Paper G 26

ERTS-A MULTISPECTRAL IMAGE ANALYSIS CONTRIBUTION FOR THE GEOMORPHOLOGICAL EVALUATION OF SOUTHERN MARACAIBO LAKE BASIN

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Multispectral analysis of ERTS-A images at scales of 1:1.000,000 and 1:500,000 has been conducted with conventional photointerpretation methods (direct observation with the aid of magnifying glass). Specific methods have been developed for the geomorphological analysis of southern Maracaibo Lake Basin (71°30' - 72°30' long. W, 8°00' - 9°00' lat. N) which comprises part of the Venezuelan Andean Range, Perijá Range, the Táchira gap and the Southern part of the Maracaibo Lake depression.

A steplike analysis was conducted to separate macroforms, landscapes and relief units as well as drainage patterns and tectonic features, which permitted the delineation of tectonic provinces, stratigraphic units, geomorphologic units and geomorphologic positions. The method of analysis allowed further knowledge on types of faults, lithologic characteristics as well as the identification of paleoprocesses and actual processes and the application of geochronological criteria on certain forms. The geomorphologic synthesis obtained compares favorably with conventional analysis made on this area for accuracy of 1:100,000 scale, and in some features with details obtained through conventional analysis for accuracy of 1:15,000 and field work.

Geomorphological units in the mountains were identified according to changes in tone, texture, forms orientation of interfluves and tectonic characteristics which control interfluvial disimetrics. Observation of tonal variation and contrast within interfluves allowed the identification of paleoforms. Geochronological inference was based on actual modeling and topographic position of forms.

Units were identified at Piedmont according to forms and topographic expression. Sedimentary deposits were identified (terraces, terraces-coluvial fans and other coluvial forms), and again, its modeling and topographic position gave way for geochronological induction.

At the plains, units were separated through a comparative analysis of tone and textural patterns as well through the evaluation of drainage characteristics. These units were redetailed according to fluvial dynamics.

1. Introduction. The main objective of this project has been to develop a method for the analysis of natural resources, valid at different physiographic media. Physical environment is being analyzed and its results are comparable with those obtained through other conventional methods, in terms of time, precision and maximum details. With this paper, a first level of analysis has concluded pertaining to Hidrography, Geology and Geomorphology. Thematic maps were prepared to the scale of 1:500,000 and details obtained were compared with fieldwork. Multispectral image (ID 1071.14361) prints at scales of 1:1,000,000 and 1:500,000 were analyzed with the aid of a magnifying glass. Analysis was conducted stepwise with the separation of macroforms, lands capes and units of relief. Interpretation of drainage patterns and of structural characteristics permitted to establish tectonic provinces, stratigraphic units, sectors and geomorphologic positions.

   The methodology utilized permitted definition of type of faults, the identification of paleoprocesses, actual processes and the application of geochronologic criteria to certain geomorphological units. A geomorphological synthesis of each one of the environments analyzed was prepared and its results are comparable in some instances to those obtained at scales of 1:25,000. Nevertheless, the method needs further revision and more sophisticated equipment in order to reach a final pattern definition stage.

   At the mountains, units were defined according to tonal changes, texture, forms and orientation of interfluves as well as for those tectonic characteristics which control disimetrics of interfluves. Tonal variations, actual modeling and relative position of deposits permitted to identify paleoforms and to conduct geochronological inferences. At the piedmont, units were defined according to form and topographic expression. Accumulations such as terraces, and aluvial fans were detected and through their modeling and position, geochronological inferences were conducted.

   At the planes, units were differentiated by tone, textural pattern and drainage pattern. Those units were redetailed according to predominant fluvial dynamics.

2. Relief. A thematic map was drawn based on analysis of linears, drainage and depth of image (especially band 5). Mountains, piedmont and plains were evaluated as separated units. Valleys were not identified in the map due to cartographic scale of 1:500,000.

In the mountains, the analysis of principal, secondary and elementary interfluves permitted a detailed appraisal of drainage as well as an approximation to the qualification of watershed modeling. Difficulties were encountered because of tonal changes due to the effects produced by the zenital angle. Shadows derived from contrasting altitude of mountains interfered form and structural characteristics differentiation.

At the Andean piedmont, modeling patterns, degree of dissection, disposition of accumulations and relative location have been taken into account. At the Perijá Region, according to its own morphographic characteristics, it was necessary to take into account tonal contrasts as well as dissection of materials to separate areas of different slope.

Towards the Macizo Avispa-Capaz area, mountain-piedmont-plains transitional areas are very short. Piedmont has been poorly developed as formed by detritic early quaternary materials.

At the planes, two subunits were defined, according to topographic characteristics: High planes and flooded planes. There were observed some semicircular tonal anomalies that could correspond to an old showline. North of this linear slope decreases and further on predominate areas of bad drainage. Flooded areas increase E to W and S-N.

Lake shore is contrasting. Eastwords, rivers Santa Ana, Catatumbo, Escalante and Chama have drawn sequences of bays and keys with combined processes of fluvial and lacustrine sedimentation. At the west coast, the sedimentation discharge is smaller; thus morphological characteristic, are more regular and gentle.

3. Hydrography. Differences in tone, relief and vegetation (bands 5 and 7) permit enough information on principal, secondary and tertiary drainage, permanente and temporal lagoons, wetlands and marshes.

The three gross landscape units condition drainage characteristics and thus, the method to analyze its patterns. A more complete morphometric analysis was left for next level of analysis.

At the mountain, with the help of preliminary morphometry, it has been possible to obtain information on sporadic (elemental) drainage aided by topographic expression. Bodies of water of glacial lagoons at the Serranías de la Culata, Tovar and Sierra Nevad are observed distantly in band 7.

At the Piedmont, the study of drainage patterns depends on topographic expression, although tone and texture are good indicators of drains. In the plains, contrasting tonal responses and textural patterns permit the recognition of permanently and temporally flooded areas. Some vestiges of paleochanels were identified, and its identification was of great help for the study of fluvial dynamics. Comparison of bands 5 and 7 was very useful in the evaluation of drainage density.

Band 7 permits a precise and detailed analysis of drainage patterns. Results obtained with orbital images better considerably 1:50,000 cartographic work at hand. In the mountains, structure exerts an important control on water channels, on their organization and on their hierarchy. At the piedmont there can be observed two combined patterns, one dentritic controlled and the other parallel.

At the plains, it was encountered that the river beds or some of their sectors, presented anomalous shapes due to structural influence. Badly drained areas are identified by the presence of wetlands, marshes, floods and are frequently marginal to the rivers and to the shoreline.

4. Geology. Two different thematic maps have been obtained: structural and stratigraphic. The criteria applied for the identification of structural characteristics was the observation of lineaments expressed mainly through significative variation of texture and tone. The presence of aligned surfaces was detected through conventional methods: Topographic expression, structural control over drainage, drastic changes in modeling, displacement of strata, etc. Faults detected (principal and secondary) were ground truthed and when there doubts they were drawn as simple lineaments. Synoptic characteristics of images permitted the detection of now regional faults as the one called falla frontal del piedemonte, which could be a quaternary fault.

The analysis of strata (dip and direction) allowed identification of folds, syncline and anticline.

In order to systematize the observation of structural characteristics, a synthetic map was drawn which shows tectonic blocks: Andes, depressión del Táchira, Perijá y Llanos.

For the identification of geological units, tone, texture and modeling were keyed. Further work is being concentrated on differentiation of rock units.

5. Geomorphology. Methodological approach varied with landscape gros units.

At the mountains sectors were identified according to tone, texture, form and disposition of interfluves and tectonic activity. At the Perijá Region, lithological differences were introduced as a criteria for sectorization. Same criteria were taken into account for details within sectors. Additional criteria were introduced (actual modeling and topographic position) for relative geochronology of accumulations. It was also possible to define the presence of altered materials (when thickness is important) through the analysis of watershed slope and softness, modeled by deep water channels. In some cases, disposition and regularity of interfluves permitted a comparative analysis of processes.

In the Macizo de Capas, it was possible to identify processes of solifluxion type. At the Piedmont the identification of sectors was mainly based on form, topographic expression and dissection of forms. There were distinguished Piedmont accumulations, terraces, cones-terraces and colluvial valleys. Their relative geochronology was infered same as in the mountains.

For the Perijá region identification parameters were tone and texture predominant forms identified were glacis and colluvial glacis.

At the plains, three different sectors were identified according to morphogenetic differentials:

East of Chama Catatumbo-Zulia-Tarra System	Chama Escalante - System Central flooded System

East of Chama river corresponds to a transitional system formed by rivers Mucujepe, Capaz and Frío. According to tone and textural patterns there were identified the following units:

- An area of gradual and transitional sedimentation. Some paleo-channels within.
- A coalescent drainage outing.

The system Escalante-Chama contains a deltaic uoting. Through textural and tonal patterns there were recognized the following:

- Channels of periodical heapage.

- Granulometry inferred from drainage patterns and resulting topographic forms.

- Heavy material has been carried near the lake shore.

In the Catatumbo-Zulia and Terra system, river outing is common with heapage of channels. Small basins and heapage channels were identified. At the central flooding sector there were identified blocked basis, areas of permanent decantation and frontal basins near the lake shore.

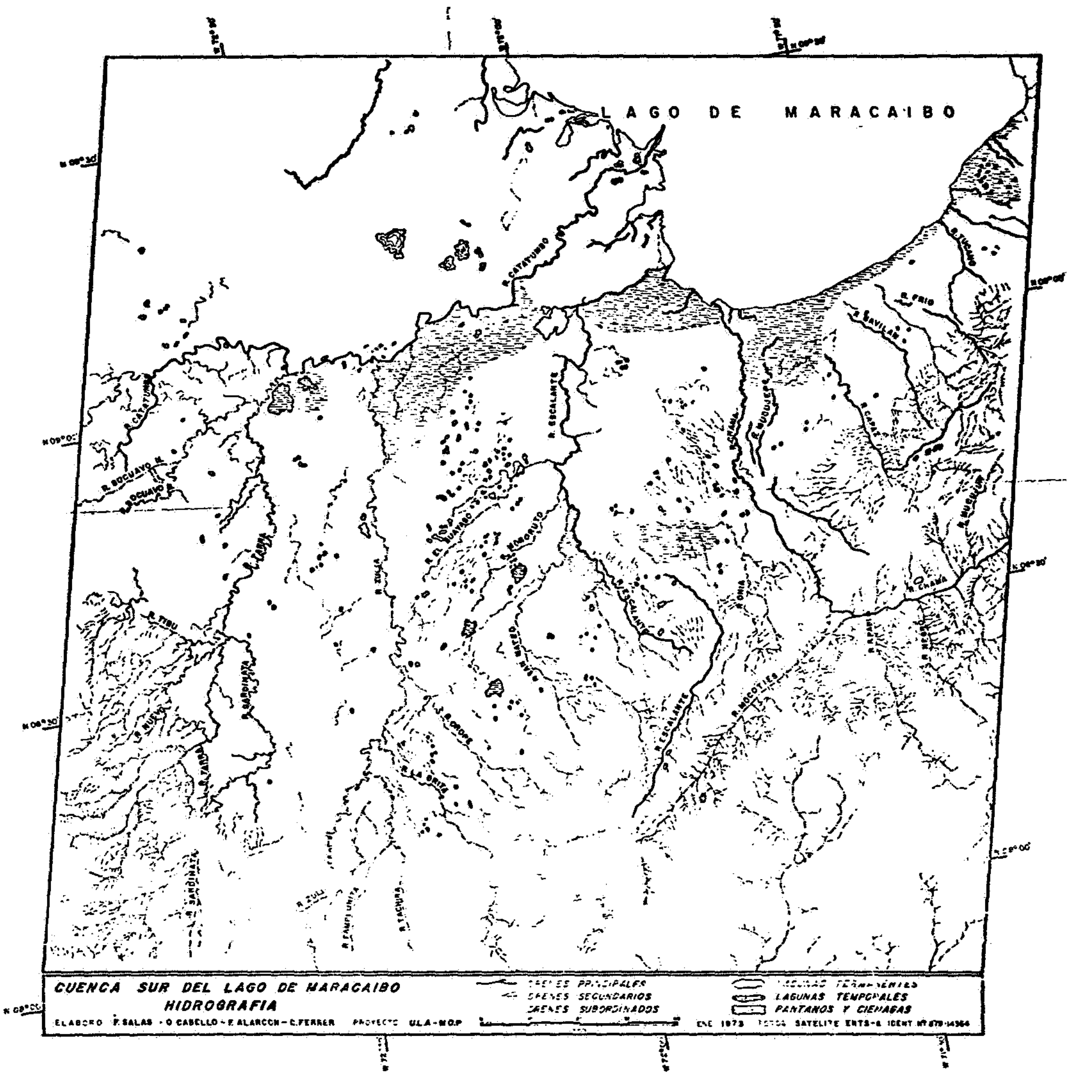

LAGO DE MARACAIBO
CUENCA SUR DEL LAGO DE MARACAIBO
HIDROGRAFIA
LAGUNAS TEMPORALES
PANTANOS Y CIENAGAS
PROYECTO ULA-MOP

Figure 1.

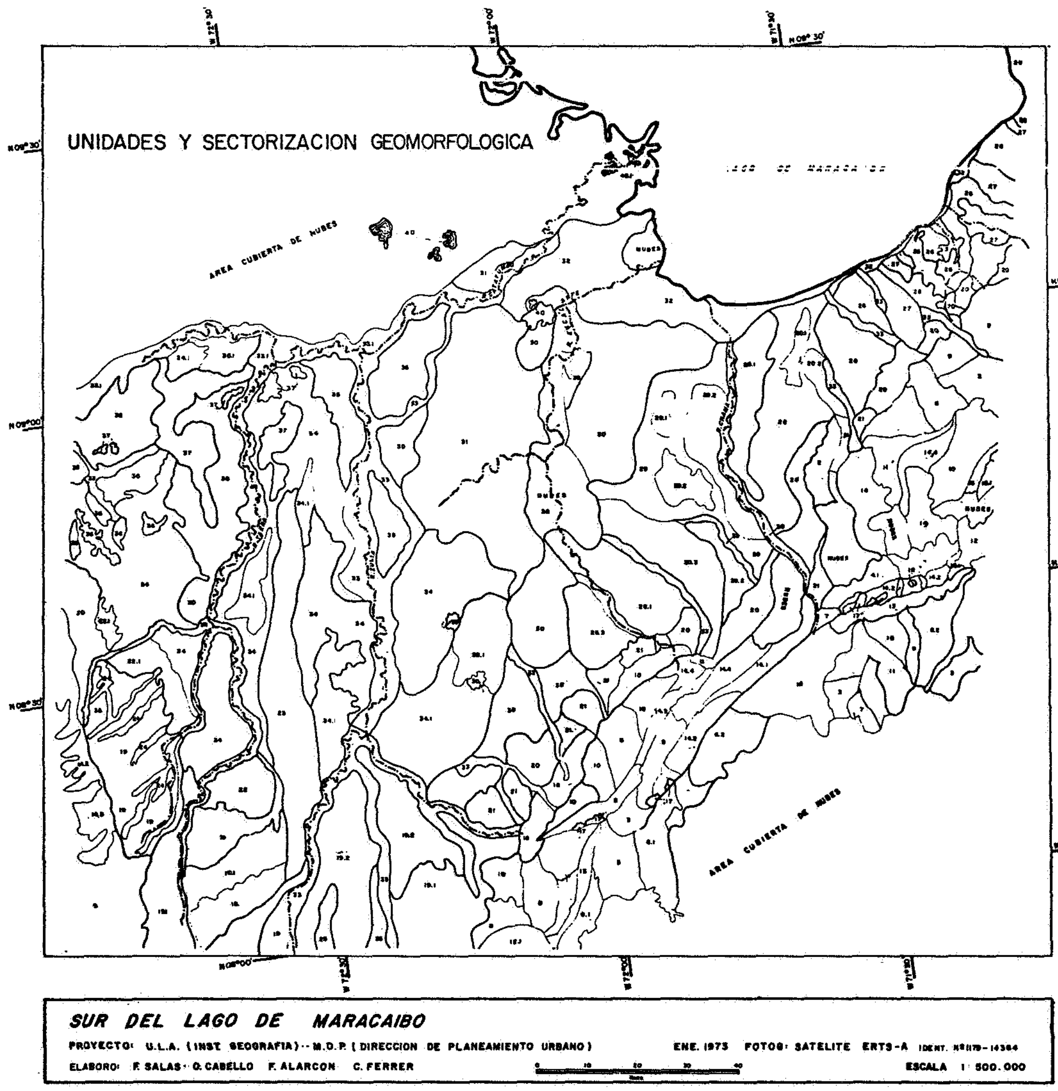

UNIDADES Y SECTORIZACION GEOMORFOLOGICA
AREA CUBIERTA DE NUBES
SUR DEL LAGO DE MARACAIBO
PROYECTO: U.L.A. (INST. GEOGRAFIA) -- M.O.P. (DIRECCION DE PLANEAMIENTO URBANO)
ENE. 1973 FOTOS: SATELITE ERTS-A
ELABORO: F. SALAS - O. CABELLO F. ALARCON C. FERRER
ESCALA 1: 500.000

Figure 2.

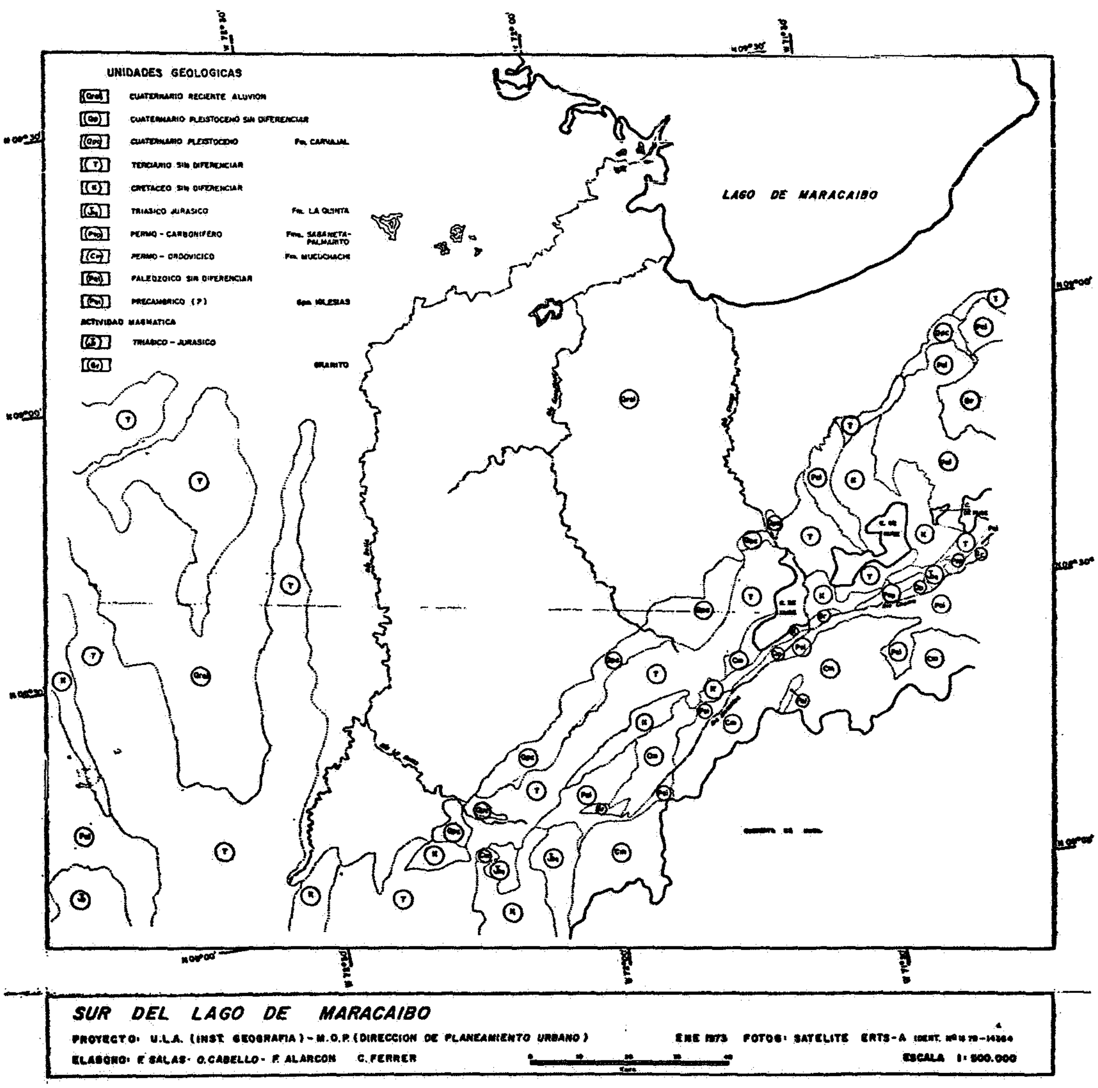
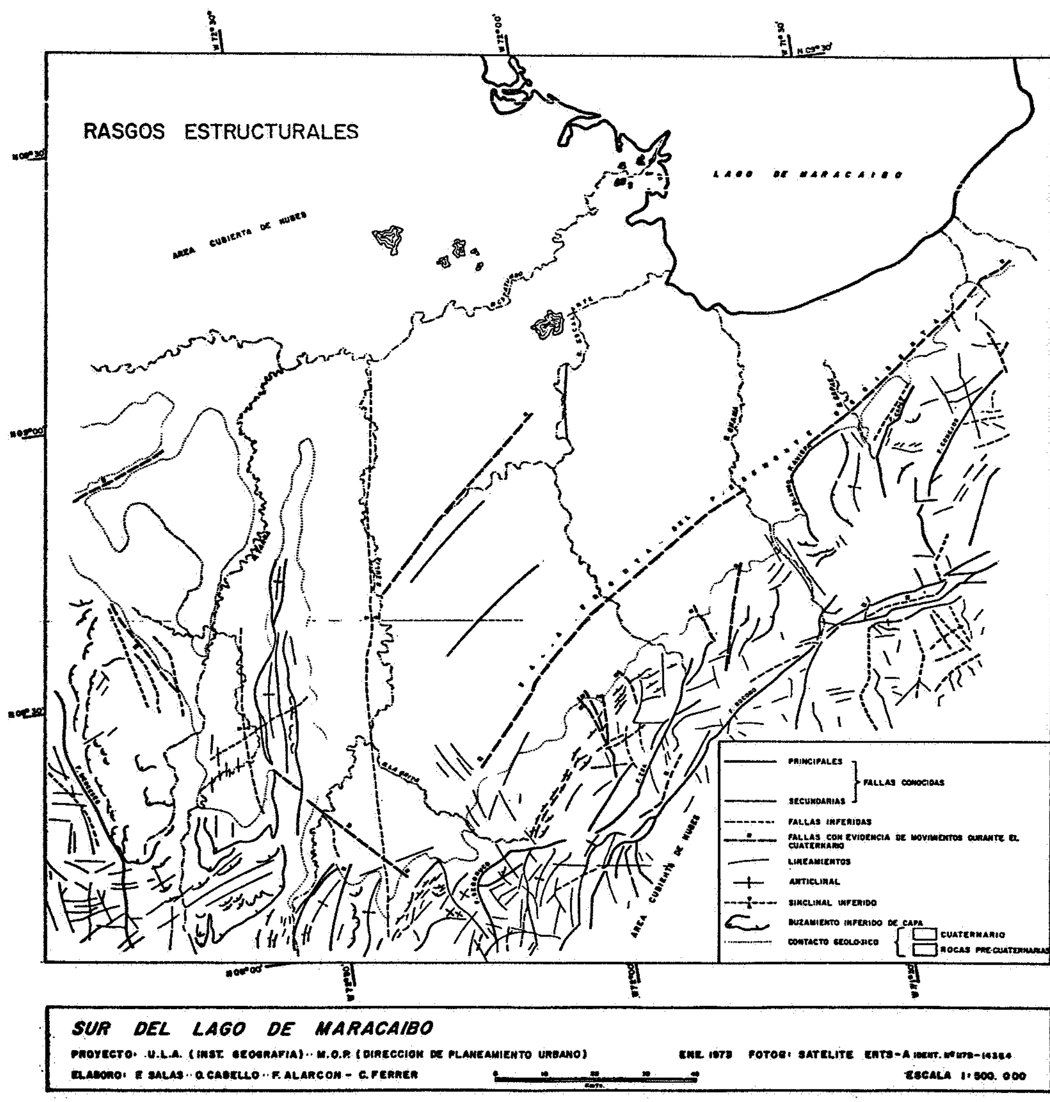

UNIDADES GEOLOGICAS
CUATERNARIO RECIENTE ALUVION
CUATERNARIO PLEISTOCENO SIN DIFERENCIAR
CUATERNARIO PLEISTOCENO
Fm. CARVAJAL
TERCIARIO SIN DIFERENCIAR
CRETACEO SIN DIFERENCIAR
TRIASICO JURASICO
Fm. LA QUINTA
PERMO - CARBONIFERO
Fms. SABANETA-PALMARITO
PERMO - ORDOVICICO
Fm. MUCUCHACHI
PALEOZOICO SIN DIFERENCIAR
PRECAMBRICO (?)
ACTIVIDAD MAGMATICA
TRIASICO - JURASICO
GRANITO
LAGO DE MARACAIBO
SUR DEL LAGO DE MARACAIBO
PROYECTO: U.L.A. (INST. GEOGRAFIA) - M.O.P. (DIRECCION DE PLANEAMIENTO URBANO)
FOTOS: SATELITE ERTS-A
ELABORO: E. SALAS - O. CABELLO - F. ALARCON C. FERRER
ESCALA 1:500.000

Figure 3.


RASGOS ESTRUCTURALES
LAGO DE MARACAIBO
AREA CUBIERTA DE NUBES
PRINCIPALES
SECUNDARIAS
FALLAS CONOCIDAS
FALLAS INFERIDAS
FALLAS CON EVIDENCIA DE MOVIMIENTOS DURANTE EL CUATERNARIO
LINEAMIENTOS
ANTICLINAL
SINCLINAL INFERIDO
BUZAMIENTO INFERIDO DE CAPA
CONTACTO GEOLOGICO
CUATERNARIO
ROCAS PRE-CUATERNARIAS
SUR DEL LAGO DE MARACAIBO
PROYECTO: U.L.A. (INST. GEOGRAFIA) - M.O.P. (DIRECCION DE PLANEAMIENTO URBANO)
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ELABORO: E. SALAS - O. CABELLO - F. ALARCON - C. FERRER
ESCALA 1:500. 000

Figure 4.

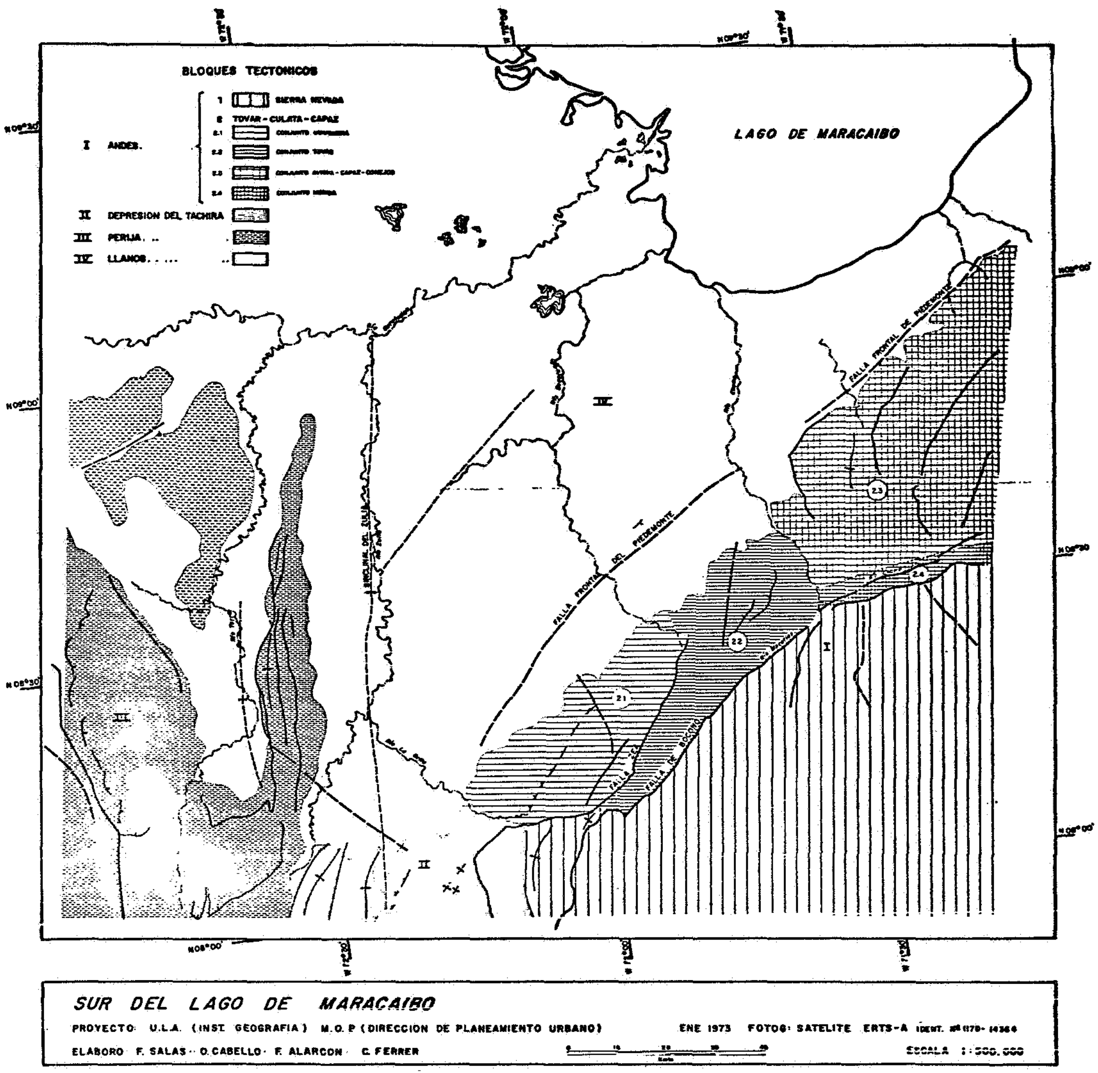
BLOQUES TECTONICOS
I ANDES.
1 SIERRA NEVADA
2 TOVAR - CULATA - CAPAZ
2.1
2.2
2.3
2.4
II DEPRESION DEL TACHIRA
III PERIJA
IV LLANOS
LAGO DE MARACAIBO
FALLA FRONTAL DE PIEDEMONTE
FALLA FRONTAL DEL PIEDEMONTE
SUR DEL LAGO DE MARACAIBO
PROYECTO: U.L.A. (INST. GEOGRAFIA) M.O.P (DIRECCION DE PLANEAMIENTO URBANO)
ENE 1973 FOTOS: SATELITE ERTS-A
ELABORO F. SALAS - O. CABELLO - F. ALARCON - C. FERRER

Figure 5.