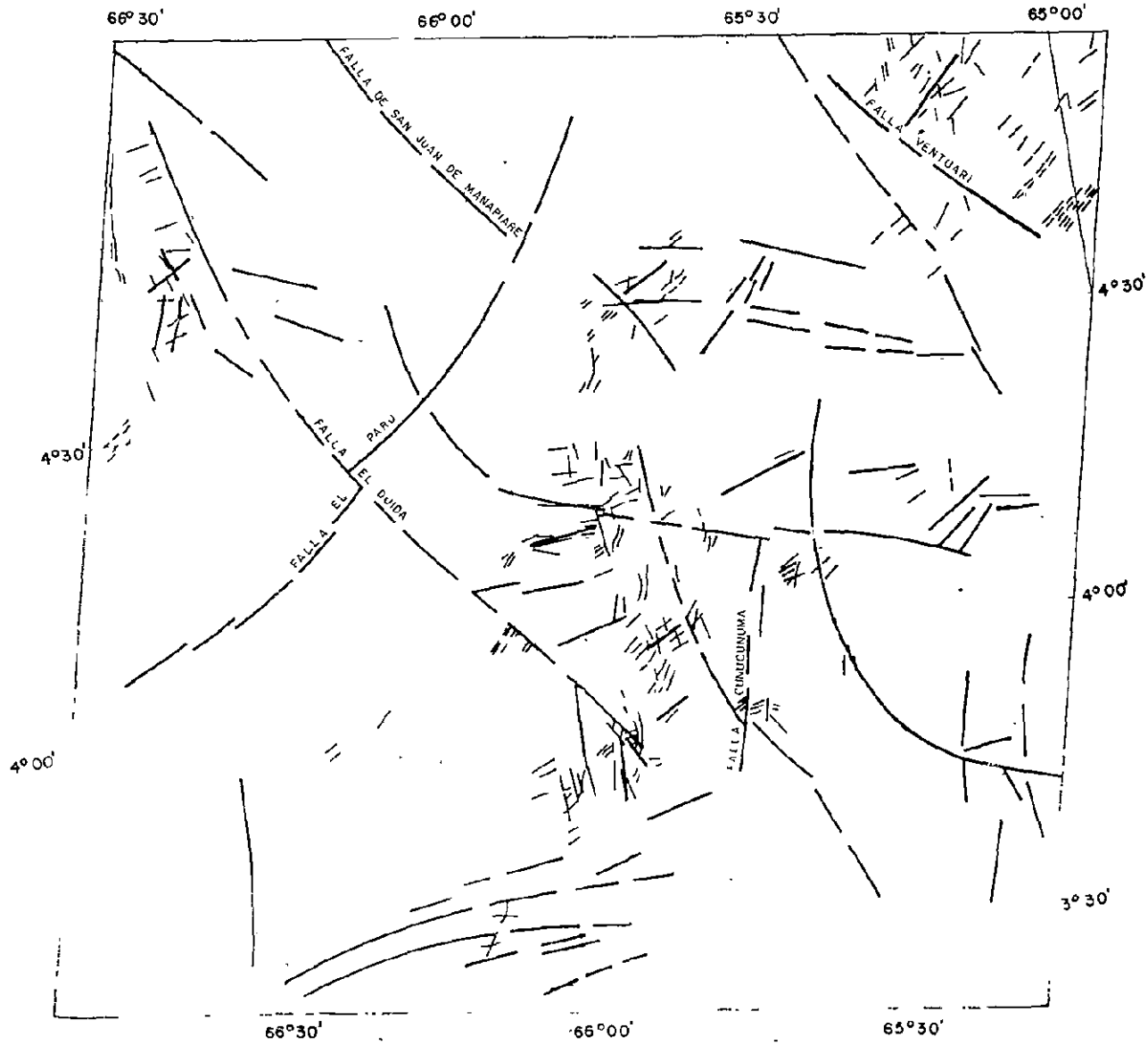
0 50 100KM

1	ALLUVIUM	5	RORAIMA UNIT	9	IGNEOUS ROCK
2	VOLCANICS	6	IGNEOUS ROCK	10	IGNEOUS METAMORPHIC BASEMENT.
3	IGNEOUS ROCKS GRANITIC	7	IGNEOUS ROCK	11	IGNEOUS METAMORPHIC BASEMENT.
4	IGNEOUS ROCKS GRANITIC	8	IGNEOUS ROCK		

FIG. 5

MINISTRY OF MINES AND HIDROCARBONS
DIRECTORATE OF GEOLOGY
DIVITION OF GEOLOGIC EXPLORATION
REMOTE SENSING DEPARTAMENT

ERTS RESOURCES TECNOLOGY SATELLITE
(ERTS. NASA)



PARU - DUIDA AREA
DATE OF IMAGE JAN-13-1973 E 1174-14091PC N-04-13/W065-4
STRUCTURAL GEOLOGY INTERPRETATION

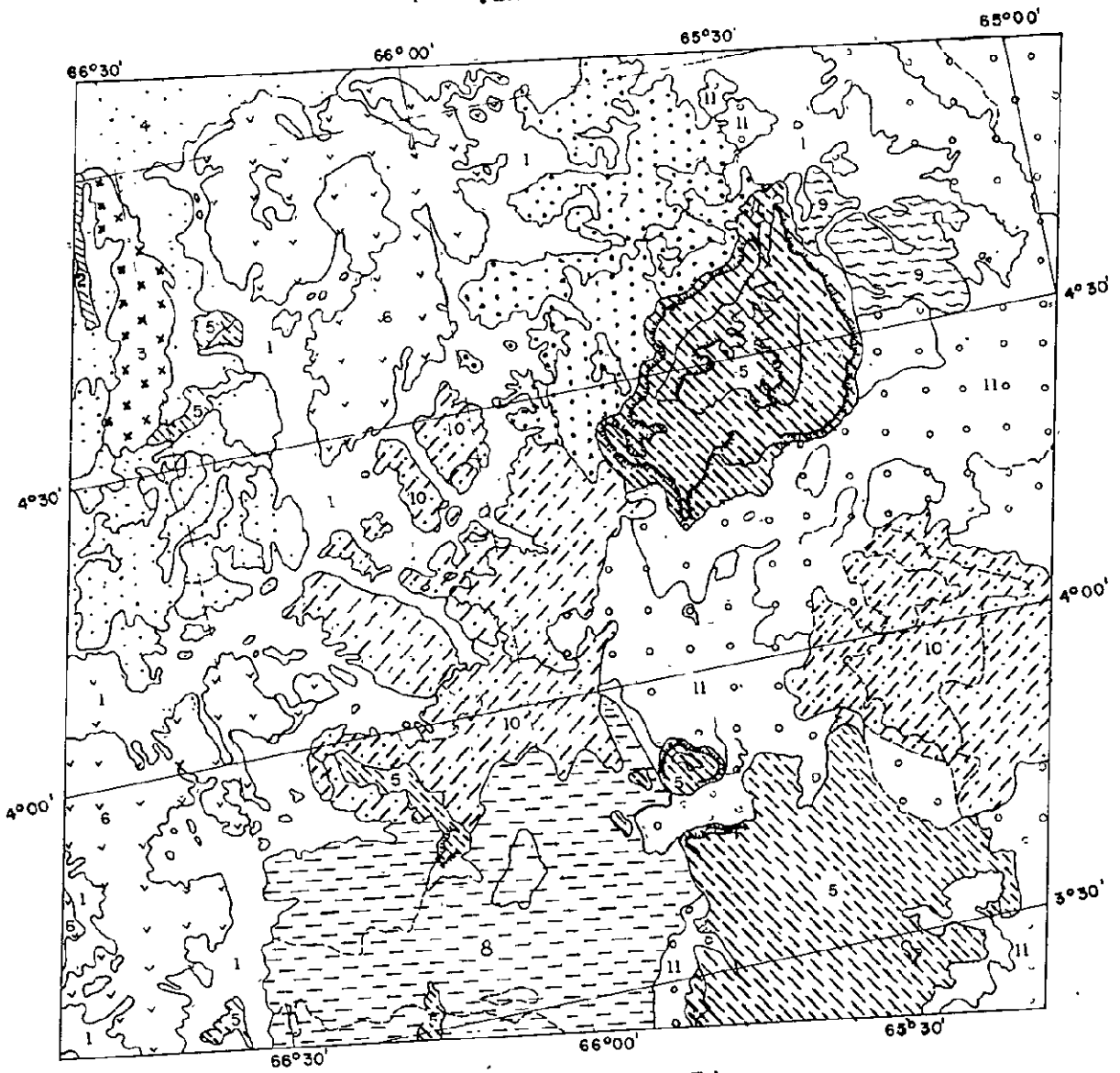
—— FAULTS
=== FRACTURES

0 50 100 KM.

FIG. 6

MINISTERY OF MINES AND HYDROCARBONS
DIRECTORATE OF GEOLOGY
DIVITION OF GEOLOGIC EXPLORATION
REMOTE SENSING DEPARTAMENT

ERTS RESOURCES TECNOLOGY SATELLITE
(ERTS. NASA)



PARU-DUIDA AREA

DATE OF IMAGE JAN-13-1973 E-1174-14091PC N-04-13/W065-49M S.S.
DRAINAGE AND TOPOGRAPHY INTERPRETATION

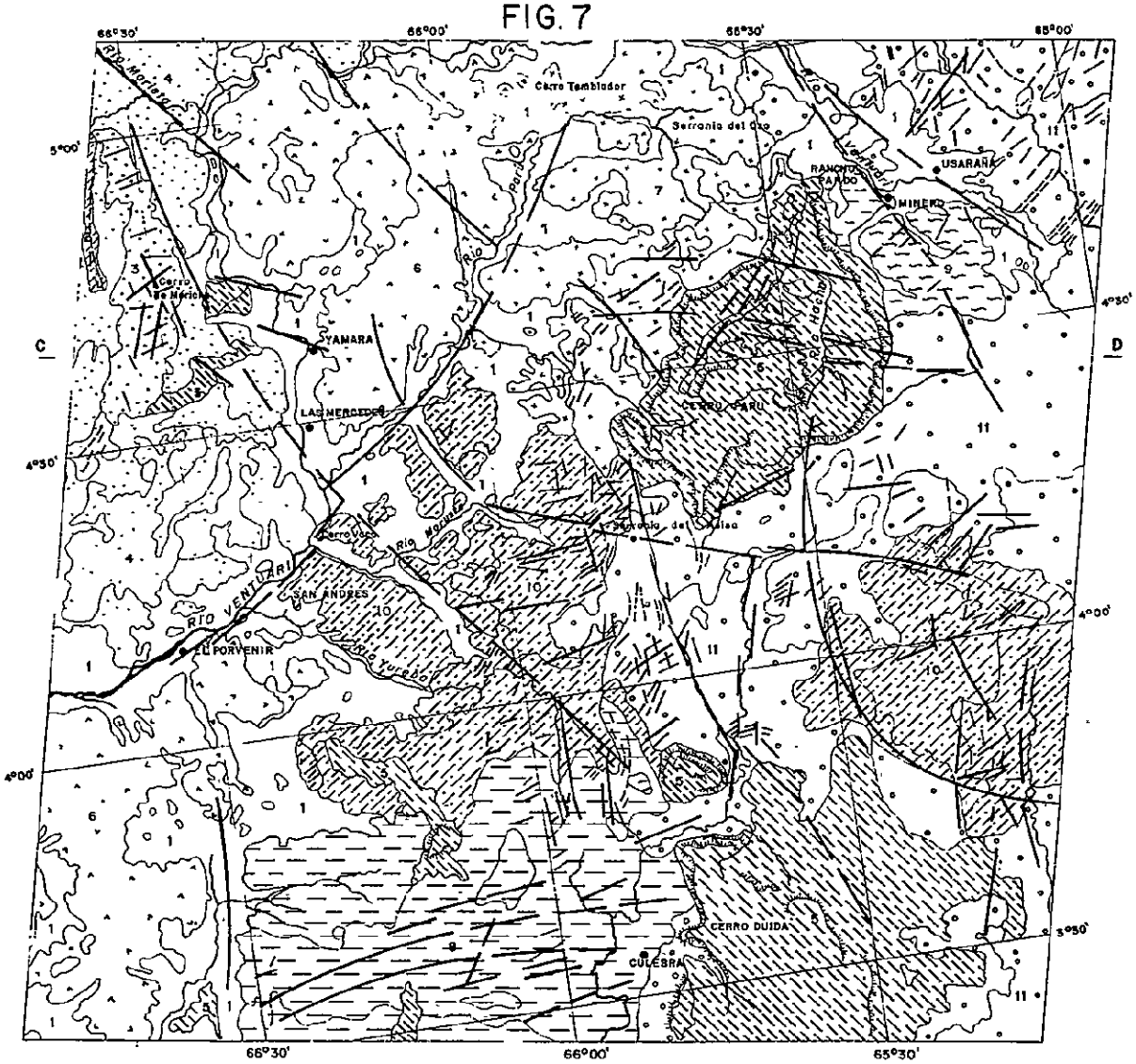
0 50 100KM

1 ALLUVIUM
2 VOLCANICS
3 IGNEOUS ROCKS GRANITIC
4 IGNEOUS ROCKS GRANITIC
5 RORAIMA UNIT
6 IGNEOUS ROCK
7 IGNEOUS ROCK
8 IGNEOUS ROCK
9 IGNEOUS ROCK
10 IGNEOUS METAMORPHIC BASEMENT.
11 IGNEOUS METAMORPHIC BASEMENT.

MINISTERY OF MINES AND HYDROCARBONS
DIRECTORATE OF GEOLOGY
DIVITION OF GEOLOGIC EXPLORATION
REMOTE SENSING DEPARTAMENT

ERTS RESOURCES TECNOLOGY SATELLITE
(ERTS. N.A.S.A)

FIG. 7



PARU - DUIDA AREA

DATE OF IMAGE JAN 13 - 1973 E - 1174 - 14091 N-04-13/ W 065-49 M.S.S.

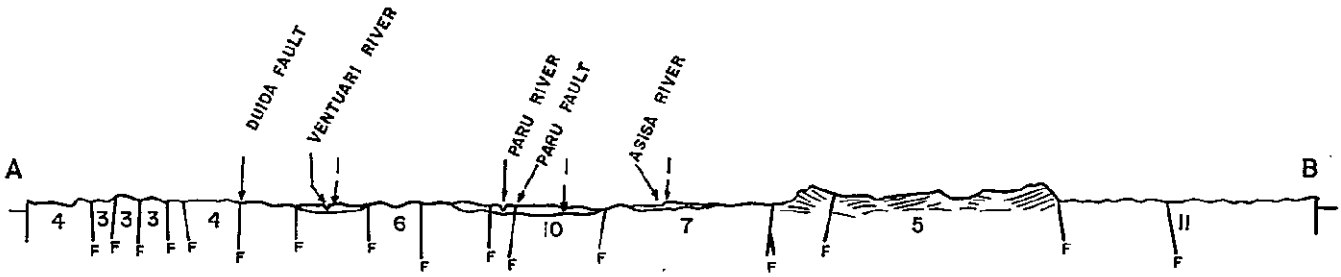
STRUCTURAL GEOLOGY INTERPRETATION

0 50 100KM

1 ALLUVIUM
2 VOLCANICS
3 IGNEOUS ROCK GRANITIC.
4 IGNEOUS ROCK GRANITIC.
5 RORAIMA UNIT
6 IGNEOUS ROCK
7 IGNEOUS ROCK
8 IGNEOUS ROCK
9 IGNEOUS ROCK
10 IGNEOUS METAMORPHIC BASEMENT.
11 IGNEOUS METAMORPHIC BASEMENT.

RIVERS
CLIFFS
FAULTS
FRACTURES
LINEAMENTS
IGNEOUS STRUCTURES
GEOLOGIC CONTACTS.

FIG. Nº8



GEOLOGIC SECTION A-B

IMAGE Nº 096 ERTS-1

GEOLOGIC SECTION.. C-D

IMAGE Nº 097 ERTS - 1

HORIZONTAL SCALE 1:1000.000

VERTICAL SCALE 1:5000.000

LEYEND

1	Alluvium	5	Roraima Unit
2	Volcanics	6	Igneous Rocks
3	Igneous Rocks Granite	7	Igneous Rocks
4	Igneous Rocks Granite	10	Igneous Metamorphic Basement
		11	Igneous Metamorphic. Basement.

GEOLOGIC SYMBOLS

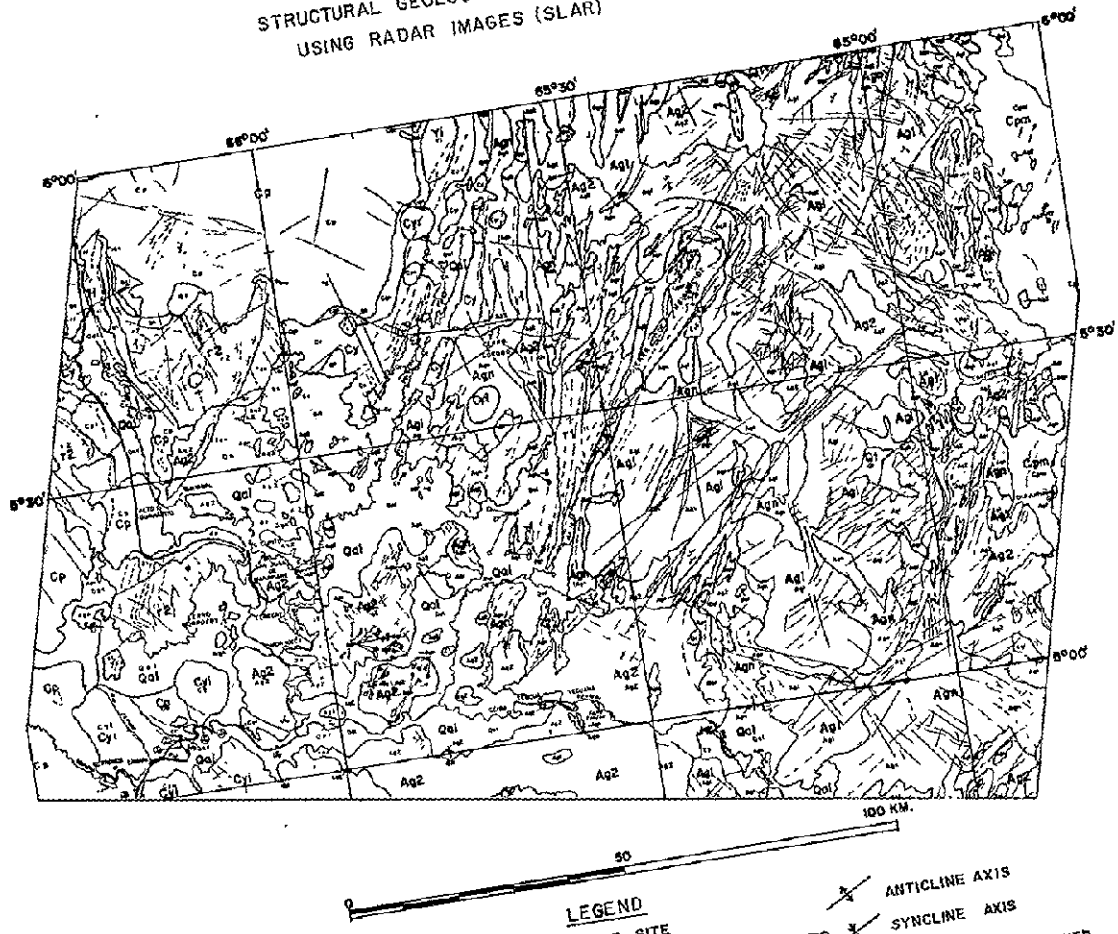
Stratification

Faults

Geologic contact

FIG.9

STRUCTURAL GEOLOGY INTERPRETATION
USING RADAR IMAGES (SLAR)



LEGEND

- Qal — QUATERNARY- ALLUVION AND COLLUVIUM
- Qt — QUATERNARY TALUS
- r1 — RORAIMA Fm
- r2 — RORAIMA Fm
- r3 — RORAIMA Fm

CUCHIVERO SERIES

- Cyl — YOUNGER INTRUSIVES
- Cp — PARGUAZA GRANITE

SAMPLE SITE

CARICHAPO PASTORA SERIES

- CPm — METAMORPHIC SEDIMENTS
- CPg — GRANITE

ARQUEAN BASAL COMPLEY

- AG1 — GRANITE GNEISS(RESISTENT)
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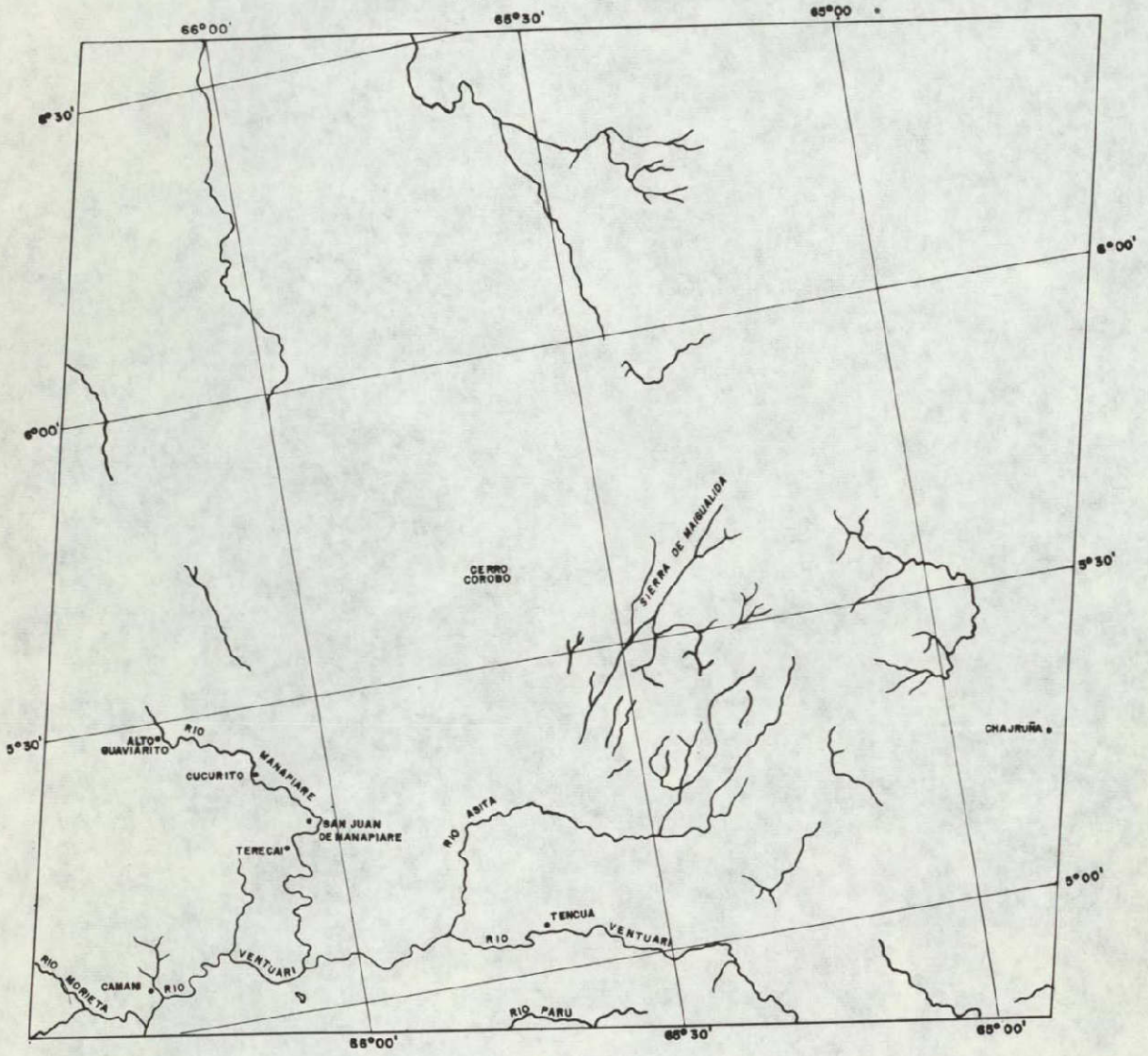
- AG3 — CONTACT GNEISS

- ANTICLINE AXIS
- SYNCLINE AXIS
- ANTICLINE OVERTURNED
- SYNCLINE OVERTURNED
- STRIKE AND DIP OF BEDDING
- STRIKE AND DIP OF FOLIATION
- FRACTURE FAULT
- STRUCTURAL LINEAMENT

FIG. 10

MINISTERY OF MINES AND HYDROCARBONS
DIRECTORATE OF GEOLOGY
DIVITION OF GEOLOGIC EXPLORATION
REMOTE SENSING DEPARTAMENT
ERTS RESOURCES TECNOLOGY SATELLITE
(ERTS N.A.S.A)

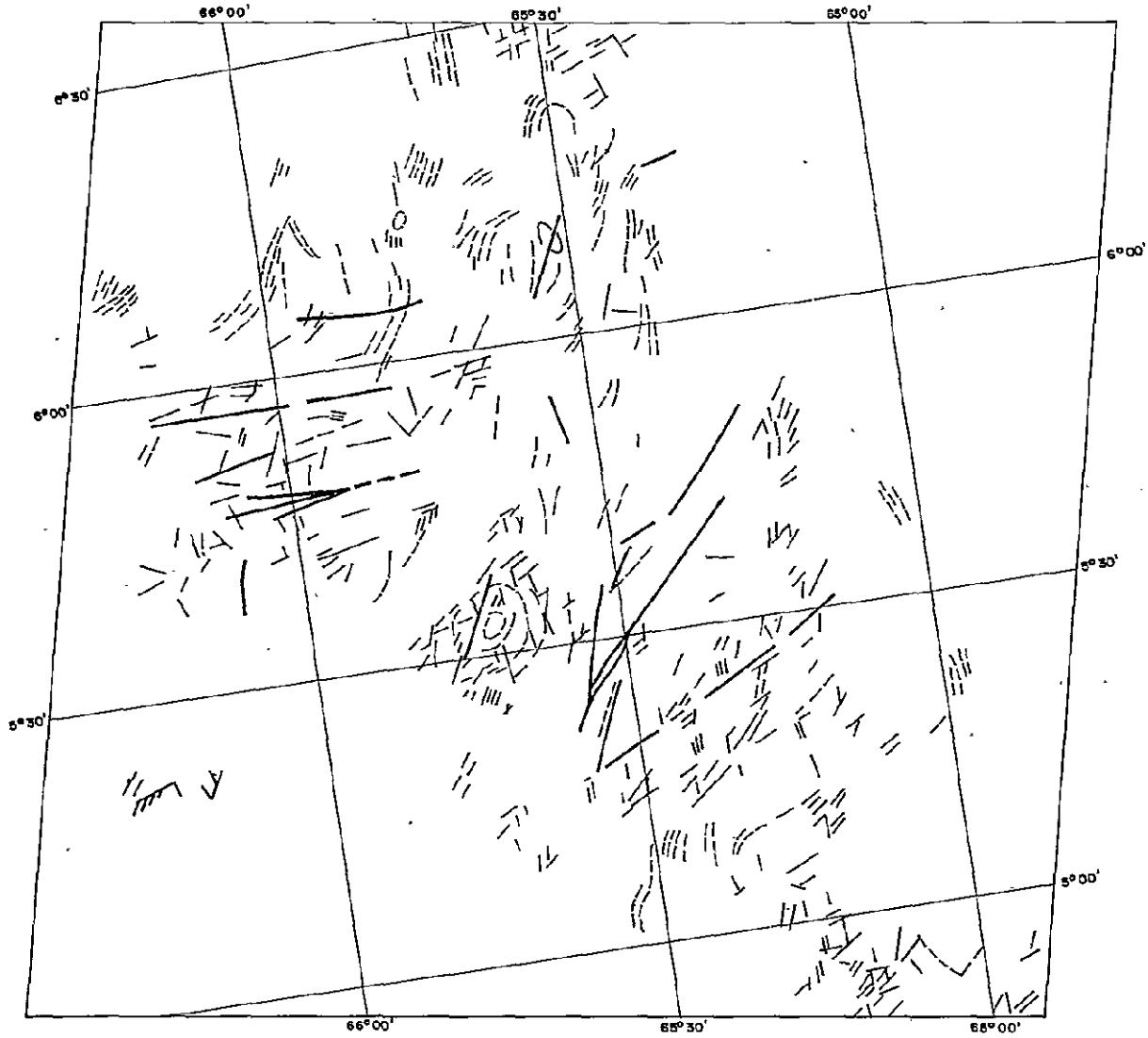


PARU - DUIDA AREA
DATE OF IMAGE JAN - 13 - 1973 E - 1174 - 140 PC N-O - /W065- 9M.SS.
DRAINAGE AND TOPOGRAPHY INTERPRETATION

0 50 100KM

FIG. 11

MINISTERY OF MINES AND HYDROCARBONS
DIRECTORATE OF GEOLOGY
DIVITION OF GEOLOGIC EXPLORATION
REMOTE SENSING DEPARTAMENT
ERTS RESOURCES TECNOLOGY SATELLITE
(ERTS. N.A.S A)



PARU - DUIDA AREA

DATE OF IMAGE JAN 13-1973 E-1174-14084 P.C N-05-40/W065-29 M.S.S

STRUCTURAL INTERPRETATION

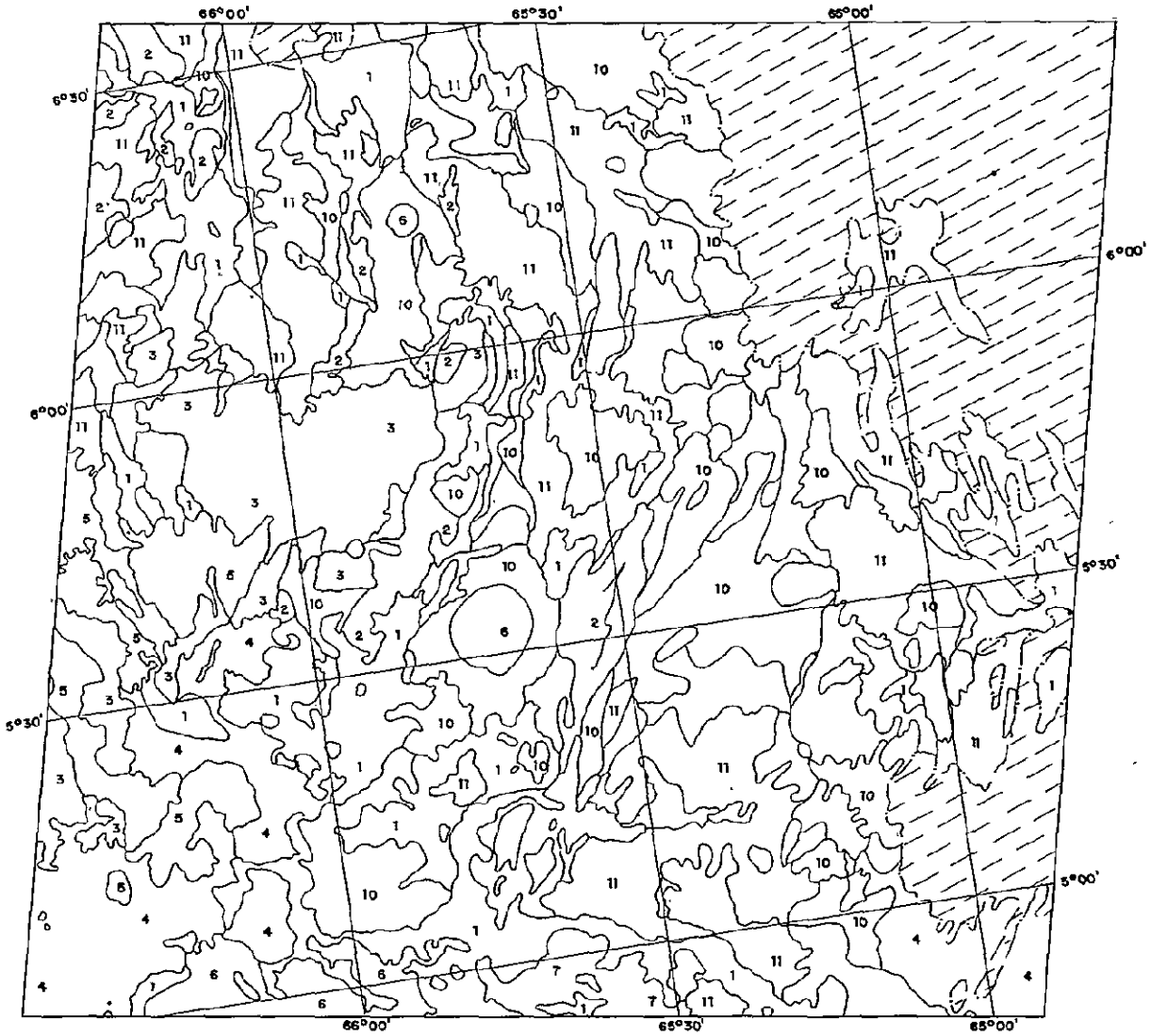
LEGEND

FAULTS
FRACTURES
LINEAMENTS
IGNEOUS STRUCTURES

0 50 100km

FIG. 12

MINISTERY OF MINES AND HYDROCARBONS
DIRECTORATE OF GEOLOGY
DIVITION OF GEOLOGIC EXPLORATION
REMOTE SENSING DEPARTAMENT
ERTS RESOURCES TECNOLOGY SATELLITE
(ERTS.N.A.S.A)



PARU - DUIDA AREA

DATE OF IMAGE JAN 13 - 1973 - E 1174 - 14091 RC N - 04 - 13/W 065 - 29 M.S.S

GEOLOGIC UNITS

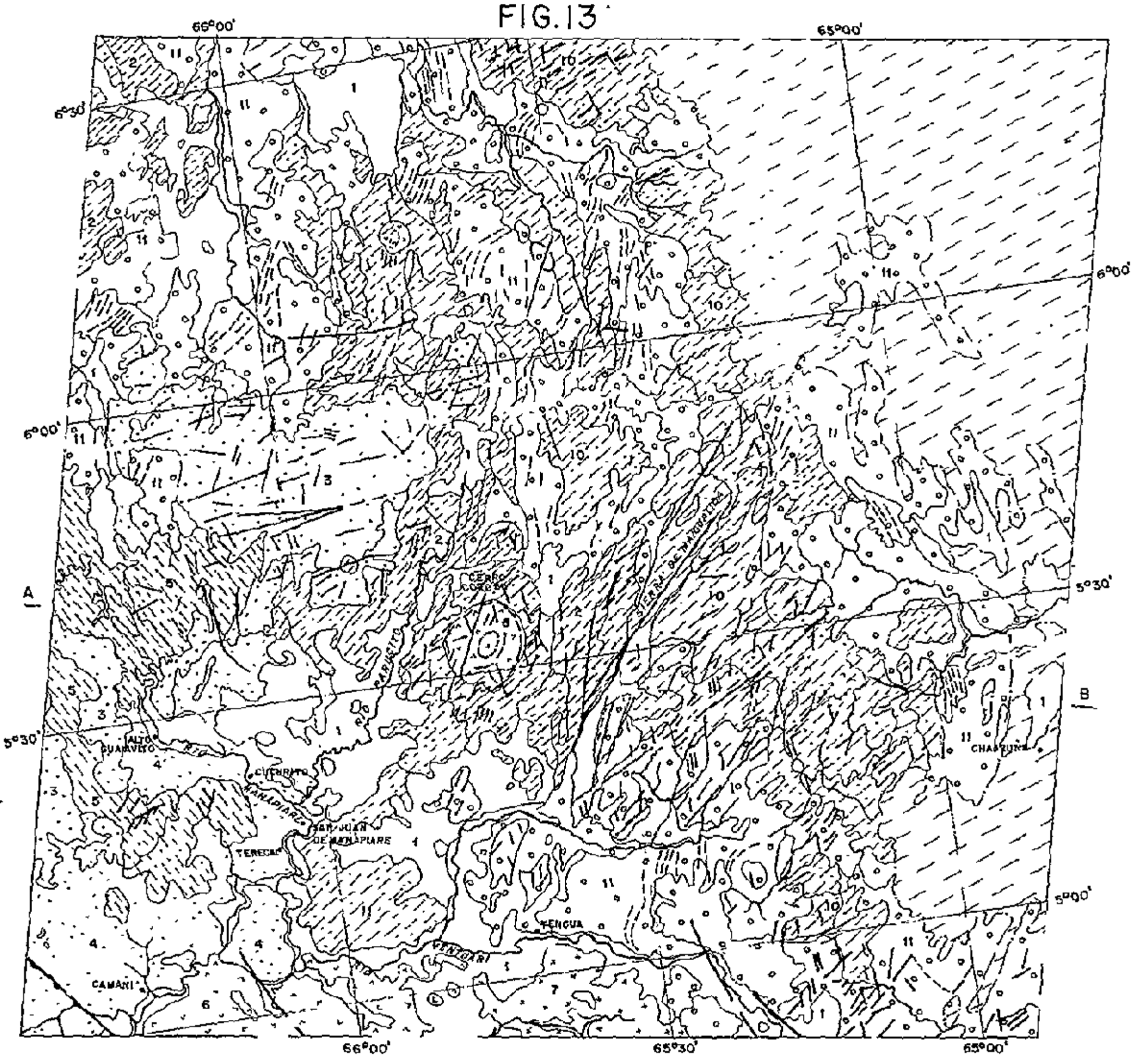
0 50 100 KM

1	ALLUVIUM	4	IGNEOUS ROCK GRANITIC.	7	IGNEOUS ROCK
2	VOLCANICS	5	RORAIMA UNIT	10	IGNEOUS METAMORPHIC BASEMENT.
3	IGNEOUS ROCK GRANITIC	6	IGNEOUS ROCK	11	IGNEOUS METAMORPHIC BASEMENT

MINISTERY OF MINES AND HYDROCARBONS
DIRECTORATE OF GEOLOGY
DIVITION OF GEOLOGIC EXPLORATION
· REMOTE SENSING DEPARTAMENT

ERTS RESOURCES TECNOLOGY SATELLITE
(ERTS. N.A.S.A)

FIG.13



PARU - DUIDA - AREA

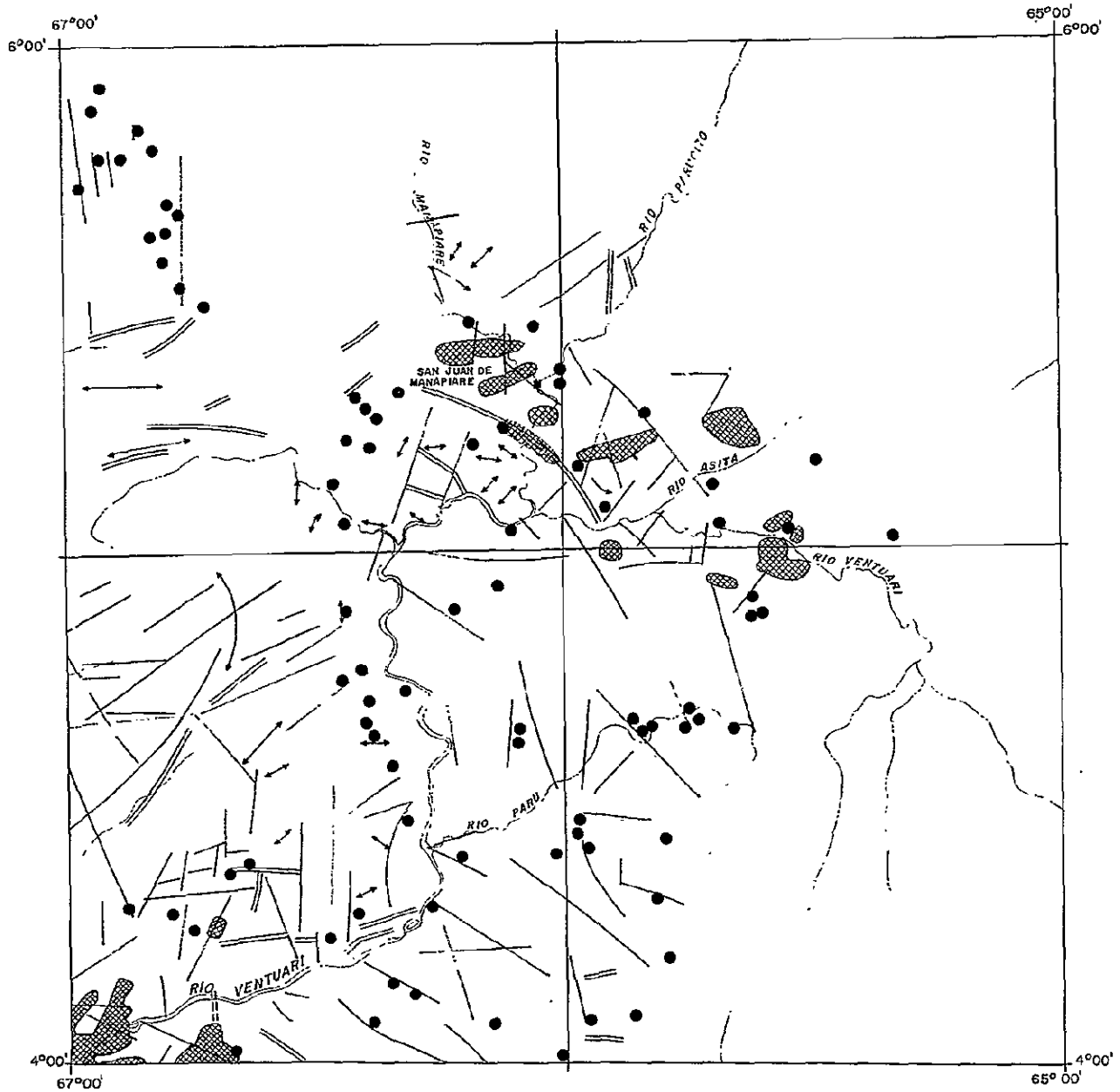
DATE OF IMAGE JAN-13-1973 E-1174-14084 N-05-40/W 065-29 M.S.S.

STRUCTURAL GEOLOGY INTERPRETATION

0 50 100KM

Symbol	Legend	Symbol	Legend	Symbol	Legend	Symbol	Legend
1	ALLUVIUM						
2	VOLCANICS	6	IGNEOUS ROCK		RIVER		FRACTURES
							LINEAMENTS
3	IGNEOUS ROCKS GRANITIC.	7	IGNEOUS ROCK		CLIFFS		IGNEOUS STRUCTURES
4	IGNEOUS ROCKS GRANITIC	10	IGNEOUS METAMORPHIC BASAMENT.				
5	RORAIMA UNIT	11	IGNEOUS METAMORPHIC BASAMENT.		FAULTS		GEOLOGIC CONTACTS

REPUBLIC OF VENEZUELA
MINISTRY OF MINES AND HIDROCARBONS
DIRECTORATE OF GEOLOGY
ERTS RESOURCES TECNOLOGY SATELLITE
(ERTS-NASA)
FIG-14



STRUCTURAL INTERPRETATION OF LINEAMENT
AND MAGNETIC AND RADIOMETRIC ANOMALIES
PROJECT VEN - 02

ESCALA APROX: 1:1.000.000

LEGEND

MAJOR MAGNETICS CORPS
DIKE
FAULTS
DEEPSTRUCTURAL AXIS
RADIOMETRICS ANOMALIES

SITUACION RELATIVA NACIONAL

TEXTURAL EXAMPLES

IMAGES 1174 - 14084 and 1174 - 14091 BAND 7

1.- ALLUVIUM

2.- VOLCANIC ROCKS

3.- GRANITIC IGNEOUS ROCKS

4.- GRANITIC IGNEOUS ROCKS

5.- RORAIMA UNIT

6.- IGNEOUS ROCKS

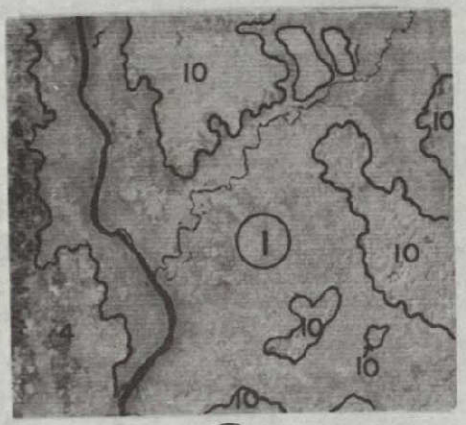
7.- IGNEOUS ROCKS

8.- IGNEOUS ROCKS

9.- IGNEOUS ROCKS

10.- IGNEOUS-METAMORPHIC BASEMENT

11.- IGNEOUS-METAMORPHIC BASEMENT


10
10
10
1
10
10
10
4

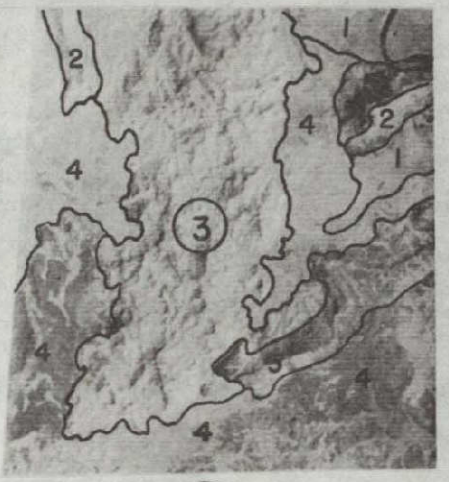
1


10
10
10
6
6
6
1
6
10
10
10
6

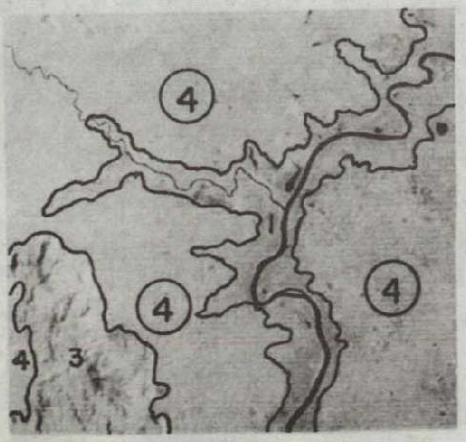
1


1
11
2
1
10
11
2
1

2


1
2
4
2
4
1
3
4
4
4

3


4
4
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4


10
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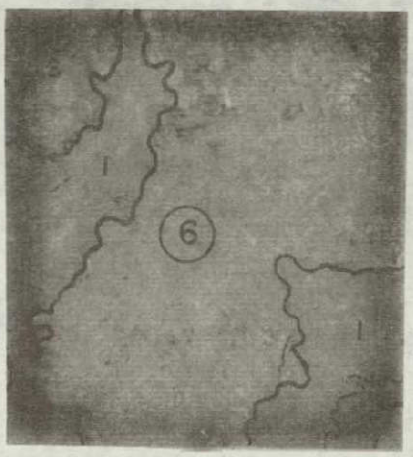
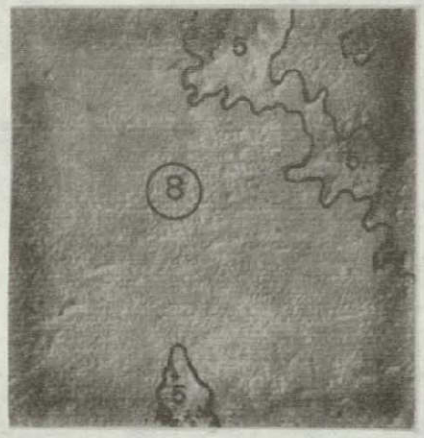
10
10

5



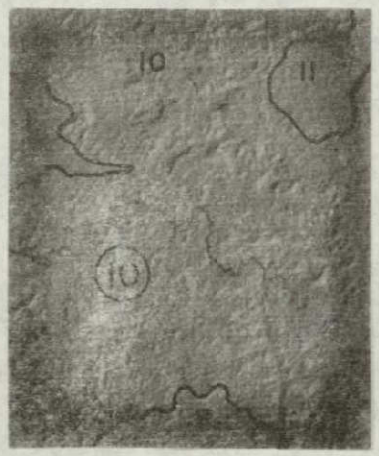
6

7



8

9



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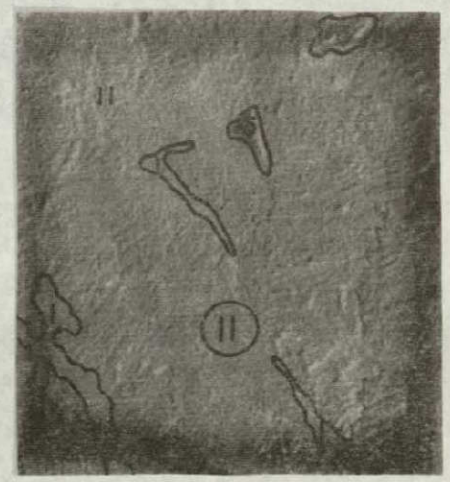

11

MINISTRY OF AGRICULTURE AND BREEDING

DIRECTORATE OF NATURAL RESOURCES

FORESTRY DIVISION

PHOTOINTERPRETATION DEPARTMENT

"DEVELOPMENT OF TECHNIQUES TO SIMPLIFY THE PROCESS OF INVESTIGATION AND ESTIMATE OF NATURAL RESOURCES IN REMOTE AND RELATIVELY UNEXPLORED AREAS" (VENEZUELA).

NUMBER SR-0120

FORESTRY

SIPAPO FOREST RESERVE COMPARATIVE ANALYSIS USING ERTS-1 IMAGES AND CONVENTIONAL PHOTOGRAPHY.

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INTRODUCTION

The total area of forest in Venezuela is approximately 480.000 Kms^2, of which 78% is completely covered by dense humid vegetation. In order to compile maps of these tropical humid regions using photointerpretation, the use of aerial pancromatic photography in scale of 1:50.000 must be employed.

These forests are located in zones that, due to their inaccessibility, heterogeneity in type and volume, lack of defined structure, qualitative and quantitative composition, are generally not taken into consideration in the overall economic structure of the country. The daily increase in demand of basic material indicate the necessity of incorporating these zones in order to help boost the country's economic resources.

Taking into consideration the urgent need for basic material, it is necessary to promote a program for the elaboration and mapping of information in these zones at the earliest opportunity, due to the fact that no work of this type has ever been carried out in these forest areas in order to determine their potential.

The use of Satellite Images is therefore justified in planning the inspection of these areas, also the use of large-scale aerial photography for obtaining detailed photo-interpretation for exploration and planning. Considering the fact that Venezuela is extremely interested in the integration of its southern region with other areas already explored, and also, the colonization of its frontiers, it is of vital importance that Venezuela participate in the Investigation Program related to Image Interpretation obtained by the use of remote sensing.

4.1. DESCRIPTION OF THE ZONE

For the study purpose of comparative photo-interpretation, the Sipapo Forest Reserve located in the Amazon Federal Territory was selected. The selection of this area for study was based on the following: (1) availability of material for conventional photography in scale of 1:50.000 and the use of Satellite Images (ERTS); (2) the lack of information of this area and the need for future incorporation of its natural forest potential and productivity in the country's economic program.

The Sipapo Forest Reserve was created in accordance with Resolution No. 16, dated 7-1-1963, and published in the Official Gazzette No. 27.044 dated 8-1-1963 (Gaceta Oficial de la República de Venezuela). The region is comprised of an area of 1,215,000 hectares.

There is an outcropping of rocks pertaining to the Guayana Shield of Pre-Cambrian era that is composed principally of granite, quartz, lavas and metasediments. The land form characteristics of the landscape in this area can be classified in three large groups: (1) Lower Plains; (2) Mountain Zones, and (3) Tepuis.

Precipitation in the area increases up to approximately 2,500 m.m. annually from North to South. The average temperature is about 25°C and diminishes to approximately 20°C to 24°C at altitudes that vary from 800 to 2,400 meters, at which temperatures the precipitation varies between 2,000 and 2,400 m.m.

The vegetation in this zone is characterized principally by the following:

a. Gramineously associated savannas that cover more or less extensive areas.

b. In the dense forest areas, according to H. L. Holdridge (Zonas de Vida de Venezuela) the following types of forests can be found:

1. Tropical humid forest.
2. Very humid pre-mountainous forest.
3. Low-mountainous Pluvial forest.
4. Pre-mountainous Pluvial forest.

The region covered by forest is the most virgin area of the country and is located between the Orinoco, Ventuari and Manapiare rivers and the Guanpi Mountain Range in the Department of Atures and Atabapo in the Amazon Federal Territorry, between parallels 4°00' and 6°00', North Latitude, and 66° to 68° of Longitude West Meridian of Greenwich.

4.2. AVAILABLE MATERIAL

The only available material at the beginning of this program for Forest Investigation (Project VEN-02) consisted of the following:

1. Conventional Aerial Photography
2. Cartographic material
3. ERTS-1 Images which were employed in the following manner:

Conventional photography

a. Scale 1:50.000

b. Cameras - Wild RC - 9 Super-wide angle.

c. Flight altitudes

d. Flight coverage - 100% of the area

Cartographic material

a. Preliminary mapping done by monocular restitution (Sketch Master) in scale of 1:50.000 that was later reduced to a more workable scale of 1:250.000. The scale of 1:500.000 was used for publication.

ERTS-1 Images

a. ERTS-1 Images No. 1229-14151 and 1229-14154 were taken with 20% of cloudiness on March 9th, 1973 during the summer season using a mutispectral system. (It is convenient to state here that the images No. 1229-14154 depended exclusively upon the wavelenght No. 7 of the M.S.S. (.8 to 1.1).

M.S.S. of ERTS 1

Band 4 of .5 to .6 u

Band 5 of .6 to .7 u

Band 6 of .7 to .8 u

Band 7 of .8 to 1.1 u

b. From this material an enlargement in the scale of 1:1.000.000 1:500.000 - 1:250.000 was obtained in film as well as on paper.

4.3 ASPECTS OF THE PHOTO-INTERPRETATION METHODS

The methods used ofr interpreting the Satellite Images as well as the conventional photography was in accordance with normal procedures:

a. Photoanalysis : 1. Analysis 2. Deduction

b. Photolecture : 3. Detection 4. Recognition

c. Interpretation : 5. Classification 6. Utility

For the photo-interpretation and delineation of the different types of vegetation in the conventional photography after a general study of the vegetation formations present in the area the following codes were used:

1. Forest: meaning dense tree-coverage above 75%

   a. Ba : High forest - when the highest stratum is above 30 meters high

   b. Bm : Medium high forest - when the height varies between 15 to 30 mts.

   c. Bb : When the height is less than 15 meters

   d. G : Galery forest - forest forming generally narrow fringes on both sides of the rivers

   e. M : Low shrubbery

2. Savannas

   a. (S) : Savannas

3. Rocky outcroppings

a. (AR) : Rocky outcropping - rocks generally bare of vegetation or overgrowth; rocks could have small percentage of vegetation or overgrowth, however, the greater area of rock must be uncovered (bare).

4. Man-made clearings

a. (T) : Deforested areas made bare by work of man for the purpose of cultivation or other motives.

Depending upon the true crown density, the forest may be classified as follows:

a. Dense - When the highest forest stratum covers more than 75% in the area

b. Clear - When the highest forest stratum is less than 75%

As regards to the physiographical characteristics, the following classifications were established in accordance with the topography of the area:

1. Flatlands
2. Undulated territory
3. High-low hills
4. Tepuis

Upon completion of the photo-interpretation, the base map was elaborated using the Watts stereo-sketch method. The original Base Map was drawn-up in the scale of 1:50.000 and was later reduced to a scale of 1:250.000 for the purpose of facilitating comparisons with the ERTS-1 images.

To facilitate the study of ERTS-1 images for interpreting the zonal vegetation, it was necessary to use a general classification system, inasmuch as the characteristics of the images (scale and resolutions) did not permit making detailed delineations. To facilitate doing this aspect of the work, it was necessary to use an identifying method based principally upon the physiographical characteristics of units that could be differentiated in the ERTS images.

Altitude characteristics, density and overhead coverage of the lower canopy could not be detected in the ERTS images, thereby causing reflection variations in the images, resulting in a change of tones.

The following units could be distinguished in the ERTS images:

1. Unit 0: Alluvial Plains

This Unit comprised all the Plain Zones in the vicinity of all important rivers, flooded zones, abandoned trenches and ditches, sand pits, natural dikes and other cleared zones. The drainage in this area is somewhat obstructed and subject to periodical flooding. Within this area, there are also several lowterraces (undulated lowlands) that are subject to prolonged floodings.

2. Unit 1: Flatlands

These plains or flatlands are composed of terraces that are origins of the various rivers and/or other geological phenomenas that are inherent to the area; they appear as plain or slightly undulated zones. The terrace could have been dissected as a result of errosion at different grades of intensity. This also include the valleys of streams that determine different types of forests.

3. Unit 2: Undulated territory and low hills

This area is composed of undulated territorry and low hills; there are a few creeks with small sloping uniformed valleys.

4. Unit 3: High hills and flat high zones

Savanna - In this zone, the vegetation that is delineated forms savannas of humid tropical climate, consisting of graminaceous formations of approximately 80 c.m. high, with a flat undulation of leaves forming a continuous base that dominates the lower strata. Plants of a ligneous specie is frequent in the area.

5. Human influence (y)

Human influence originated by:

a. Clearings for agriculture (temporary or permanent) where local ground products are cultivated.

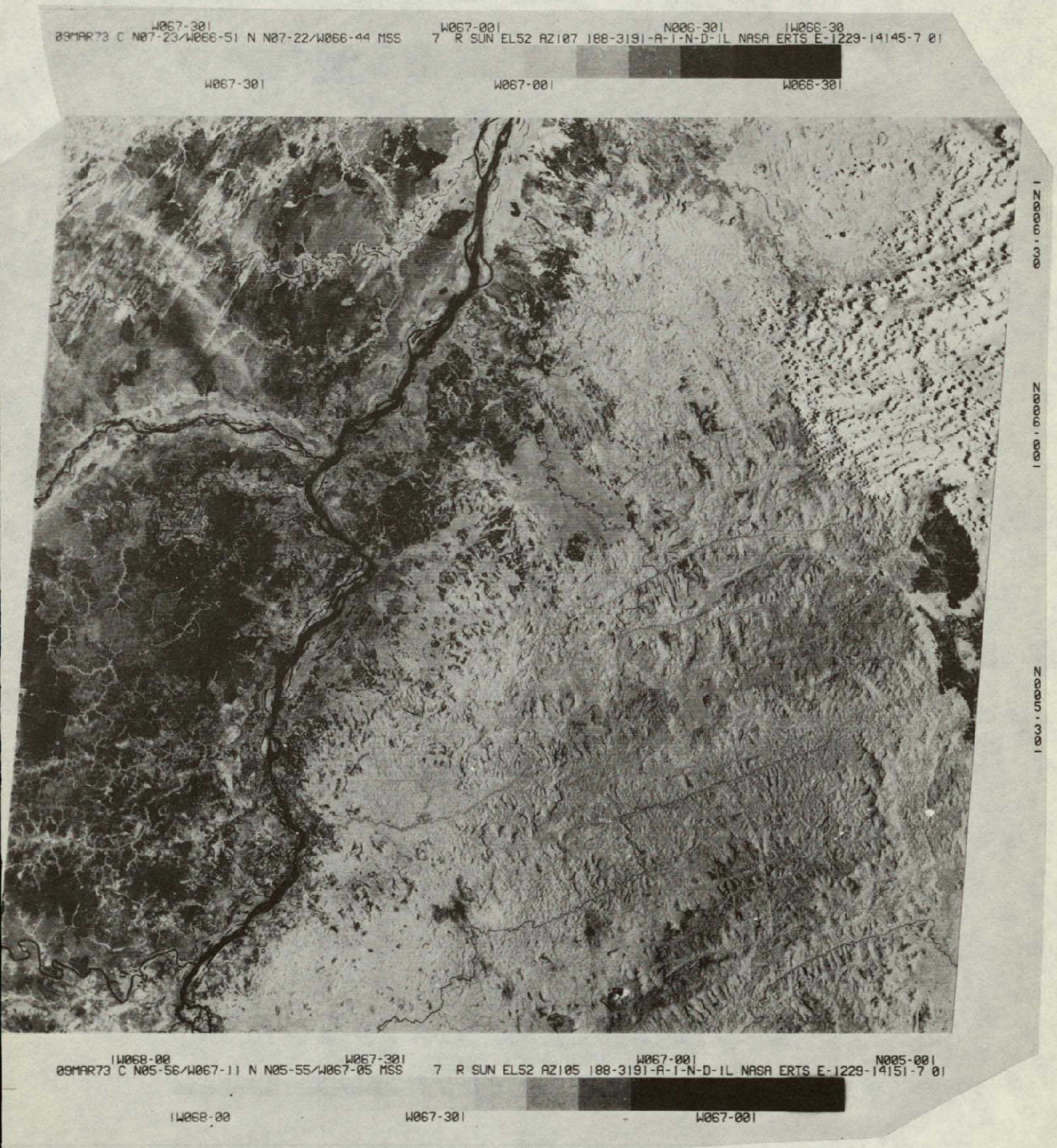
b. Pastures, etc., etc.

c. Man-made constructions, such as roads, towns, canals and so on, are also included in this definition.

4.4. RESULTS - COMPARISONS OF CONVENTIONAL PHOTOGRAPHY WITH ERTS-1 IMAGES

In order to make comparisons of interpretations of the conventional photography with ERTS-1 images, six (6) stereotriples and one stereogram were made and their positions were located in the images of bands 5 and 7.

ORIGINAL PAGE IS
OF POOR QUALITY




1W068-00 W067-301 W067-001
09MAR73 C N05-56/W067-11 N N05-55/W067-05 MSS 7 R SUN EL52 AZ105 188-3191-A-1-N-D-IL NASA ERTS E-1229-14151-7 01
1W068-00 W067-301 W067-001
100°50'00"N
100°40'00"N
103°40'00"W
103°30'00"W
W068-001 W067-301 W067-001
09MAR73 C N04-31/W067-32 N N04-29/W067-25 MSS 7 R SUN EL52 AZ103 188-3191-A-1-N-D-IL NASA ERTS E-1229-14154-7 01

STO-01. Region 0. Plains Alluvial, Puerto Ayacucho (Port of Ayacucho)

Original scale: 1:50.000

Date of photography - November 1970 (end of rainy season).

Pancromatic films.-

0. Alluvial plain zones

3. Course of water-flow: Water was observed to be varying between dark to clear grey tones in the rivers due to sedimentation.

4. Areas were covered by low vegetation.

5. The Ayacucho settlement (Port of Ayacucho) is situated on the right side of the Orinoco River.

6. Urban zone is cleared of vegetation.

AR: Rocky outcropping. Visibility is clear. The rock could be characterized principally for its lack of vegetation, growths (bare rock) or other almost non-existent overgrowths.

S: Savanna with very little vegetation and other growths

ERTS IMAGES

Band 5:

Scale: 1:250.000

Date on which the Images were taken: March 9, 1973 (dry season)

The limits of Alluvial Plains could be easily identified (marked off) owing to its dark grey tone, however, the different types of forest could not be identified. Low river-sands (river bands) were observed to be of a white tone, during the dry-season (summer).

Zone No. 4, is covered by low vegetation of a darker tone due to

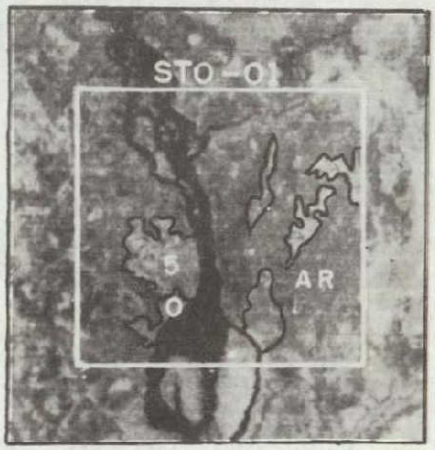
a greater absorption of electro-magnetic radiation of the vegetation.

The populated area No. 5 has a grey tone similar to a rocky outcropping with dark shades, and clearness that could be mistaken, however, it is possible to differentiate between the geometric delineations of the populated area.

The populated area No. 6, belongs to a settlement by reason of which there is no vegetation; the tone here is much clearer.

The rocky outcropping can be distinguished by its grey tone and pronounced relief impression.

The savanna that has very little vegetation and growths has a clearer grey tone than the outcropping rocks.



ST0-02. Savanna regions and Alluvial Plains

Original scale 1:50.000 (add stereogram)

Date of aerial photography: November 1970 (rainy-season)

Pancromatic film was used.

The savanna is distinguished by a very clear grey tone and is subdivided into:

S. Savannas without shrub vegetation

S1. Savannas with dispersed shrub vegetation

S2. Savannas with shrub vegetation and humid soil

M. Shrub

0. Alluvial flat region. A medium dense forest may be observed in this region. We also can distinguish:

5. Dark coloured stagnant waters due to lack of suspension material.

6. Lighter coloured stagnant waters due to less waterbed deepness.

G. Galery forest.

ERTS IMAGES

Band 4:

Scale: 1:250.000

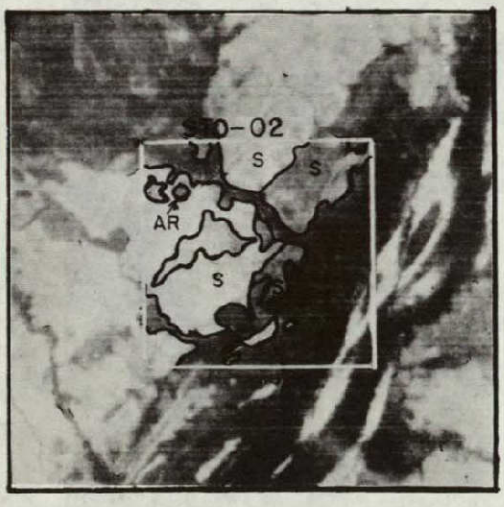
Date of photography: March 9, 1973 (Rainy season).

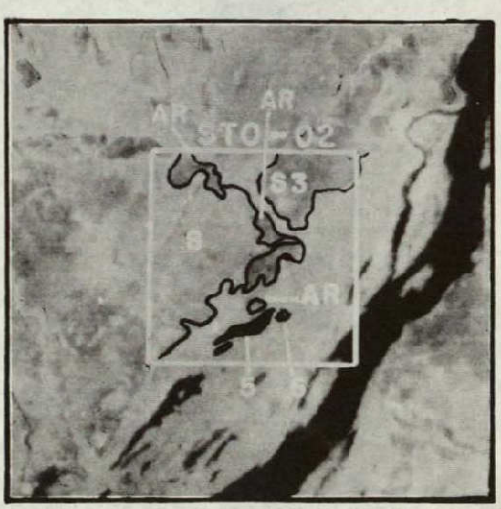
The savanna area shows different shades of grey due to the existence of shrub vegetation and soil humidity.

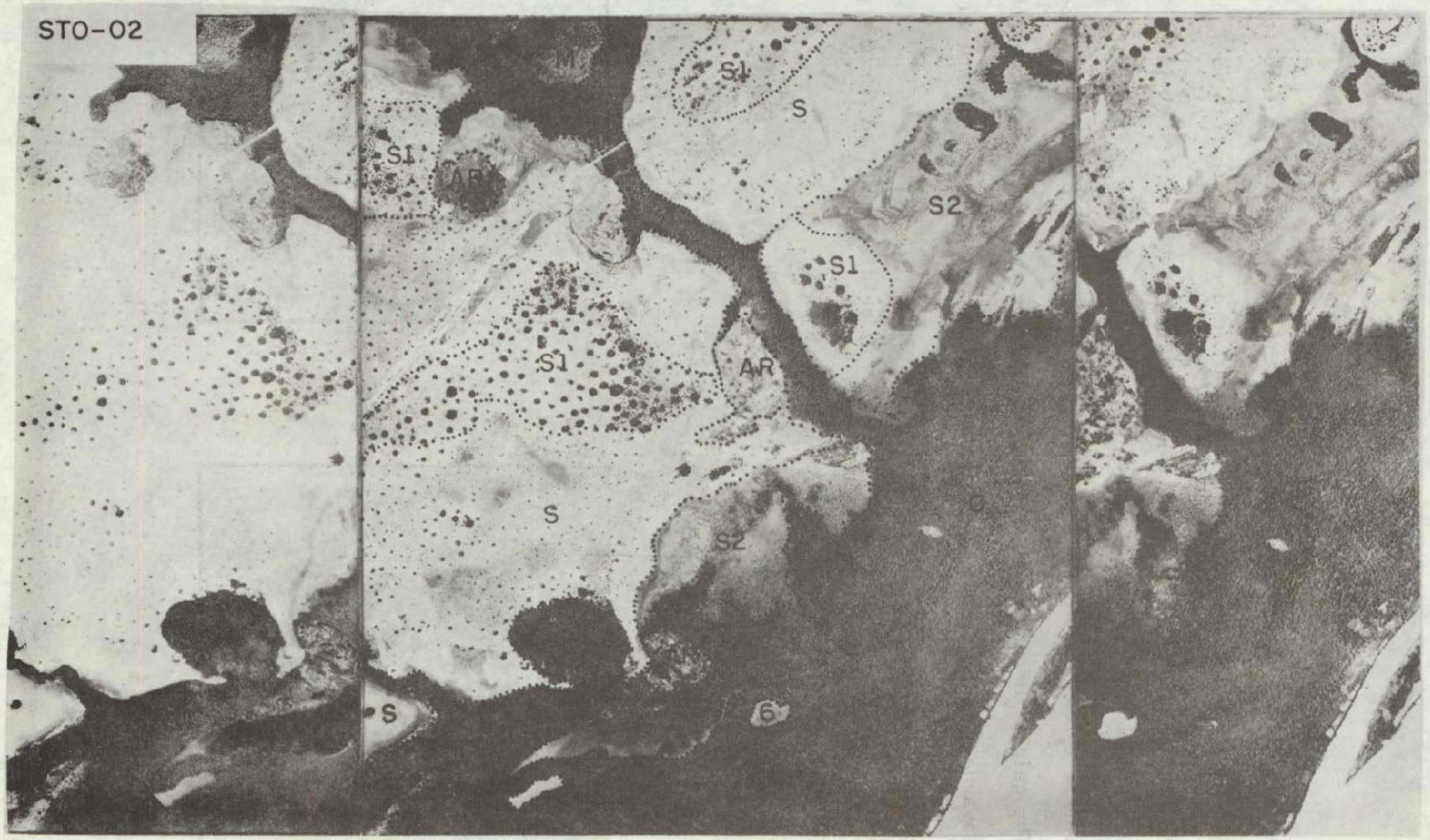
The savanna (S) without shrub vegetation presents a light grey tone, while the darker grey tone is due to the trees which dispersed presence absorb

more electromagnetic energy. In (S2) the shrub vegetation is dispersed, but the humidity of the soil produces a darker grey tone than in (S1). M shows a darker tone since the area is covered with dense low vegetation. The alluvial flat land can be delineated but without possible differentiating of the forest types, due to the fact that only the uniform dark tone can be observed. The galery forest (G) is distinguishable for its darker shade length in the savanna (lighter tone), as well as for its characteristic shape due to drainage patterns.

The stagnant water 5 and 6 may be distinguished for their tone and by their conditions indicated on the esterogram.






STO-02
S1
S
S1
AR
S2
S1
S1
AR
S
S2
S
6

STO-03. Region of flat land and low hills

Original scale: 1:50.000

Date of photography: November, 1970.

Pancromatic film.

1. Flat land zone, with the presence of a meandric river.

2. Rolling land zone and low hills

Y Human influence which can be recognized by its geometric form.

ERTS IMAGES

Band (7) 1:250.000

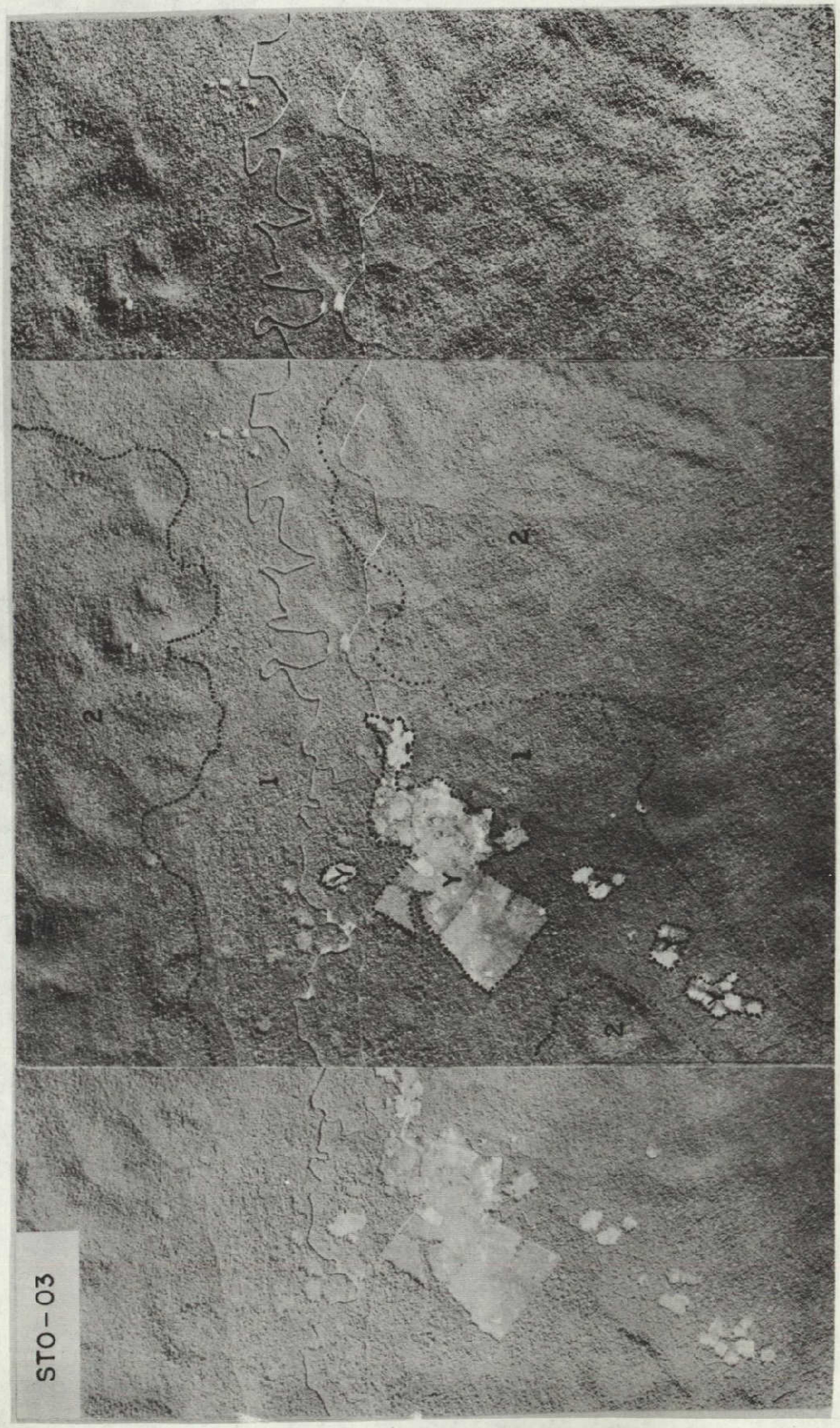
Date of photography March 9, 1973 (rainy season).

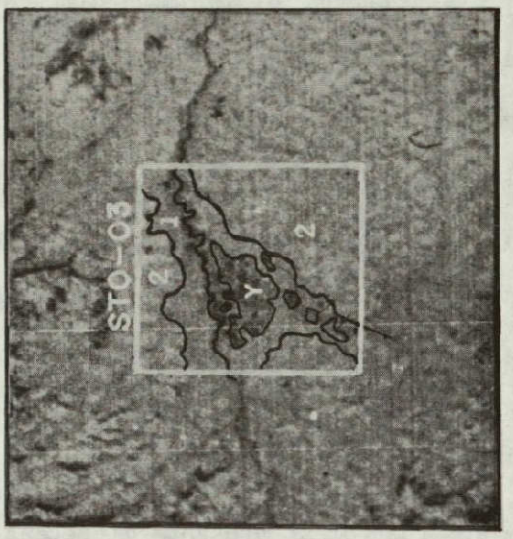
For the esterogram STO-03, the band 7 has been selected for the following reasons:

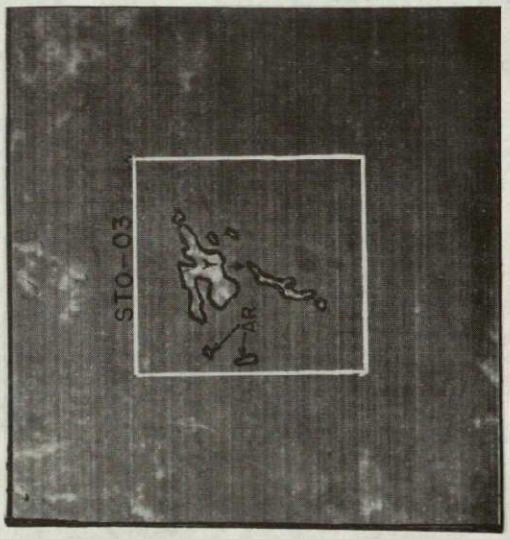
a. Band 5, presents with the tree vegetation a very dark tone which enables to only distinguish the rocky outcrop.

b. The human influence in the area can be more clearly observed on band 7 due to its darker tone, geometric form and for being generally near or on river shores. Although the tone may be mistaken for the rocky outcrop, it can be distinguished due to the latter's highlights picture.

c. The vegetation has a light grey more or less uniform tone. The hills can be easily observed.







STO-04. Rocky outcrop. Flat land and hills. High hills and high flat zones.

Original scale: 1:50.000

Date of photography: November, 1972 (rainy season)

Pancromatic film

AR. Rocky outcrop, easily distinguishable. Usually characterized for being a nude rock without vegetation, or if existing, very low and scarce, mainly located in zones with drainages.

1. Flat zone. There exist higher and denser forests, generally with a canopy of equal height.
2. High Hills. The forest presents different stratus heights, being the highest trees located in the valleys near the streams, due to edaphological, and humidity conditions.

ERTS IMAGES

Band 7. March 9, 1973 (dry season)

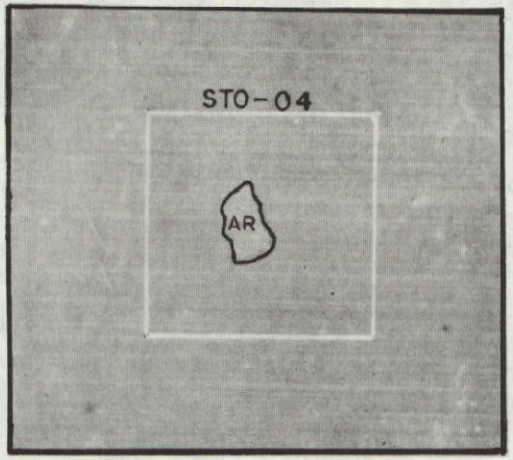
Scale: 1:250.000

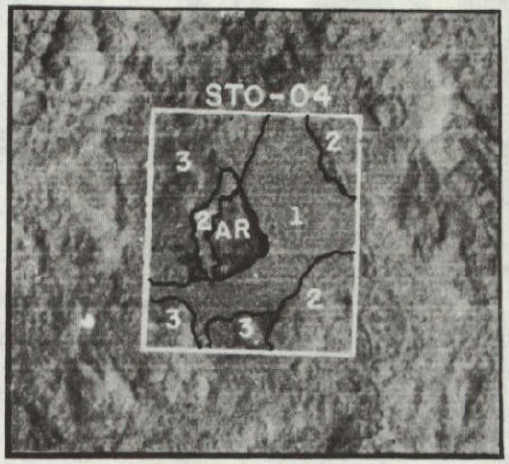
The rocky outcrop may be easily distinguished due to its dark tone and well projected shadow

Zone 2 is distinguished for the irregular tone and dissection pattern of the terrain.

Zone 3, more accentuated characteristics as zones, and therefore the highlights can be more clearly distinguished.

C. 2


STO-04
AR


STO-04
3
2
2
AR
1
2
3
3

STO-05. Region of rolling land low and high

Scale: 1:50.000

Date: November, 1970

Pancromatic film

AR. Rocky outcrop. Can be observed without difficulties. Usually characterized for being a nude rock without vegetation or if any, very low and scarce.

2. Zone with low hills. A medium dense forest can be observed

3. Zone with high hills. A forest with variable canopies height can be seen the major height and treetops are in the stream valleys due to the edaphological and humidity conditions.

ERTS IMAGES

Band 7

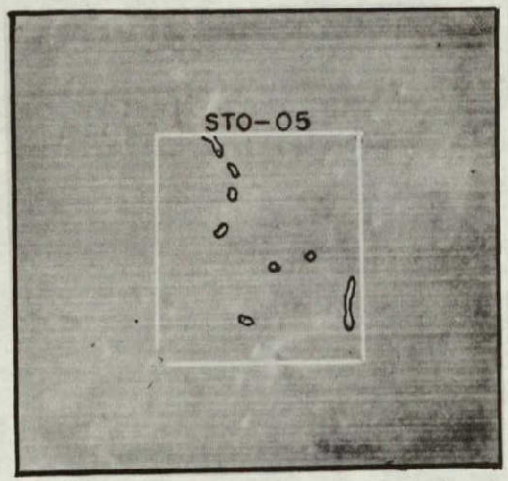
Date: March 9, 1973

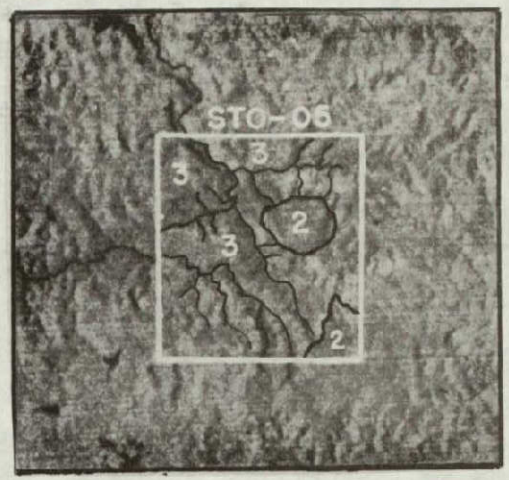
Scale: 1:250.000

The rocky outcrop can be easily distinguished.

Zone 2 can be distinguished by the regularity of the tone and the little dissection of the terrain.

A high flat land can easily be distinguished between the pointed lines, which corresponds to the continuation of the high flat land identified as Zone 2.


STO-05


STO-06
3
3
2
3
2

ST0.06. Rocky outcrop. Corrugated land and High Hills.

Savannas

Original scale: 1:50.000

Date: November, 1970

Pancromatic film

AR. Rocky outcrop. Hardly distinguishable. Characterized usually for being a nude rock without vegetation or if any, very low and scarce.

2. Low Hills. A medium dense forest can be observed

3. High Hills. A forest of variable canopies heights can be observed, the major heights and treetops feeding in the stream valleys due to edaphological and humidity conditions.

S. Savanna. This type of the savanna does not present tree vegetation Savanna. There appear shrub vegetation grouped lengthly to the drainages, as well as outcrops.

ERTS IMAGE

Band 5

Date of Photography: March 9, 1973 (dry season)

Scale: 1:250.000

The rocky outcrop can be distinguished for its light tone related to vegetation.

The savanna with dispersed shrub vegetation (SI) presents a lighter grey tone than that of the rocky outcrop due to the scarce vegetation.

The other type of the savanna (S) lacks shrub vegetation and appears

having a very light grey tone.

Zones 2 and 3 present the same uniform dark grey tone, which difficults the differentiation of the vegetation types.

Band (7)

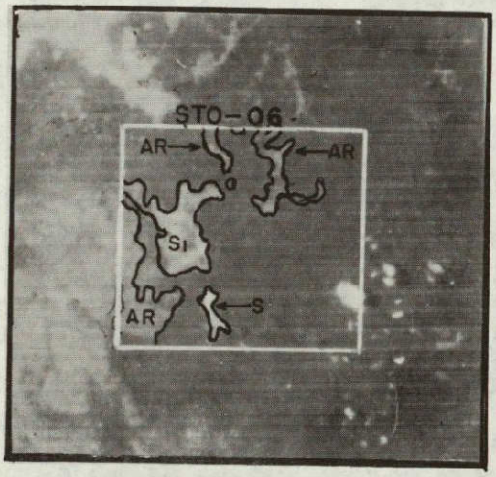
Date of photography: March 9

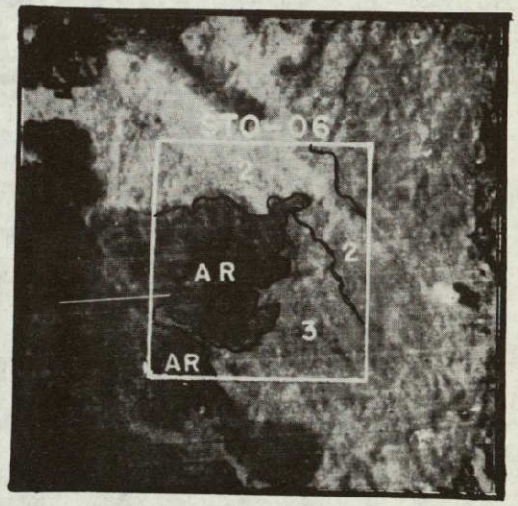
Scale: 1:250.000

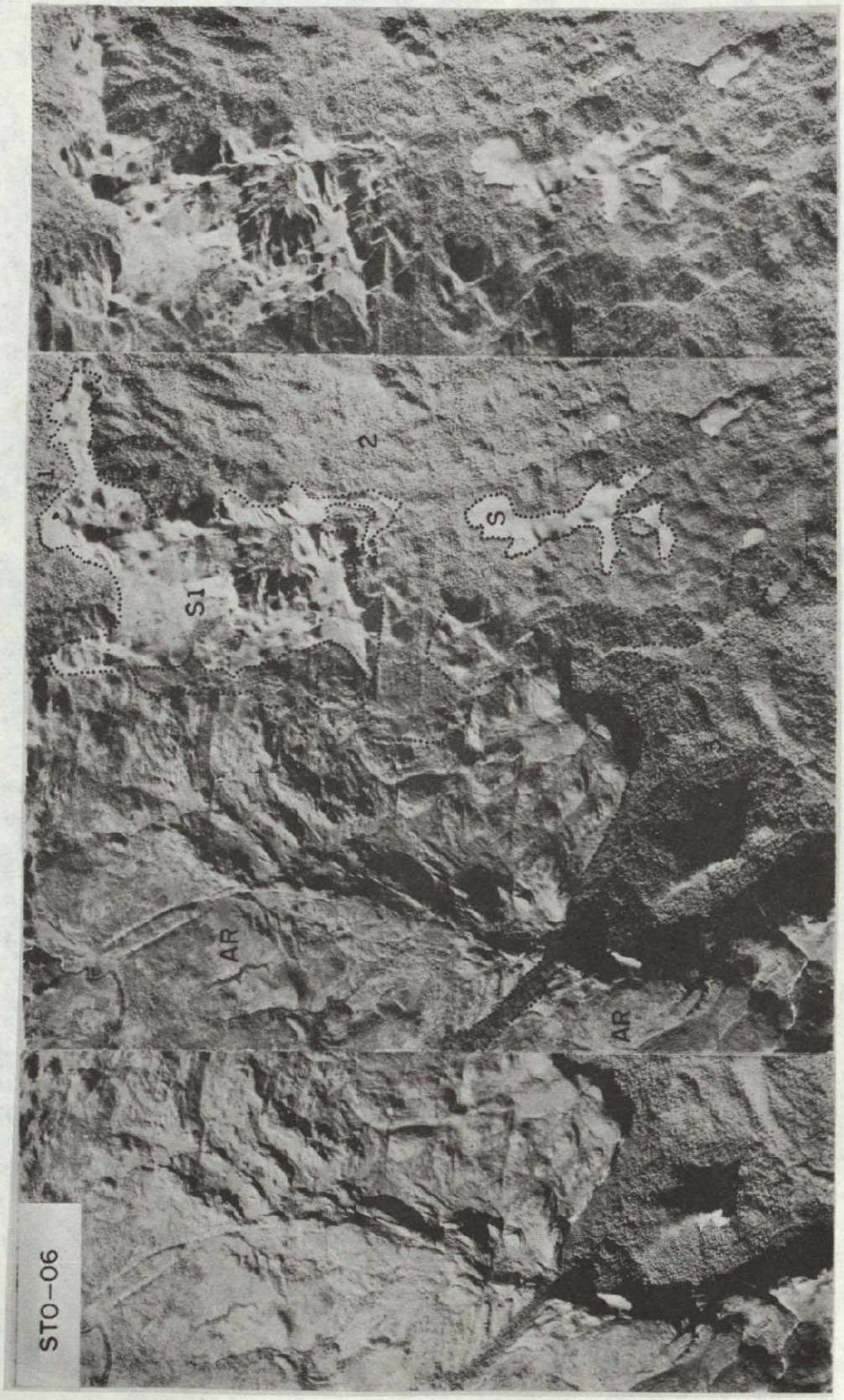
The rocky outcrop presents a very dark grey tone.

The zones corresponding to S/S1 on Band 5, cannot be distinguished fir presenting the same tone as the rocky outcrop.

Zones 2 and 3 can be separated by the different tones indirectly due to the grade of the dissection of the area.







STI. 01. Flat land. low hills and high flat land

Original Scale -1:50.000

Date of photography Novembre 1970 (rainy season)

Pancromatic Film

1. Region of flat land, (high, light forest).

2. Region of high flat land (medium dense forest).

3. Zone of low hills (high, light forest).

AR. Rocky autcrop.

ERTS IMAGE

Band 7

Scale 1:250.000

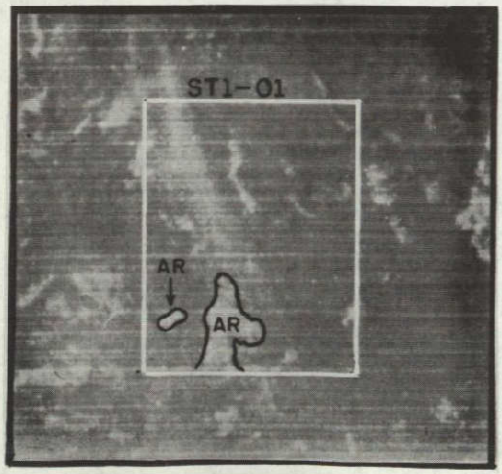
Date of photography March 9, 1970 (rainy season)

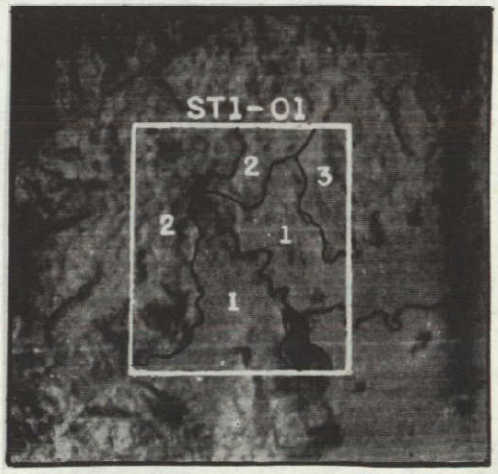
The rocky outcrops (AR) are clearly distinguished for their dark grey tone and the sence of relief which is observed.

Zone 1 presents a river of sinousidal form and a uniforme grey tone.

Zones 2 and 3 show low hills and high flat land.

Zone 3 con be mistaken for zone 1 due to its tone but presents certain impression of relief wich permits the separation.





From the comparison of all conventional photographies and ERTS IMAGE, and based on the study realized on band 5 and 7, in a general manner the following elements can be separated.

1. Hydrography

a. Lakes, moors and rivers can be clearly distinguished. When there are courses of small waters, they can be identified in the savannas and only in the presence of galery forests.

The alluvial plain land and abandoned streams can be delineated on both bands, the water showing on both bands a dark tone.

On band 5 there is a difficulty to separate the forest zone from the water streams, due to the same dark tone they present. The sands, when the water stand is shallow, may be identified by the higher tone.

On band 7 (8a 1.1) the alluvial plain land and the water courses can be easily separated due to the different tone, but the sands cannot be distinguished.

On band 5, when high vegetation appears (forest) the water courses cannot be distinguished since they present the same black tone as the vegetation, and this, due to a greater absorption of the electromagnetic energy by the leaves.

On band 7 on the contrary, the water courses of greater water volume are easily delineable, and those with less water volume may be followed taking into account the relief impression.

2. Topography

On band 5 the topography can be identified only in the savanna re-

gion (light grey tone), but when there exists a tree vegetation (dark tone) then no topographical separation can be made. The rocky outcrop on this band is observed by its dark grey tone, but presents a lighter tone than that of the forestal vegetation.

On band 7, the topography of the flat land zone covered by savanna may be identified by its dark tone, whereas in the zones covered by tree vegetation on flat land as well as on the rolling land the low and high hills and rocky outcrops can be separated.

The flat land zone presents light grey tones, that difficult the separation of the savanna, if it is not done by relief impression.

3. Vegetation

1. Savanna.

On band 5, the savanna presents a light grey tone, but the presence of shrub vegetation and soil humidity let it appear in a darker tone.

On band 7, the savanna presents a dark grey tone, but due to the presence of tree vegetation and greater soil humidity it appears of a lighter tone.

This difference in the savanna's aspect on both bands is due to the difference in the wave length and consequently to the higher or lower absorption and reflection of electromagnetic energy.

2. Forest types

On band 5, the vegetation zones (tree and shrub) can only be distinguished for their uniform darker tones, but the forest types cannot be differentiated.

On band 7, the tree vegetation limits may be separated by their light grey tone, but no separation can be made of the forest types within them. Some separation can be effected only if the physiographical characteristics are used as well as some small differences in the texture of the image.

3. Human influence.

a. Tree Felling

These may be observed on band 7, whenever their surface is of considerable extension. Due to the darker grey tone than that of the surrounding land, to the geometric forms, and to the fact that, usually they are sited near or at river shores, they can be mistaken for rocky outcrops, but they are different for not giving relief impression. Indigenous small crop cultures ("conucos") may also be distinguished because of their rounded form. On band 5, roads and settlements may be detected.

4.5. FINAL CONCLUSIONS

From the study (work) carried out the following conclusions can be enumerated: later, and with more experience in this technique and after more sound studies, more definite criterion shall be given.

1. The ERTS image permits the obtention of a panoramic vision of the area, and facilitates the exact delineation of major drainages (Band 7).
2. The topographic changes may be easily observed (Band 7)
3. The rocky outcrops are easily distinguishable on Band 5 and 7.
4. The savanna areas may be delimited on both bands, 5 and 7.
5. The shrub vegetation zones are distinguishable on both bands, 5 and 7 without possible separation of forest types, this is possible only when the physiographic conditions of small textural differences are taken into account (Band 7).
6. The human influence can be observed on bands 5 and 7, when presenting certain extension of importance.

FOLDOUT FRAME 1

FOLDOUT FRAME 2

REPUBLIC OF VENEZUELA

MINISTRY OF AGRICULTURE AND BREEDING

DIRECTION OF RENOWABLE NATURAL RESOURCES
FOREST DIVITION
PHOTO INTERPRETATION SECTION

SIPAPO FOREST RESERVE
(NORTH SECTOR)

PRELIMINARY INTERPRETATION OF IMAGES ERTS-1
(N°1229-14151) BAND 7

COMPARISONS WITH CONVENTIONAL PHOTOGRAPHY

SCALE 1:500.000

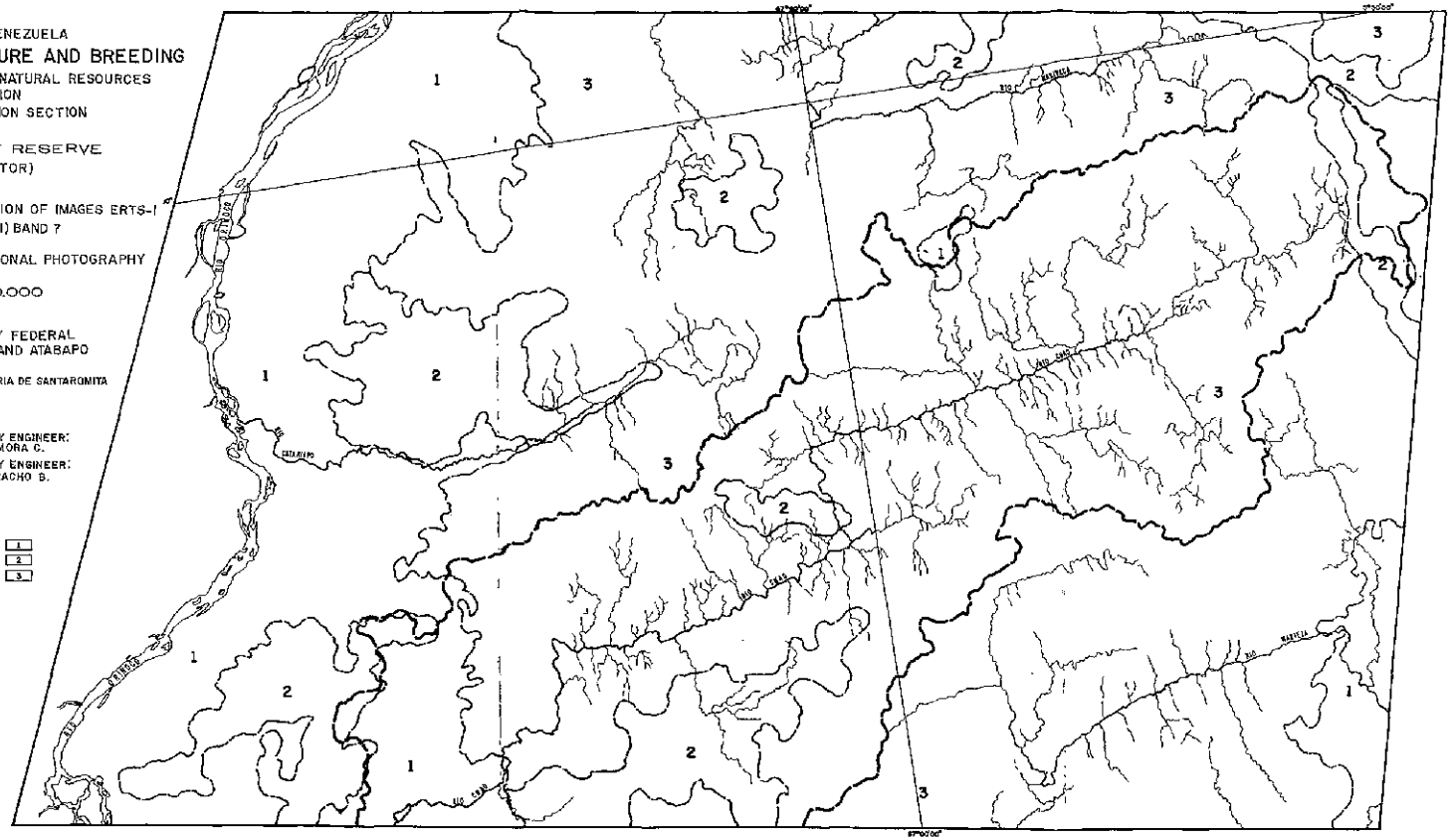
UBICATION
AMAZONAS TERRITORY FEDERAL
DEPARTAMENT ATURES AND ATABAPO

CO-INVESTIGATOR: ENGINEER GLORIA DE SANTAROMITA

COLLABORATE { FORESTRY ENGINEER: ROMULO MORA C.
FORESTRY ENGINEER: JESUS BRACHO B.

TOPOGRAPHY

LAND PLANE 1
LAND SCALLOPED 2
LAND OF HIGHLAND LOW 3



FOLDOUT FRAME 1

FOLDOUT FRAME 2

REPUBLIC OF VENEZUELA

MINISTRY OF AGRICULTURE AND BREEDING

DIRECTION OF RENOWABLE NATURAL RESOURCES

FOREST DIVITION

PHOTOINTERPRETION SECTION

SIPAPO FOREST RESERVE
(SOUTH SECTION)

PRELIMINARY INTERPRETATION OF IMAGES ERTS-1
(Nº1229-1454) BAND 7

SCALE 1:500.000

UBICATION
AMAZONAS TERRITORY FEDERAL
DEPARTAMENT ATURES AND ATABAPO

CO-INVESTIGATOR FORESTRY ENGINEER GLORIA DE SANTAROMITA

COLLABORATE
- FORESTRY ENGINEER: ROMULO MORA C.
- FORESTRY ENGINEER: JESUS BRACHO B.

LEGEND

- FOREST
- SAVANNAS
- DESFOREST AREA
- ENHABITED PLACE

MINISTRY OF PUBLIC WORKS

DIRECTORATE OF NATIONAL CARTOGRAPHY

CHART DIVISION

REMOTE SENSING DEPARTMENT

"DEVELOPMENT OF TECHNIQUES TO SIMPLIFY THE PROCESS OF INVESTIGATION AND ESTIMATE OF NATURAL RESOURCES IN REMOTE AND RELATIVELY UNEXPLORED AREAS" (VENEZUELA).

NUMBER SR - 0120

CARTOGRAPHY

CARTOGRAPHIC APLICATIONS OF ERTS-1 IMAGES IN SMALL SCALE TOPOGRAPHIC AND THEMATIC MAPS.

By: Pedro MOLINA
Geodetic Engineer

Rafael LAIRET
Geographer

INTRODUCTION

The utilization of ERTS-1 Images for the elaboration of small scale maps (1:250.000 to 1:1.000.000) of the study area, was established as a goal during the VEN-02 program.

Before receiving the first usable images (April, 1973), it was only counted on Conventional photographs and Radar Images which were used to elaborate preliminary charts at a scale of 1:100.000 and 1:500.000.

Programs were established to obtain astronomic first order points in the area using Geodetic Satellites.

The results obtained up to the present show the possibility of elaborating, small scale maps and updating maps at scales of 1:250.000 and smaller, from ERTS-1 Images.

5.1. CHARACTERISTICS OF THE ERTS-1 IMAGES

In July 23, 1972, N.A.S.A. orbitted the ERTS-1 Satellite with the following orbital parameters.

Orbit parameter	Nominal orbit	Definitive orbital
Semi Major Axis	7.294,69 Km	7.285,82 Km
Inclination.	99.092 deg	99.114 deg
Period.	103.267 min	103 min 16 seg
Eccentricity	0	0.0006
Time at descending node (equatorial crossing)	9:30 a.m.	9:30 a.m.
Coverage cycle Duration	18 days (251 Rev)	18 days (251 Rev)
Distance between Adjacent grounds tracks.	159.38 Km	159.38 Km.

Of the onboard satellite equipment, information was only received from the M.S.S. (Multispectral Scanner).

The M.S.S. is a linear exploratory system, whose exploratory part is an oscillating mirror which sweeps the scene beneath the satellite and perpendicular to the flight direction. It simultaneously obtains data from four spectral bands in the visible region (0.5 - 1.1).

The instantaneous field of view (ifov) of each detector is of 79 mts. on the terrain.

The sensor sweeps 474 mts. along its trayectory each 73.42 mili-

seconds; the six detectors sweep the 185 Km. in approximately 3 sec.

According to the N.D.F.E., error sources are classified in the following manner:

1. External sensor errors
2. Internal sensor errors
3. Processing errors

Each of these errors can affect the position accuracy and/or the image registration.

The external errors are:

Name of error	MTS.
1. Sensor Alignment	656
2. Ephemeries position	128
3. Exposure time	22
4. Attitude	814
Resultants	1.052 mts.

The internal errors are:

1. Mirror jitter
2. Scan start time
3. Detector alignment
4. Sample time
5. Scan end time
6. Uncertainty in calibration of mirror scan profile and drift.

The root means square error (RMS) established by N.A.S.A., and produced by the internal errors sources of the M.S.S. is approximately 25 mts.

When combined, the internal with the external errors of the M.S.S. imagery, the resultant error is approximately 1,053 mts. on the input imagery to the N.D.P.F.

In the N.D.P.F. or data proccessing center the imagery is being proccessed and after are sent to the principal investigators.

Positional Mapping Accuracy

Film Products	1,075 mts.
Paper Products	1,085 mts.
Registration Accuracy	155 mts.

The precision output product produced by the N.D.P.F., using control points have the following R.M.S.:

Positional Mapping Accuracy

Film Products	235 mts.
Paper Products	250 mts.
Registration Accuracy	150 mts.

The material received is formed by positive third generation 70 mm images with mean errors equivalent to those pertaining to the first graphic of positional mapping accuracy.

In the work done with the ERTS-1 images, for cartographic purposes, the starting point errors were those which appear in the bulk products distributed to the principal investigators by the G.S.F.C.

Precision images were elaborated within the VEN-02 program using photographic rectification (ZEISS SEG V), with mean errors which fall within the tolerance margen established for the reproduction scales (1:250.000 and 1:500.000).

The following chapters will treat in greater detail, errors, rectification, precision processing (photographic) and the obtained results.

5.2. AVAILABLE MATERIAL

Before receiving the first ERTS-1 Images, the existing basic cartographic material was:

Conventional Photography

Scale	Camera	FD	Work	Work Scale	Control	%Area
1:50.000	Wild Reg	88,5 mm	Preliminary Charts	1:100.000	2nd Order Points	75%

Radar

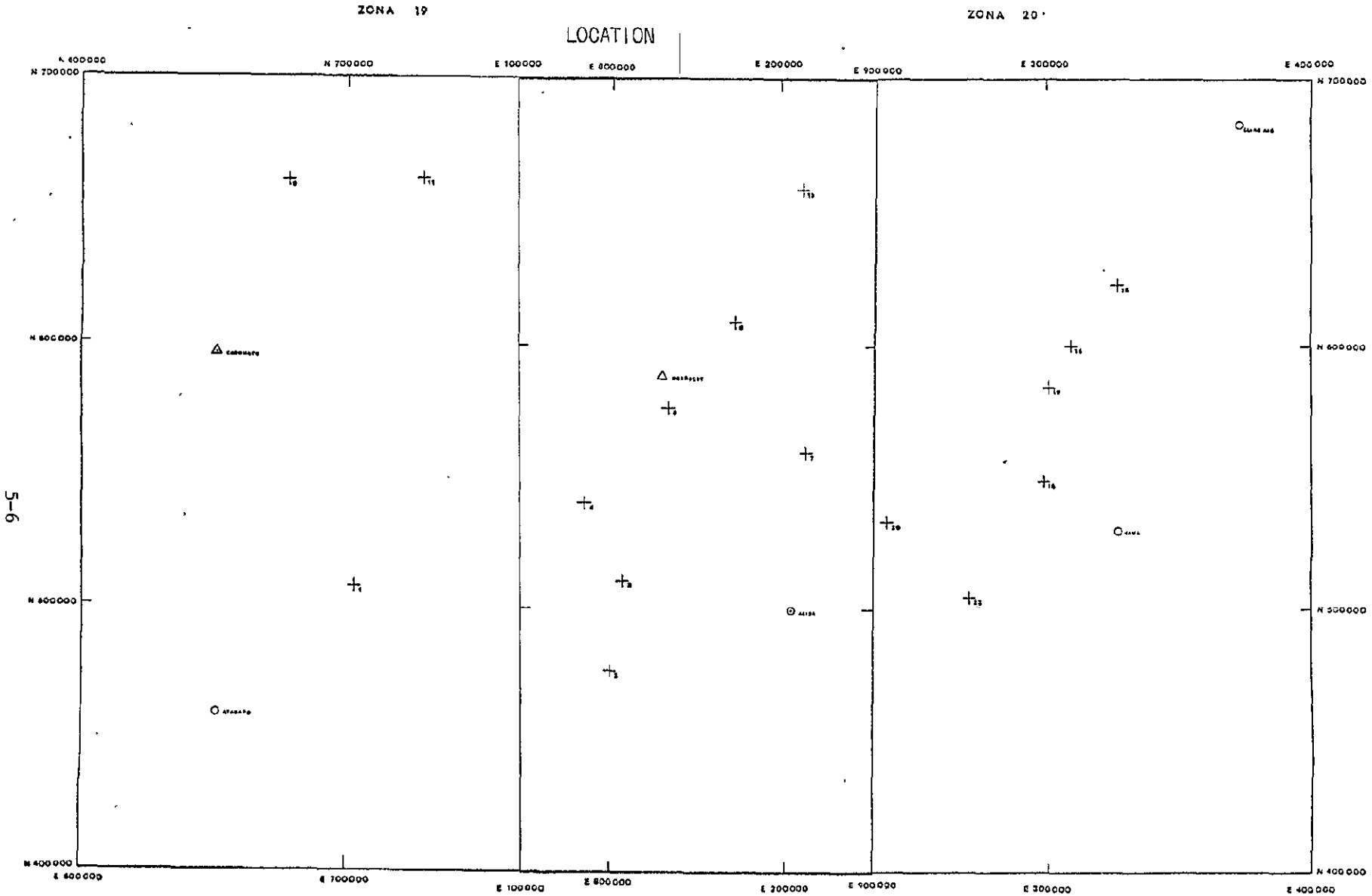
1:400.000	Goodyear APQ 102	3,12 cm	Preliminary Charts	1:500.000	2nd Order Points	100%

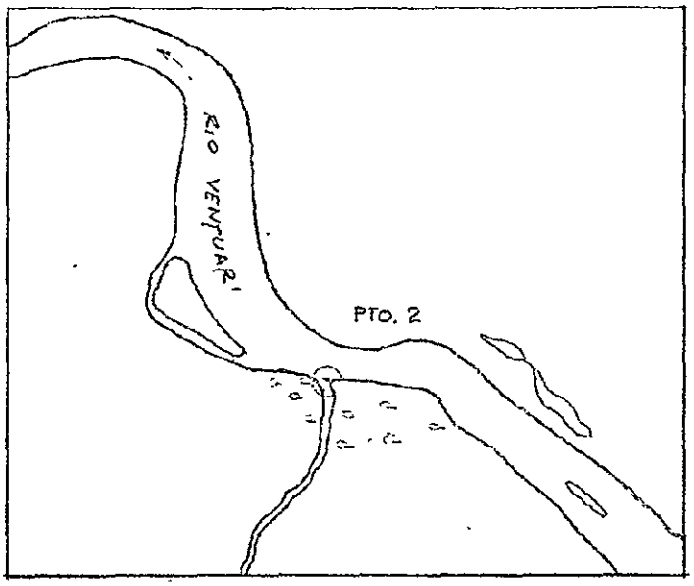
Within the proyect area, 65°-67° 30' longitude west and 4°-6° latitude north, first order triangulation, first and second order astronomic points were measured, as part of the program were available (see diagrams and figures).

The basic cartographic material used was a map at a scale of 1:100.000 this map covered the sectors west and north of the study area between 6°and 6°30' north latitude, between 66° and 68° longitude west.

CONTROL POINTS

LOCATION





POINT 2 DESCRIPTION ---

AREA AMAZONAS TERRITORY

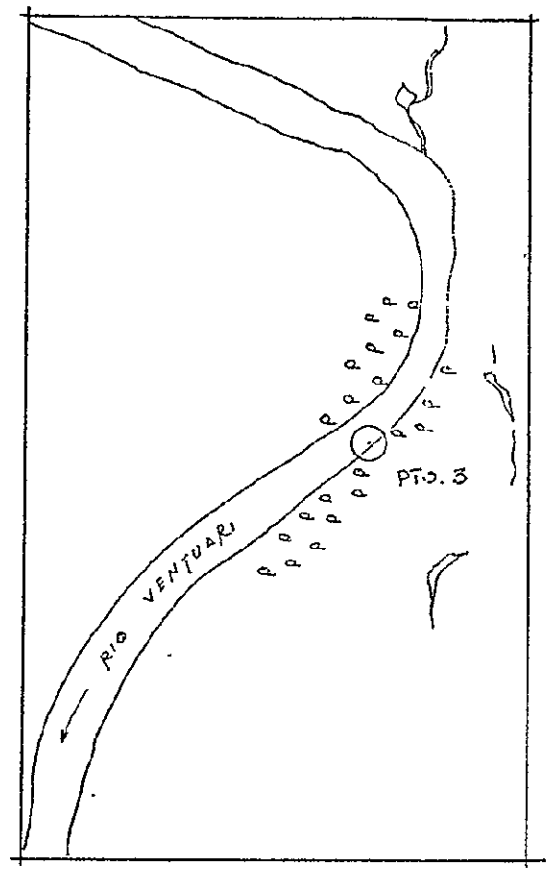
N Zone 19 475.830 E 799.887 ELEV --

LATITUD 4° 18' 0" LONGITUD 66°17' 54" ELEV --

Map Name ---- PHOTO 05 04 07 188

SPHEROID ---

N Zone 20 476.091 E 133.765



POINT 3 DESCRIPTION --

AREA AMAZONAS TERRITORY

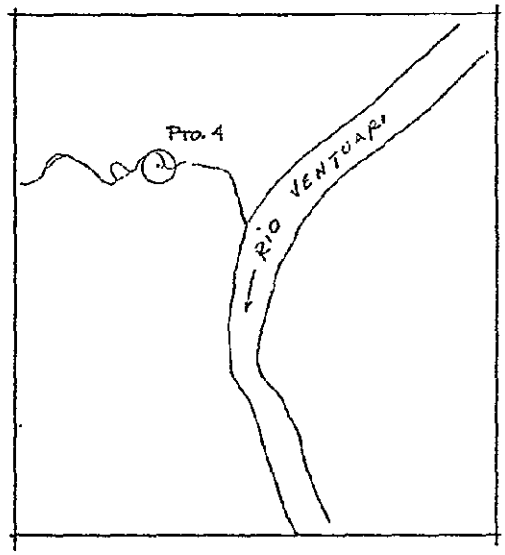
N Zone 19 510.381 E 804.602 ELEV --

LATITUD 4° 36' 43" LONGITUD 66° 15' 17" ELEV --

Map Name ---- PHOTO 05 04 07 1339

SPHEROID ----

N Zone 20 510.620 E 138.764



POINT 4 DESCRIPTION --

AREA AMAZONAS TERRITORY

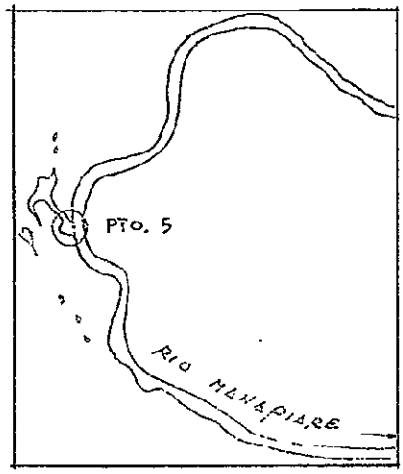
N Zone 19 539.914 E 790.027 ELEV --

LATITUD 4° 52' 46" LONGITUD 66°23' 6" ELEV --

Map Name ---- PHOTO 05 04 07 1939

SPHEROID ----

N Zone 20 540.295 E 124.438



POINT 5 DESCRIPTION --

AREA AMAZONAS TERRITORY

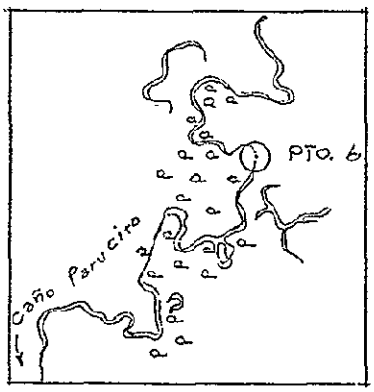
N Zone 19 576.152 E 821.747 ELEV --

LATITUD 5° 12' 20" LONGITUD 66° 5' 52" ELEV --

Map Name ---- PHOTO 05 04 07 1189

SPHEROID ----

N Zone 20 576.256 E 156.350



POINT 6 DESCRIPTION --

AREA AMAZONAS TERRITORY

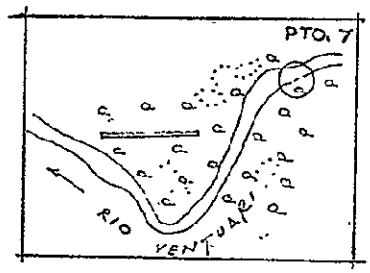
N Zone 19 608.646 E 846.842 ELEV --

LATITUD 5° 29' 53" LONGITUD 65° 52' 13" ELEV --

Map Name ----- PHOTO 05 04 07 684

SPHEROID ----

N Zone 20 608.502 E 181.915



POINT 7 DESCRIPTION --

AREA AMAZONAS TERRITORY

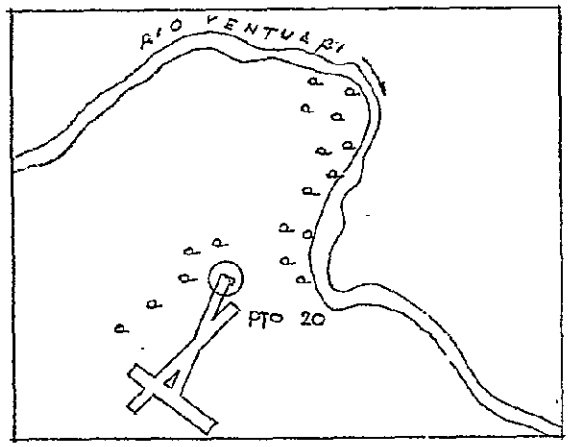
N Zone 19 599.146 E 873.949 ELEV --

LATITUD 5° 2' 59" LONGITUD 65° 37' 42" ELEV --

Map Name ---- PHOTO 05 04 07 1168

SPHEROID ----

N Zone 20 558.766 E 208.531



POINT 20 DESCRIPTION --

AREA AMAZONAS TERRITORY

N Zone 20 533.042 E 239.237 ELEV --

LATITUD 4° 49' 6" LONGITUD 65° 21' 3" ELEV --

Map Name ---- PHOTO 26 - 083 N

SPHEROID

The control points that were used to rectify the images to elaborate the controlled mosaic of the area, are shown in a graphic at a scale of 1:2.000.000.

5.3 CARTOGRAPHIC QUALITY OF THE IMAGES

To make a good evaluation of the ERTS-1 images from a cartographic point of view several parameters were analized: positioning, resolution, distances and cartographic accuracy.

Positioning

Control points were identified over the study area. These were first and second order astronomic points. The first order were measured during the geodetic satellite jointly with the I.A.G.S. (Defense Map Agency).

Prior to the geociver program the department had a series of points within the study area 16 of them were second order and a few, first order from the triagulation net, Puerto Paez-Samariapo.

A list of coordinates of all these points is shown below:

COORDENADAS U. T. M.

MERIDIANO CENTRAL 69 ZONA 19

		φ	λ	N	E
Punto	1	4° 35' 21"	67° 10' 13"	507537	702976
Punto	2	4° 18' 0"	66° 17' 54"	475830	799687
Punto	3	4° 36' 43"	66° 15' 17"	510381	804602
Punto	4	4° 52' 46"	66° 23' 6"	539914	790027
Punto	5	5° 12' 20"	66° 5' 52"	576152	821747
Punto	6	5° 29' 53"	65° 52' 13"	608646	846842
Punto	7	5° 2' 59"	65° 37' 42"	559147	873049
Punto	13	5° 56' 55"	65° 38' 17"	658566	872315

COORDENADAS U. T. M.

MERIDIANO CENTRAL 63 ZONA 20

		φ	λ	N	E
Punto	2	4° 18' 0"	66° 17' 54"	476091	133765
Punto	3	4° 36' 43"	66° 15' 17"	510620	138764
Punto	4	4° 52' 46"	66° 23' 6"	540295	124438
Punto	5	5° 12' 20"	66° 5' 57"	576256	156350
Punto	6	5° 29' 53"	65° 52' 13"	608502	181915
Punto	7	5° 2' 59"	65° 37' 42"	558766	208531
Punto	13	5° 56' 55"	65° 38' 17"	658220	207898
Punto	15	5° 38' 9"	64° 38' 47"	623195	326873
Punto	16	5° 25' 30"	64° 43' 9"	599936	309486
Punto	17	5° 16' 57"	64° 47' 52"	584212	300741
Punto	18	4° 57' 37"	64° 48' 50"	548572	298860
Punto	20	4° 49' 6"	65° 41' 3"	533042	239237
Punto	23	4° 33' 28"	65° 4' 5"	504128	270530

septiembre 1.972

U.T.M COORDINATES	N	E	Z	ZONA
MORROCOY	537.876.26	819.474.48	840.24	19
ATABAPO	458.777.66	650.583.62	215.51	19
SAN CARLOS	212.460.12	716.405.65	79.05	19
COCUY	138.951.95	742.942.51	295.57	19
MAROA	301.806.14	661.818.01	79.64	19
COROMOTO	595.730.682	651.180.783	371.40	19
ASISA	499.098.35	202.692.59	1.665.24	20
DUIDA	363.395.83	211.038.16	2.232.29	20
CERRO ARO	682.924.27	372.830.61	490.54	20
JAUA	529.620.24	326.989.91	2.227.98	20
FRONTERA 4	348.054.26	364.278.39	1.413.34	20

GEOGRAPHICAL COORDINATES	ϕ	λ	Z
MORROCOY	5° 18' 42".332	66° 07' 04".732	840.24
ATABAPO	4° 08' 57".912	67° 38' 36".204	215.51
SAN CARLOS	1° 55' 15".782	67° 03' 16".466	79.05
COCUY	1° 15' 22".348	66° 49' 00".599	295.57
MAROA	2° 43' 46".555	67° 32' 39".681	79.64
COROMOTO	5° 23' 16".8519	67° 38' 03".0471	371.40
ASISA	4° 30' 37".471	65° 40' 44".380	1.665.24
DUIDA	3° 17' 08".424	65° 35' 59".623	2.232.29
CERRO ARO	6° 10' 37".493	64° 08' 56".024	490.54
JAUA	4° 47' 22".907	64° 33' 35".846	2.227.98
FRONTERA 4	3° 09' 53".416	64° 13' 16".991	1.413.34

Positioning errors were evaluated in the following manner.

Grid lines corresponding to longitude and latitude were drawn in the images.

Control points were identified in the images by visual inspection with the aid of 4 x magnifier. The points identified were located first in conventional photography.

From this location on the images, their position were calculated in images geographical coordinates.

The image that was used for this evaluation is:

Image No.

Date: November

Point 4: Ground Coordinates

Lat. : 4°52' 46" Long : 66°23' 06"

Point 5: Ground Coordinates

Lat. : 5°12' 20" Long : 66°05' 52"

Point 4: Images Coordinates

Lat. : 5°01' 00" Long : 66°20' 00"

Point 5: Images Coordinates

Lat. : 5°19' 30" Long : 66°01' 45"

Differences between Coordinates:

Point 4: Lat. 8' 14" Long 3' 06"

Point 5: Lat. 7' 10" Long 4' 07"

Graphs show the direction and magnitude of both errors.

RESOLUTION

According to NASA the minimum detectable area for the M.S.S. system is 79 mts. (I.F.O.V.), including all of the other six detectors is 474 mts.

During the time of the investigation several analysis were conducted to evaluate the precision levels for the identification of different objects in the ERTS-1 images.

Two parameters were taken in consideration

1) Size of objects
2) Tonal response differential (caused by back ground conditions).

It is well known that size of the objects affects the capacity of detection of any sensor.

Objects less than 79 mts. in size are very hard to detect, unless the differential contrast in tone is very high.

The contrast between the objects and surrounding areas is very important to a good identification.

Therefore, some objects larger than 79 mts. are difficult to detect due to their poor contrast, between the object and the surrounding area.

The best examples that were found, to prove the usefulness of the systems for detection techniques were: airports, cultivated areas, highways, and very small tree groupings that are very close to the limit of the system in resolution.

The Airports that were identified as examples are, Puerto Ayacucho, Yutaje and Manapiare, the dimensions of these airports are very similar and built in areas with very large differences in tones.

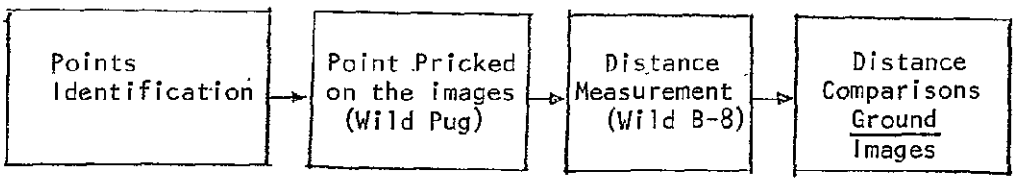
The measurements and tonal analysis were made using bands 5, and 7.

The same analysis were performed of all the existing roads and trails. With respect to the vegetation groupings and cultivated areas, band 5 was chosen due to the fact that it is the one which permits a better vegetation identification. Measurements and calculations were also performed using the color composites of the corresponding images.

DISTANCES

The accuracy of a distance is a very important element in checking the fidelity of the scale during the process of rectification; for the calculation of distances, the points that were used are the ones mentioned before. The ones measured with geoceiver and first order triangulation were the most important ones.

The process for the measurement was conducted as follows:



Accepting the images as an orthogonal projection of the earth's surface, the trigonommetric formulae for distance measurement was used.

Aplying the same process to the image No. 1102-14090 of November 2, 1972

$$d = \sqrt{(576.152 - 539.914)^2 + (821.747 - 790.027)^2}$$

$$d = \sqrt{2.319.351.044}$$

$$d = 48,159 \text{ km}$$

For image at a scale 1:1.000.000

	x	y
Point 4.	754.01	386.63
Point 5.	729.16	345.45

$$\text{Distance} = \sqrt{x^2 + y^2} = 48,088 \text{ mm.}$$

Assuming that the enlargement was exact at 1:1.000.000 (3,369 enlargement factor), the differences between ground and image distance was.

Ground	:	48,159	km	
Image	:	48,088	km	
Difference	:	0,071	km	= 71 mts.

5.4. CONCLUSIONS

Cartographic Precision

Due to the inexistence of precise cartographic information in the area, it was necessary to choose another close by, for which photogrametric charts at scales of 1:250.000 and 1:100.000 (Western zone of Bolivar, Eastern Apure and Northwestern part of the Amazonas) exist.

In order to verify the cartographic precision of the images, the images were superposed on maps at the same scale. In the first part of the process non-rectified images were used after which, rectified images were used.

In general the images coincided very well with the maps existing discrepancies only in the rivers, this is due to the fact that the rivers are constantly changing their courses.

In maps at scales of 1:250.000 or less, the information which can be extracted from the ERTS-1 images is of incalculable value in the topographic planimetric aspect as well as in the thematical aspect.

Topographic Maps - Photo-maps and thematical Maps

The utilization of ERTS-1 images in the elaboration of topographic maps and thematical maps implies the following process:

1) Scale determination
2) Image processing
3) Reproduction-publication

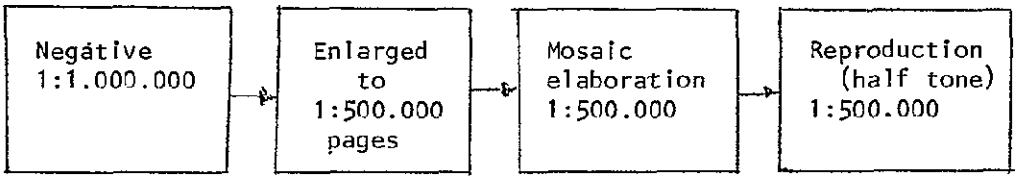
1) Scale determination

The experience won during the program, showed that the optimum scale for photo-maps to be 1:500.000 and for the basic work in the

elaboration of topographic and thematical maps to be 1:250.000.

The scale of 1:500.000 was chosen for the elaboration of photo-maps due to the problems which arose in the processing of the originals because of the loss of details and contrast which are very important in said maps.

The procedure followed was:



2) Image Processing

The elaboration of controlled and semi-controlled photo-maps was established. In the elaboration of the semi-controlled photo-maps only the scale was corrected using control points, but in the elaboration of controlled mosaics the normal procedure of rectification was followed.

Procedure:

(graph)

3) Reproduction-publication

For the reproduction and the later publication, the materials chosen were the most adecuate, amongst these are the screens used in the elaboration of the half tones.

175 and 300 lines/inch screens were used in the black and white prints and for the color reproduction 175 lines/inch screens were used.

These screens were chosen in order to maintain the reproduction's detail level close to the resolution level of the multispectral system.