# ABSTRACT


- Petroleum reservoirs in the Oficina Formation contain the second largest conventional oil reserves in Venezuela, and are by far the largest if the Orinoco Oil Belt is included. In order to determine the geologic features of these reservoirs, as well as their areal statistical distribution and geometry, a study was made of a selected interval where the sands present less coalescence, and the reservoirs are clearly defined and individualized. The study area comprises 1900 $km^2$ of the Greater Oficina Area; core samples, logs and reservoirs maps were used.

- It was found that intervals *I* and *R* consist of interbedded sandstones, shales, some siltstones and occasionally lignites. Based upon lithologic mesoscopic features, eight (8) characteristic lithofacies could be defined.

- Rocks classified as sub-litharenites, sub-arkoses, arkoses, lithic sandstones and graywackes could be inferred as belonging to a progradational fluvio-deltaic system, sourced in the Pre-Cambrian shield.

- The diagenetic level reached by the lower-middle sequence of the Oficina Fm. in this area corresponds to the intermediate stage, where significant processes of cementation by oxides, carbonates and silica are of equal intensity and magnitude to the leaching of feldspars and other detritic particles, giving these rocks good potential reservoir qualities.

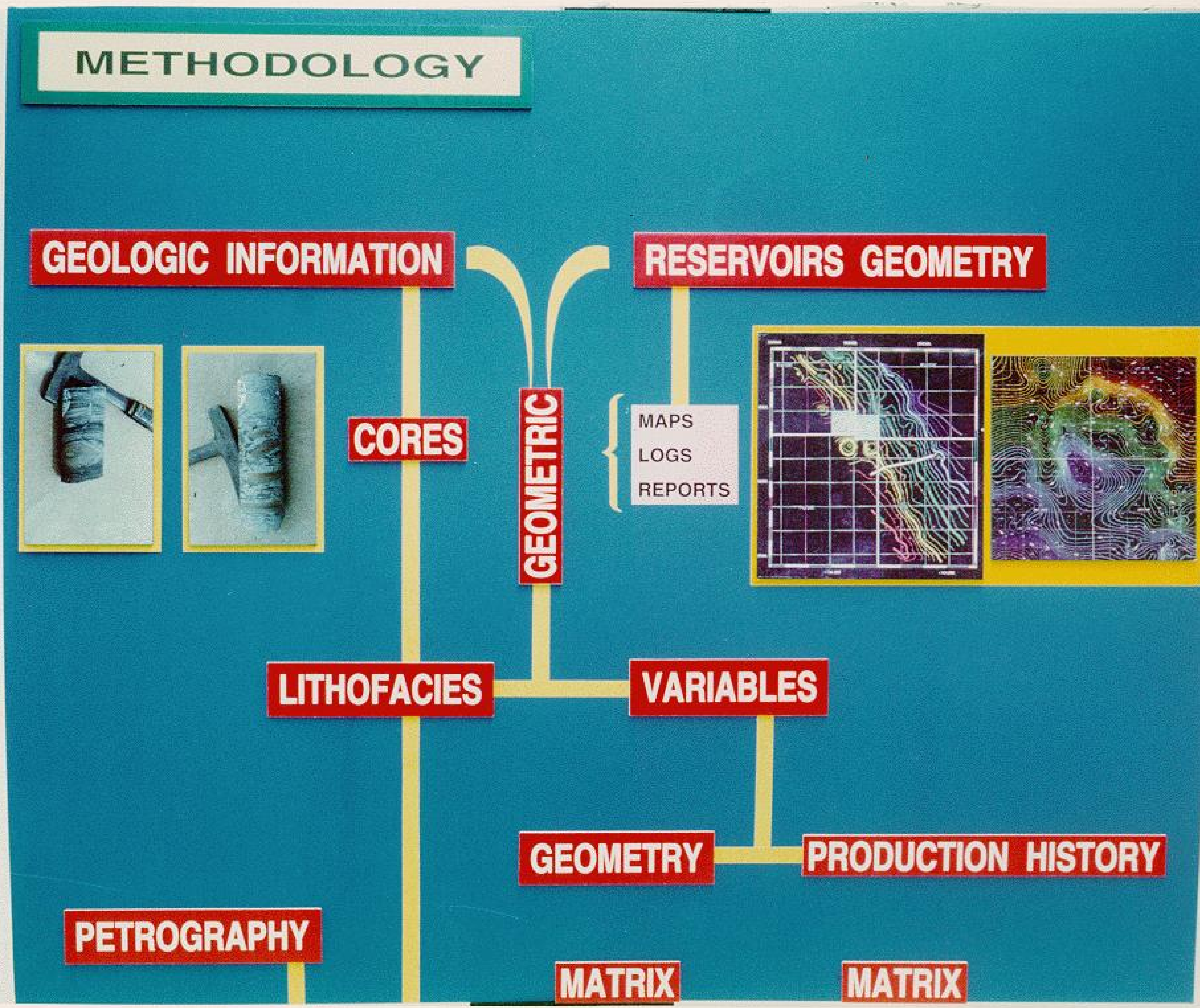
- Descriptive statistical evaluation was performed on 140 reservoirs representing all lithofacies populations in this interval. Based on this analysis, the reservoirs were statistically grouped in classes which are a funtion of their geometry, spatial location and type of hydrocarbon content.

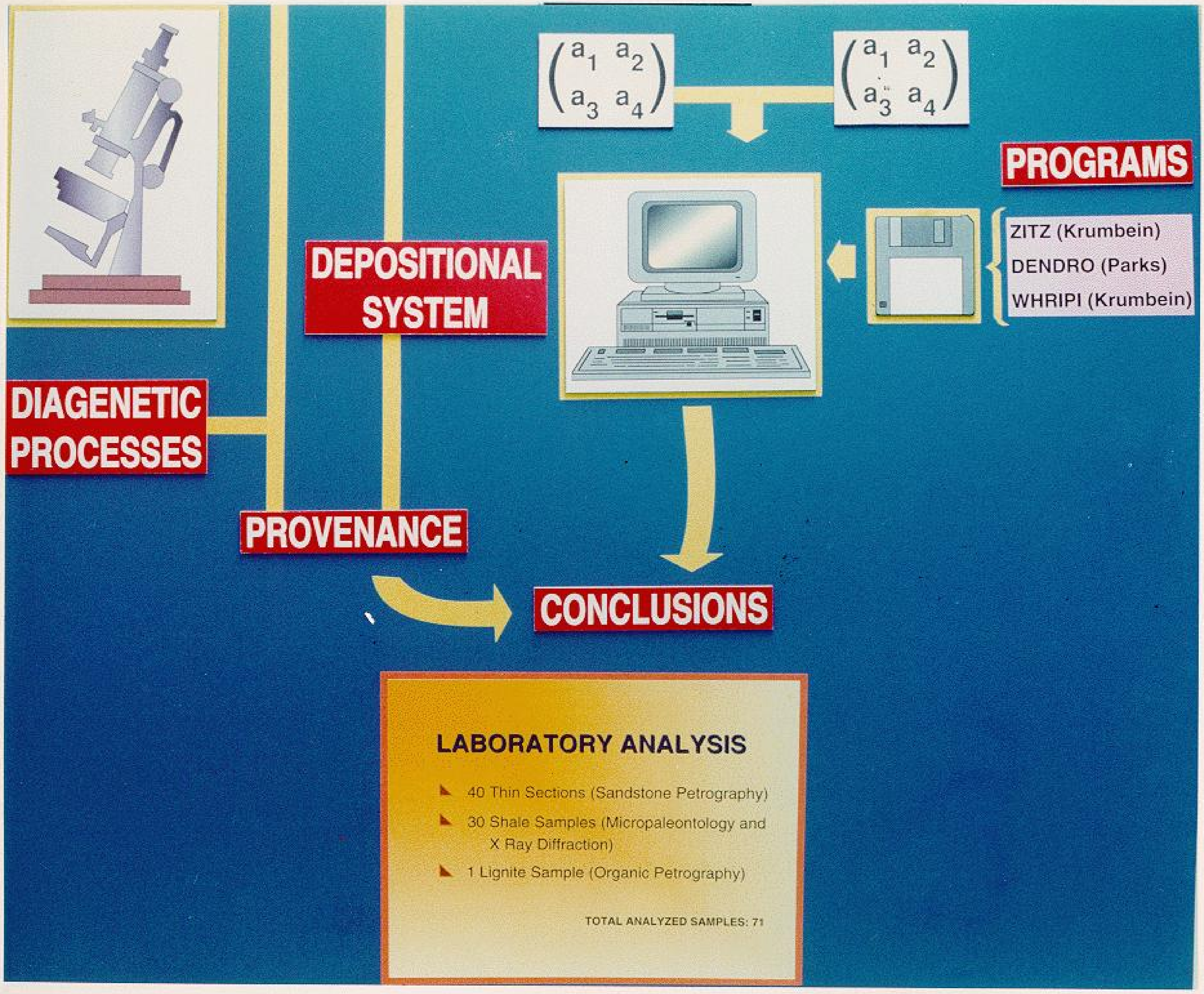

## INTRODUCTION

The exploration history of the Eastern Venezuela Basin as a hydrocarbon province began in 1909, when the Venezuelan Development Company LTD started exploration in the states of Anzoategui, Monagas, Sucre and Delta Amacuro.

Three years later, in August 1912, well Bababui-1, considered the first exploratory well in Venezuela, was successfully drilled to a depth of 615´in the vecinity of the Guanoco asphalt lake. In 1928 the giant Quiriquire field on the northern flank of the basin, and in 1937, the giant Oficina field on the southern flank, were discovered.

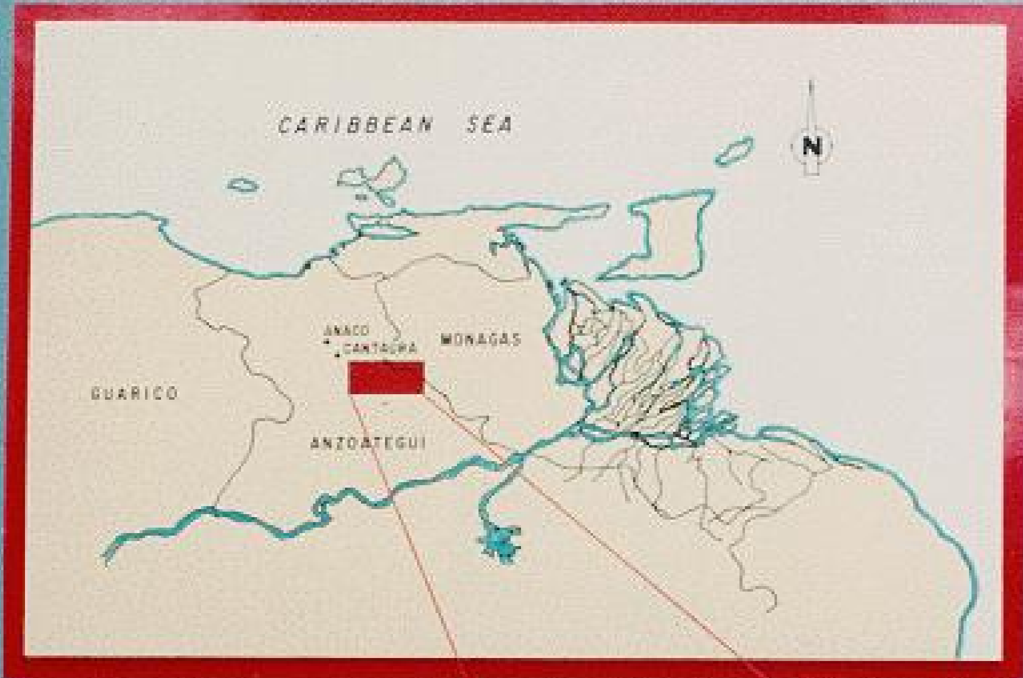
During the last 20 years, considering the great hydrocarbon potential of this basin, the research and exploration efforts of the Venezuelan petroleum industry were extended over the entire basin and offshore into the Orinoco delta and Paria gulf. At the present time, research is directed to obtain a better understanding of the tectonic-sedimentary environment and its relation to the factors controlling the hydrocarbon accumulations.


METHODOLOGY
GEOLOGIC INFORMATION
RESERVOIRS GEOMETRY
CORES
GEOMETRIC
MAPS
LOGS
REPORTS
LITHOFACIES
VARIABLES
GEOMETRY
PRODUCTION HISTORY
PETROGRAPHY
MATRIX
MATRIX

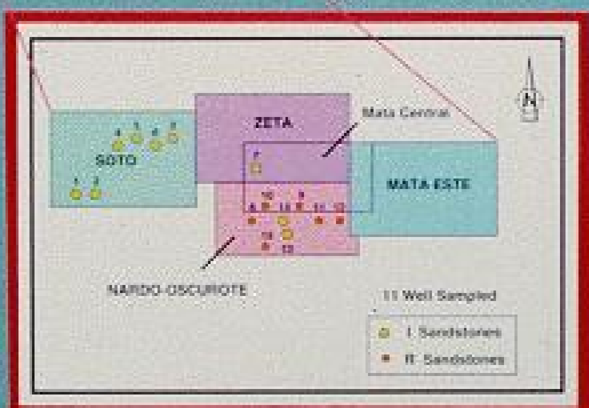


$\begin{pmatrix} a_1 & a_2 \\ a_3 & a_4 \end{pmatrix}$
$\begin{pmatrix} a_1 & a_2 \\ a_3 & a_4 \end{pmatrix}$
PROGRAMS
ZITZ (Krumbein)
DENDRO (Parks)
WHRIPI (Krumbein)
DEPOSITIONAL SYSTEM
DIAGENETIC PROCESSES
PROVENANCE
CONCLUSIONS
LABORATORY ANALYSIS
40 Thin Sections (Sandstone Petrography)
30 Shale Samples (Micropaleontology and X Ray Diffraction)
1 Lignite Sample (Organic Petrography)
TOTAL ANALYZED SAMPLES: 71

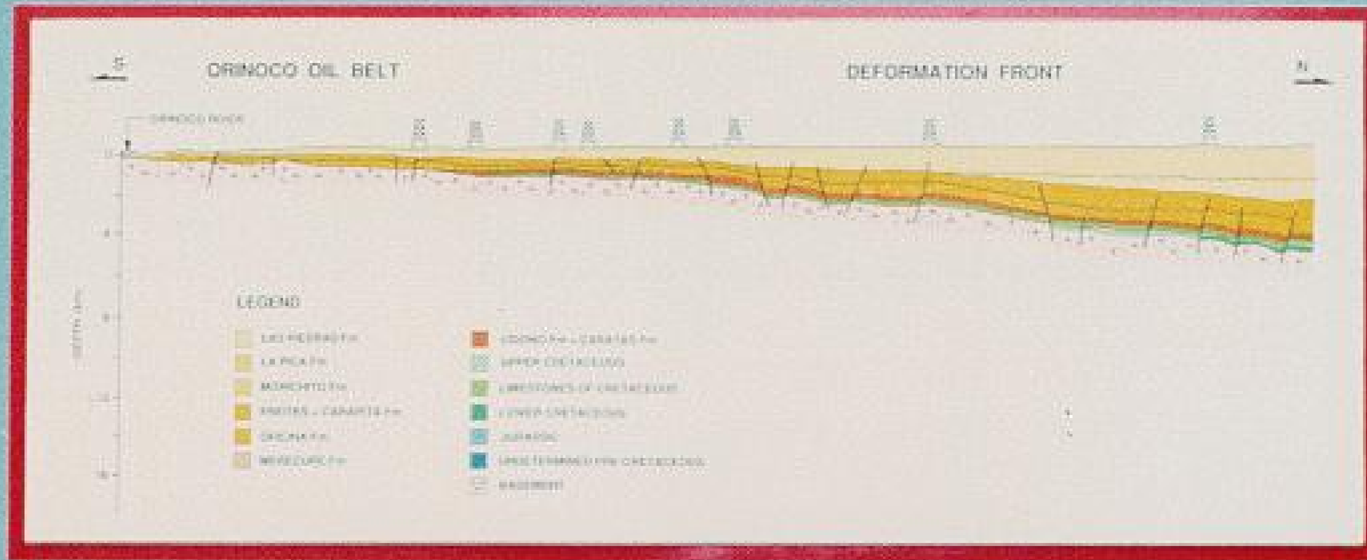
# STUDY AREA




## RELATIVE LOCATION

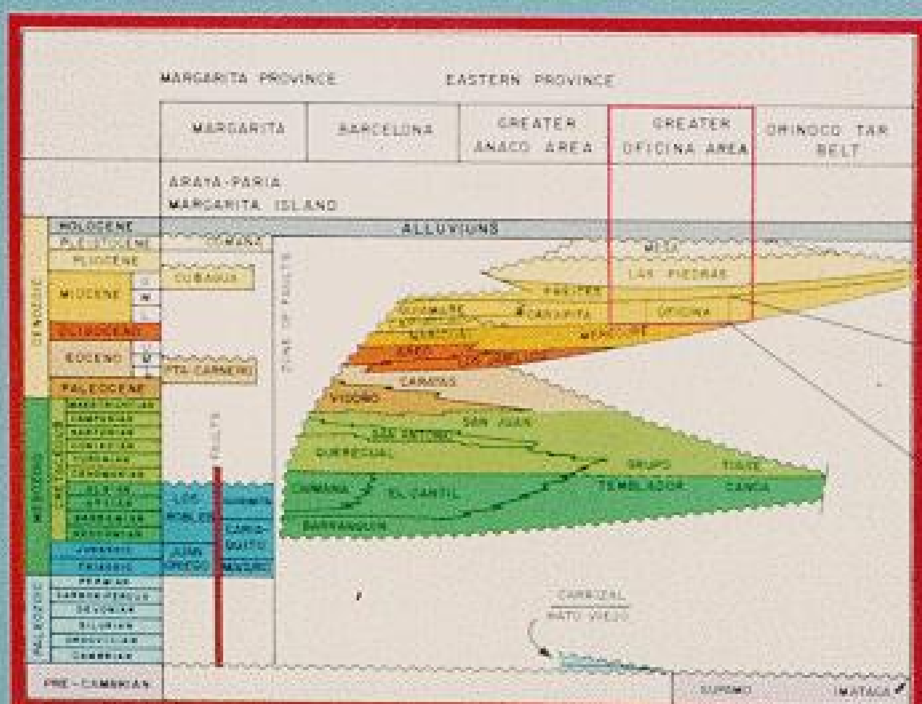



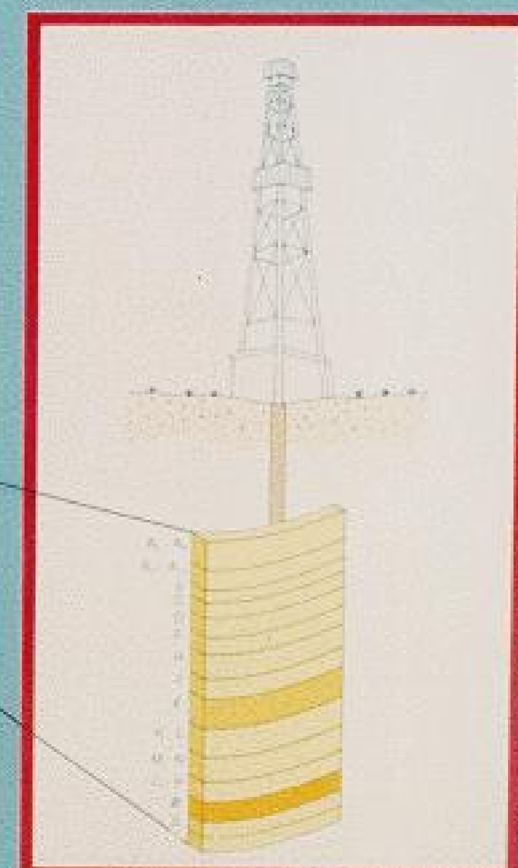

## RESERVOIRS MAP




From PARNAUD et al. (1995)

## GENERALIZED GEOLOGIC CROSS-SECTION



## CHRONOSTRATIGRAPHIC CHART

# RESULTS

## LITHOFACIES

**$A_0$**

MASSIVE SANDSTONE, BEIGE TO LIGHT BROWN; FAIR TO WELL CONSOLIDATED. VARIABLE GRAIN SIZE. SLIGHT IMBRICATION IN THE COARSE AND GRANULAR FRACTION, WITH OCCASIONAL HYDROCARBON STAINS.

**$A_1$**

SANDSTONE. VARIABLE MEDIUM TO FINE GRAIN SIZE, RED COLORS AND HETEROLITHIC ASPECT. POORLY TO VERY POORLY CONSOLIDATED; IMPORTANT CLAY CONTENT. FLASER, PARALLEL AND WAVY LAMINATION, AS WELL AS FLUIDIZATION AND ORGANIC ACTIVITY STRUCTURES.

**$A_2$**

SANDSTONE LIGHT GRAY TO BROWN, LESS HETEROGENEOUS THAN LITHOFACIES $A_1$. CURRENT SEDIMENTARY STRUCTURES SAME AS $A_1$. SIDERITE NODULES ARE COMMON.

**$A_3$**

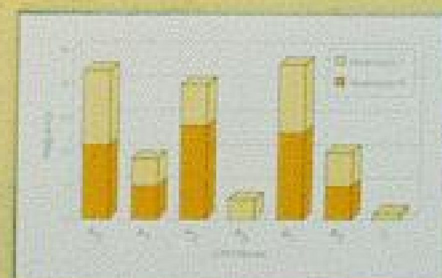
CONGLOMERATIC TO COARSE GRAINED MASSIVE SANDSTONES, LIGHT TO DARK BROWN. CHARACTERISTIC SMALL LENSES AND SCOURING.

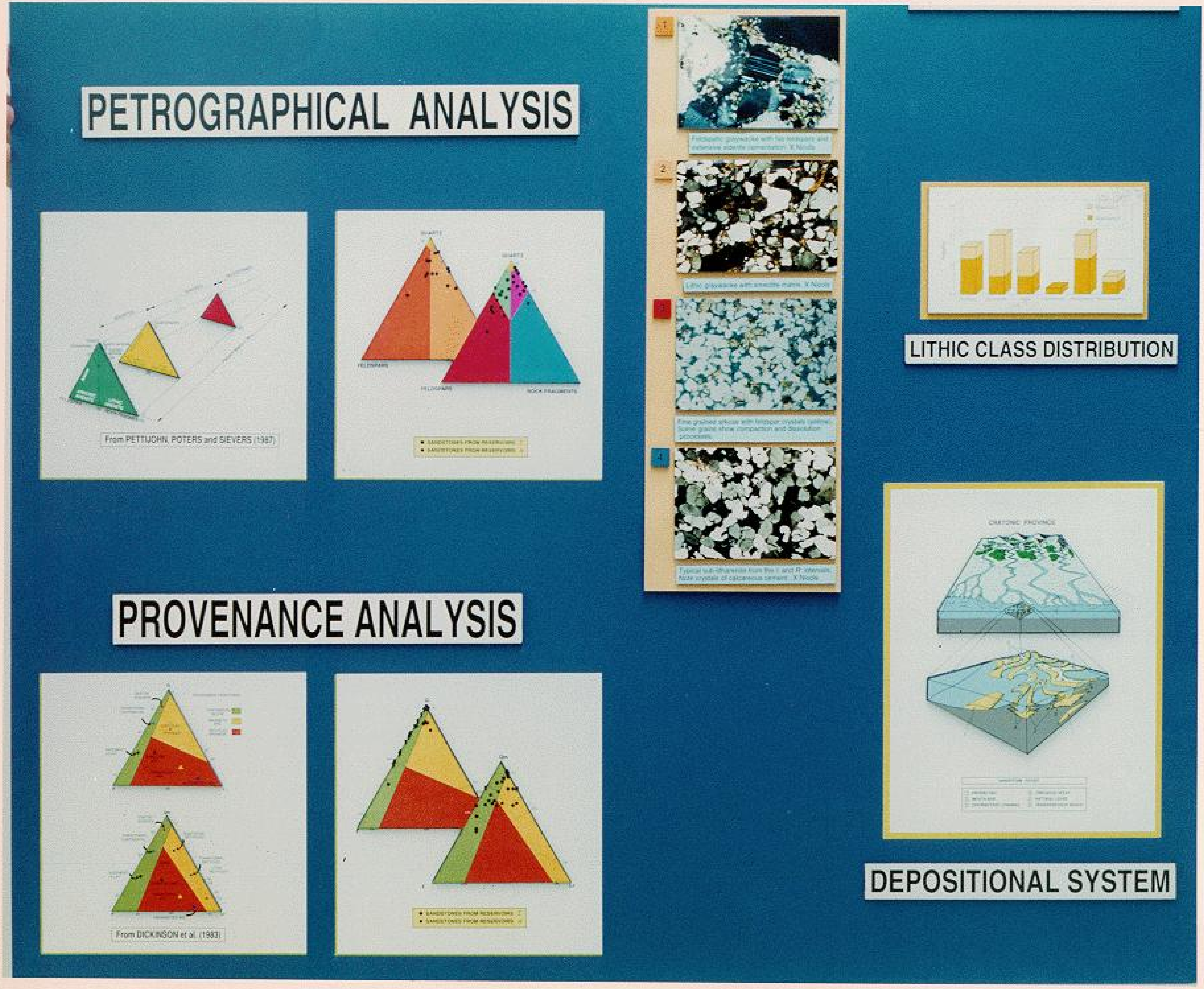
**$B_1$ and $B_2$**

SHALES, DARK BROWN TO DARK GRAY AND BLACK. ABRUPT CONTACT WITH LITHOFACIES $A_0$ AND $A_1$. DISCOIDAL CLAY NODULES WITHOUT VISIBLE INTERNAL STRUCTURES.

**L**

LIGNITE, MASSIVE WITH CONCHOIDAL FRACTURE




PETROGRAPHICAL ANALYSIS
From PETTIJOHN, POTERS and SIEVERS (1987)
LITHIC CLASS DISTRIBUTION
PROVENANCE ANALYSIS
From DICKINSON et al. (1983)
DEPOSITIONAL SYSTEM

# DIAGENETIC PROCESSES & RESERVOIR ATTRIBUTES

## • Physical Processes

*Compaction*
*Pressure-Solution*

Muscovite crystal showing important compaction process. X Nicols

Stylolite surface with hydrocarbon stains.

## • Chemical Processes

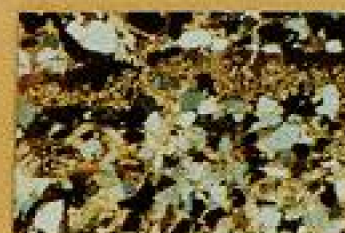
*Precipitation (authigenesis)*
*Dissolution (leaching or lixiviation)*
*Replacement*
*Recrystallization and Neomorphism*
*Aggradation of Clay Minerals*

Calcareous cement filling secondary pore space and reducing porosity.

Spectacular deformation of muscovite crystal due to precipitation of Fe-oxide.

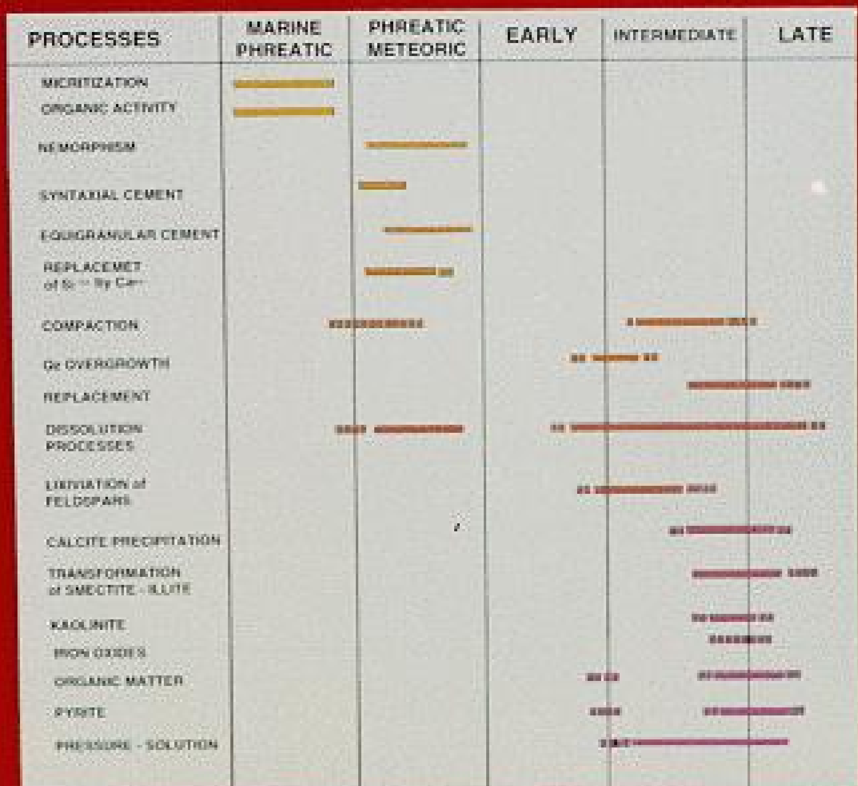
Secondary porosity due to extensive dissolution of feldspar crystals; the crystalline system controls the pore shape.

Micrite to sparite transformation process in calcareous matrix. X Nicols



Transformation of fibrous into microcrystalline and sparite calcite within the structure of an equinoid shell. X Nicols.

## PARAGENESIS

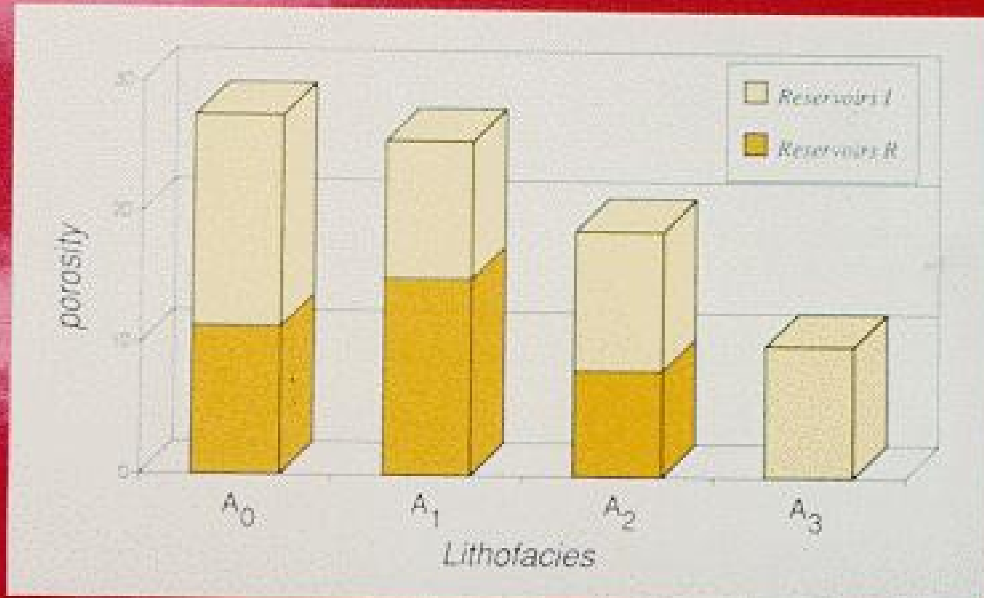



From BLATT (1979)
HAYES (1979)
LONGMAN (1980)
SHANMUGAN (1985)
LONGMAN (1980)
SURDAM et al. (1987 and 1989)

# GENERALIZED CURVES OF ATRIBUTTES RESERVOIRS

*I* - RESERVOIRS

*R* - RESERVOIRS


## RESERVOIR ROCK ANALYSIS

The petrographic study and diagenetic evolution identified the processes causing major impact on the reservoir quality parameters as the following:

Dissolution: mainly localized in the fraction of soluble particles (feldspar, intraclasts) and calcareous matrix, noticeably improving secondary porosity of studied samples.

Precipitation: represented by development of early to late authigenic Fe-oxide, calcite, siderite and siliceous cement, causing loss of primary and secondary porosity and permeability.

Lithofacies $A_2$ and $A_0$ in both *I* and *R* intervals of the Oficina Fm show the largest total porosity $\Phi$ values.

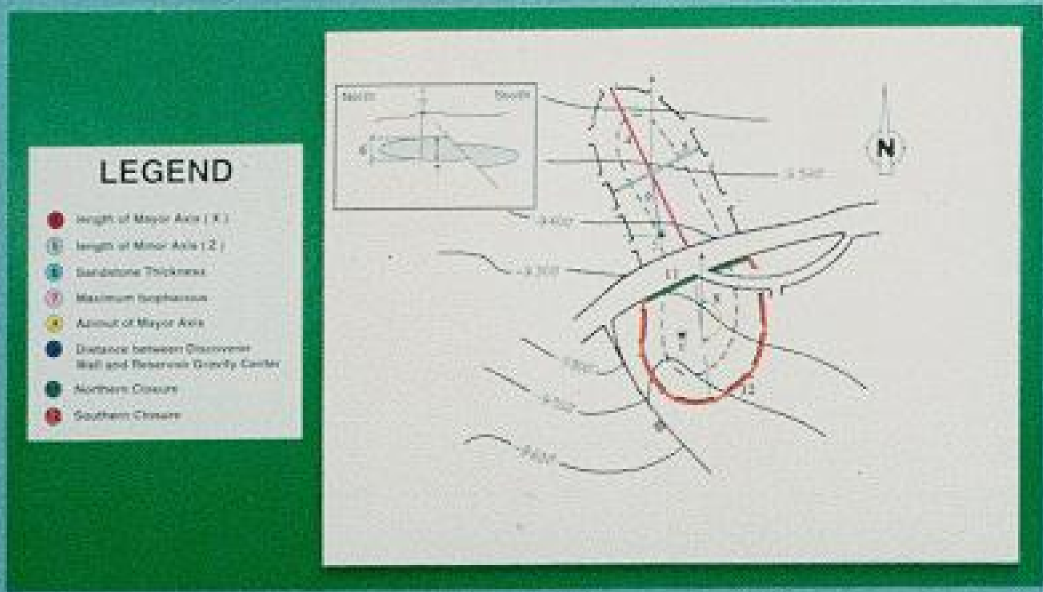
In stratigraphic sense, the interaction of dissolution and precipitation-cementation processes determine the middle section of both *I* and *R* intervals as the most promising reservoir prospects

Q-MODE CLUSTER ANALYSIS - 140 *I* RESERVOIRS, 12 VARIABLES

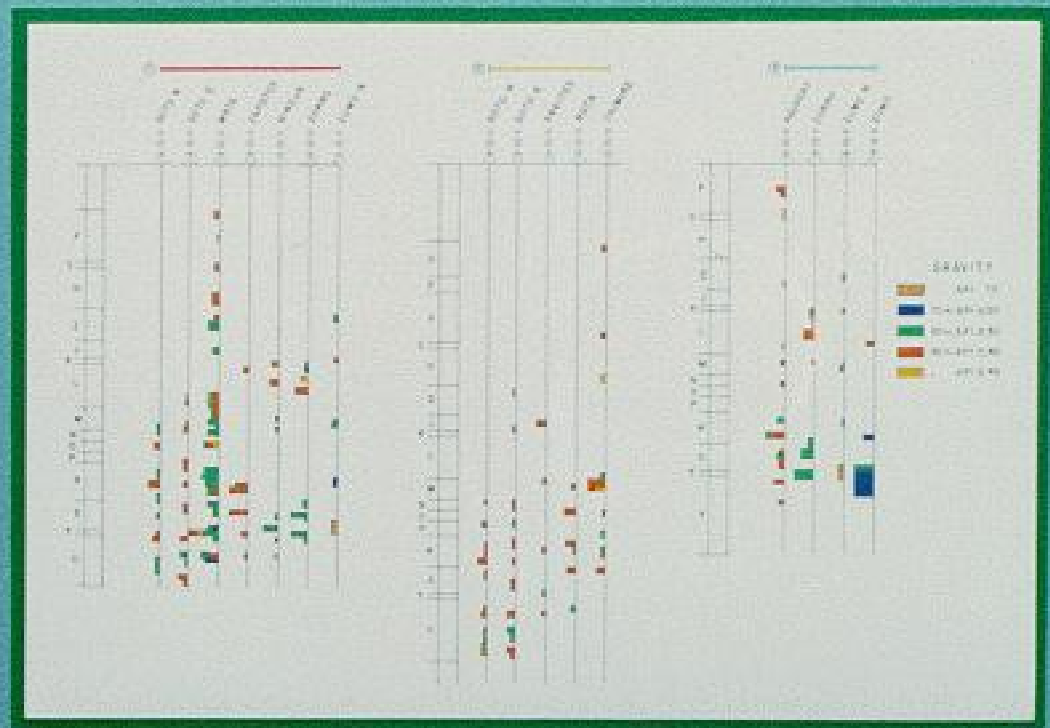
Q-MODE CLUSTER ANALYSIS - 56 *I* RESERVOIRS, 14 VARIABLES

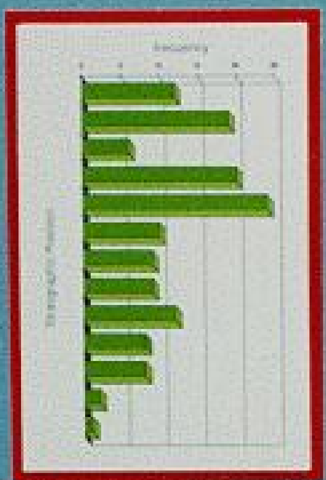
# RESERVOIR CHARACTERISTICS (STATISTICAL ANALYSIS)

## RESERVOIRS STATISTIC VARIABLES

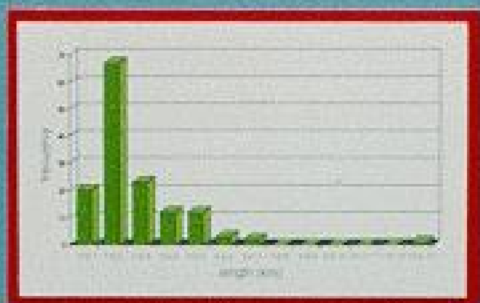



## LOCATION OF I - RESERVOIRS - GREATER OFICINA AREA



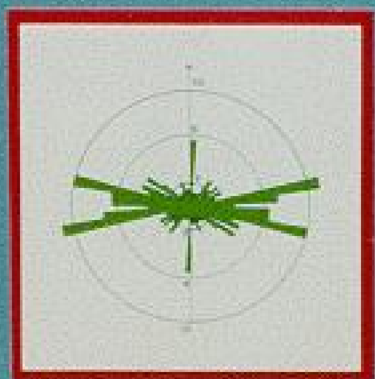


Sandstone Code



Length of Major Axis (X)

Length of Minor Axis (Z)



Azimut of Major Axis

Northern Closure

Southern Closure

# CONCLUSIONS

Reservoirs of the Oficina Fm "*I* - sand" are found mainly in the upper and middle portion (60%) of this stratigraphic interval, in the central sector of the study area.

Statistical study of the reservoir variables define the typical *I* - reservoirs:

a- symmetrical axes of 1-2 km length (48%)

b- net oil sand between 2' and 6' (90%)

c- preferential E-W orientation (60%)

d- northern closure mainly oil/water contact (31%)

e- southern closure mainly south-dipping faults (60%)

f- API gravity between 20º and 40º (70%)

Eight (8) different reservoir families in a population of 140 reservoirs from interval *I* might be established based on their geometric charactistics, using Q-mode classification analysis. These families are reduced to six (6) if, in addition, production variables are used.

The reservoir families are statistically determined by the following variables: type of closure, length and orientation of axes, spatial and stratigraphic location, and API gravity.

The middle Miocene *I* and *R* sand intervals of the Oficina Fm are sedimentary holosomes deposited in delta front to pro-delta environments, with sediment sources on the Guayana shield.

Geometry of the sandstones varies from local, individual, lenticular sand bodies to regional, extensive, coalescing sand sheets.

The lithology of the *I* and *R* intervals is composed of a sequence of sandstones, shales, some siltstones and occasional important regional lignites. Sedimentary structures are frequent and together with the lithology permit the recognition of eight (8) distinct lithofacies.

Petrographic studies indicate that the *I* interval is composed of sub- litharenites, arkoses, and lithic graywackes, while interval *R* is composed mainly of sub-arkoses and lithic graywackes.

Sandstone components are : quartz, feldspar ( orthoclase, microcline, Na-plagioclase) and rock fragments as principal constituyents. Smectite-illite, caolinite, Ca-carbonate and Fe-oxides as matrix. Fe-oxides, Ca-carbonate, siderite and silica as cement.

Porosity in most of the studied samples is derived from extensive dissolution processes.

Physical diagenetic processes ( compaction, pressure-solution) and chemical processes ( cement precipitation, dissolution of detrital particles, replacement and transformation of clay matrix) indicate intermediate to strong diagenesis.

The areal and stratigraphic distribution of sandstone lithic components and diagenetic processes postulate the intermediate levels of the *I* and *R* sandstone intervals as the most promising reservoir rocks.

In terms of lithofacies, the most attractive reservoirs are lithofacies $A_2$ for the *I* interval, and lithofacies $A_0$ for the *R* interval.

## Acknowledgements

We wish to thank CORPOVEN, S.A. for the generous support in providing the basic information, i.e. reservoir maps, core samples and production data required for this analysis.

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DISEÑO Y ELABORACION : ARTES GRAFICAS INTEVEP S.A.