

# **PS** Source Rock Potential of Coal and Carbonaceous Shales of Petroleum Systems in the Eastern Venezuela Basin\*

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## **Abstract**

Although more than 10% of the petroliferous basins of the world are dominated by non-marine source rocks, the processes and critical factors that control hydrocarbon generation and expulsion in coals and associated carbonaceous shales are not completely understood. Numerous studies, however, suggested that terrestrial organic matter have the capacity to generate and expel commercial quantities of liquids. The origin of oil and gas in the Eastern Venezuela Basin (EVB) is no less controversial than in any other coal-dominated basin. The existence of petroleum source rocks other than the traditional Upper Cretaceous, marine Querecual Formation has been suggested since the forties but has not been completely verified. This study documents the characteristics of the carbonaceous rocks in EVB.

118 Tertiary samples from 18 outcrop locations and 38 cores from 31 wells were geochemically characterized. The locations spanned the Mountain Front of the La Costa Mountain range and the Serranía Oriental area. Rocks were subjected to a full suite of analyses, including organic microscopy, to assess the organic facies and extent of thermal maturity. Rocks can be classified in three groups: One enriched in vitrinite, one in amorphous OM and a third characteristically exinitic. RockEval Pyrolysis confirmed that last group belongs to the classical type II-III, whereas the other two groups fit into type II kerogen, perhaps caused by enrichment in lipids. Gas Chromatography shows a clear oil-type signature for hydrocarbons generated after hydrous pyrolysis. Our study confirmed the existence of an Oficina (!) Petroleum System in the Eastern Venezuela Basin.

# Source Rock Potential of Coal and Carbonaceous Shales of Petroleum Systems in the Eastern Venezuela Basin

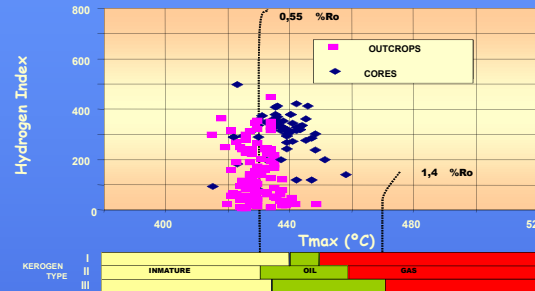
## ANGEL FRANCISCO CALLEJÓN - ADRY BISSADA

### RESULTS

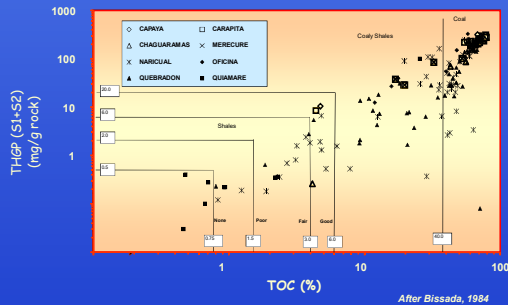
EXAMINATION OF MATURITY LEVELS, BY ROCKEVAL Tmax AND VITRINITE REFLECTANCE, INDICATED THAT THE ORGANIC MATTER IS GENERALLY IMMATURE OR IN AN EARLY STAGE OF MATURITY.

HOWEVER, A FEW OF THE SUBSURFACE CORES SHOW MATURITY EQUIVALENT TO PEAK OIL GENERATION, REFLECTED BY THE PRESENCE OF BITUMEN IMPREGNATION ON SOME SAMPLES AS EVIDENCE BY THE ROCKEVAL PYROLYSIS PARAMETERS S1 AND S2

### Maturity Diagram



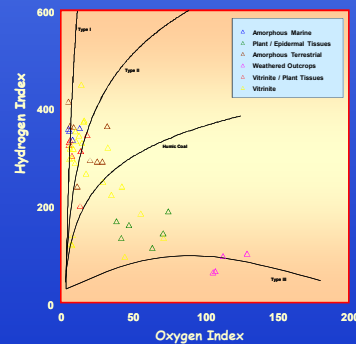
Relationship between Organic Carbon content and the Total Hydrocarbon Generation Potential for Coals and Coaly Shales in EVB



After Bissada, 1984

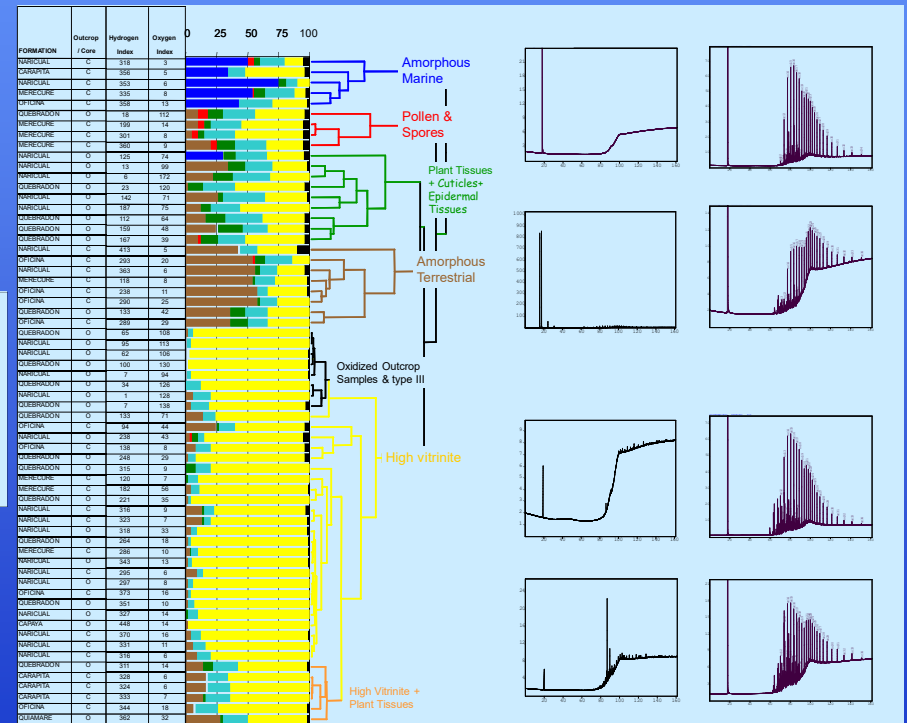
EVALUATION OF ROCKEVAL ANALYSIS INDICATES THAT MOST OF THE COALS AND COALY SHALES HAVE GOOD TO EXCELLENT POTENTIAL FOR OIL GENERATION

Source Rock Characterization Based on van Krevelen-type diagram



### ORGANIC FACIES

STATISTICAL CLUSTER OF SAMPLES Based on Organic Microscopy and RockEval Pyrolysis



WHOLE OIL GC of Extractable Organic Matter

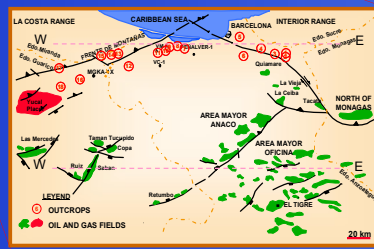
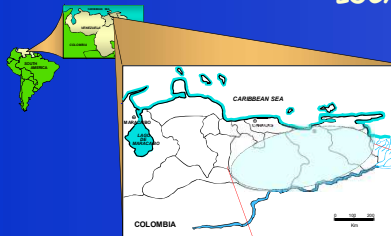
WHOLE OIL GC After Hydrous Pyrolysis

INTREPRETATION ON ORGANIC MICROSCOPY ON ISOLATED KEROGEN AND PYROLYSIS ROCK-EVAL INDICATES THE PRESENCE OF THREE MAIN GROUPS OF ORGANIC MATTER: ONE ENRICHED IN VITRINITE, ONE IN AMORPHOUS ORGANIC MATTER AND A THIRD IN EXINITES.

ROCKEVAL PYROLYSIS CONFIRMED THAT LAST GROUP BELONGS TO THE CLASSICAL TYPE II-III, WHEREAS THE OTHER TWO GROUPS FIT INTO TYPE II KEROGEN, PERHAPS CAUSED BY ENRICHMENT IN LIPIDS



### EASTERN VENEZUELA BASIN LOCATION MAP



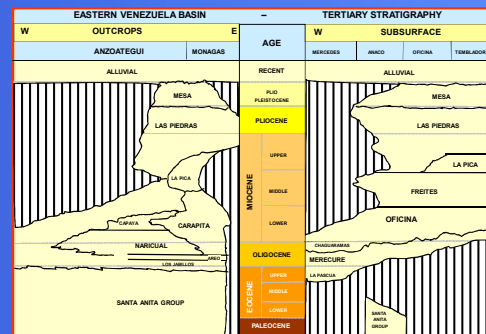
### INTRODUCTION

TO DATE, THE ROLE OF THE COALS AND COALY SHALE SEQUENCES OF THE EASTERN VENEZUELA BASIN IN SOURCING HYDROCARBONS HAS NOT BEEN ADEQUATELY ADDRESSED. THE WIDE VARIABILITY OF DEPOSITIONAL FACIES, BOTH AREALY AND STRATIGRAPHICALLY, AND THE HETEROGENEITY OF THE NON-MARINE ORGANIC MATTER IN THE COALS AND CARBONACEOUS SHALES ACROSS THE AREA WAS HARDLY ADDRESSED.

### OBJECTIVES

- DEVELOP A BETTER UNDERSTANDING OF THE ROLE OF COALS AND CARBONACEOUS SHALES IN OIL AND GAS GENERATION AND EXPULSION.
- FORMULATE A COMPREHENSIVE GEOLOGIC / GEOCHEMICAL MODEL TO DESCRIBE THE RELATIVE CONTRIBUTION OF THE COAL-DOMINATED TERTIARY SECTION TO THE OIL RESERVES IN THE EASTERN VENEZUELA BASIN.

### CHRONOSTRATIGRAPHIC CHART



### SCOPE

GEOCHEMICALLY CHARACTERIZE THE COALS AND COALY SHALES OF THE TERTIARY SECTION OF THE EASTERN VENEZUELA BASIN (EVB) FROM OUTCROPS AND WELL CORES IN TERMS OF THEIR PROPERTIES AS SOURCE ROCKS FOR OIL AND/OR GAS

IDENTIFY THE DIFFERENT ORGANIC FACIES, THE RATE OF TRANSFORMATION AND THE TYPE OF HYDROCARBONS THEY ARE CAPABLE OF GENERATING

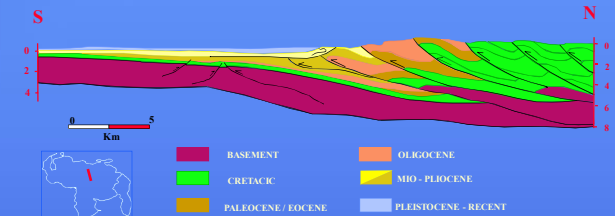
COMPARE THE ACQUIRED PARAMETERS ON THE ROCKS WITH THOSE ALREADY REPORTED FOR THE OILS IN THE BASIN TO STABLISH POSSIBLE LINKS BETWEEN THE POTENTIAL SOURCE ROCKS AND THE ACTIVE PETROLEUM SYSTEM(S) IN THE AREA

### RESULTS

EXAMINATION OF MATURITY LEVELS, BY ROCKEVAL T<sub>max</sub> AND VITRINITE REFLECTANCE, INDICATED THAT THE ORGANIC MATTER IS GENERALLY IMMATURE OR IN AN EARLY STAGE OF MATURITY.

HOWEVER, A FEW OF THE SUBSURFACE CORES SHOW MATURITY EQUIVALENT TO PEAK OIL GENERATION, REFLECTED BY THE PRESENCE OF BITUMEN IMPREGNATION ON SOME SAMPLES AS EVIDENCE BY THE ROCKEVAL PYROLYSIS PARAMETERS S1 AND S2

### GUARICO SUBBASIN CROSS SECTION



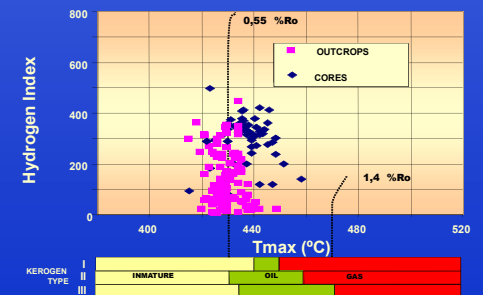
MODIFIED FROM EDVGA, 1997

### SAMPLING

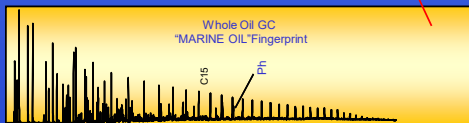
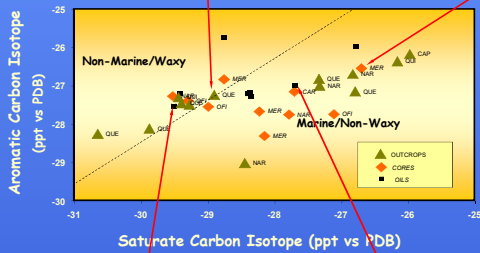
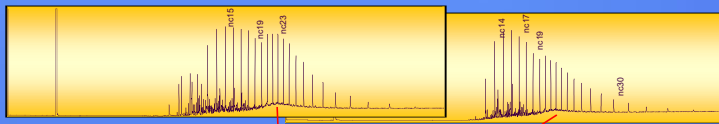
118 TERTIARY SAMPLES FROM 18 OUTCROP LOCATIONS AND 38 CORES FROM 31 WELLS WERE GEOCHEMICALLY CHARACTERIZED.

THE LOCATIONS SPANNED THE MOUNTAIN FRONT OF THE LA COSTA MOUNTAIN RANGE AND THE SERRANIA ORIENTAL AREA, COVERING AGES FROM UPPER EOCENE TO MIDDLE MIOCENE

### Maturity Diagram



**Gas Chromatography after hydrous pyrolysis at 350 °C for 3 days**

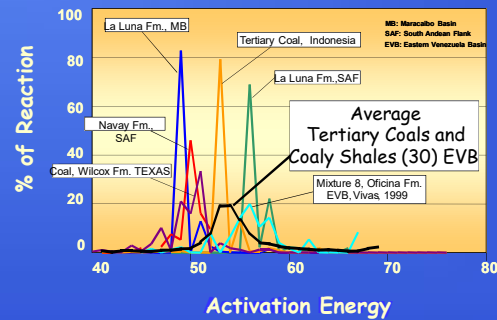


THE PLOT OF  $\delta^{13}C$  SATURATES vs.  $\delta^{13}C$  AROMATICS SUGGESTS THAT SOME OILS ARE ORIGINATED FROM SOURCE ROCKS CONTAINING MAINLY TERRIGENOUS ORGANIC MATTER, WHILE THE SOURCE ROCKS FOR THE REMAINING SAMPLES WERE DOMINATED BY MARINE ORGANIC MATTER (QUERECUAL FM. TYPE).

LINES REPRESENTS THE BEST SEPARATION BETWEEN MARINE AND NONMARINE OILS (AFTER SOFER, 1984).

KINETIC DATA DERIVED FROM PYROLYSIS EXPERIMENTATION USING A "PYROMAT" SHOWS A SURPRISINGLY UNIFORM DISTRIBUTION OF ACTIVATION ENERGIES FOR ALL THE THIRTY SAMPLES ANALYZED AND ALSO SHOWS A FASTER REACTION RATE THAN THE ARTIFICIAL MIXTURE 8, REPORTED BY VIVAS (1998), IMPLICATING A PROBABLE EARLIER GENERATION OF OIL.

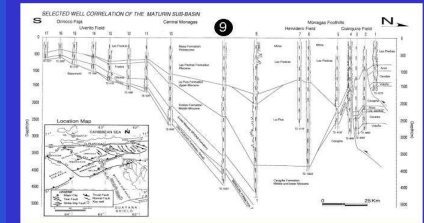
**ACTIVATION ENERGY DISTRIBUTIONS**



THE SIMILARITIES IN BEHAVIOUR OF THE ORGANIC MATTER IN TERMS OF REACTION RATES MAY IMPLY THAT OIL-PRONE EXINITES MAY DOMINATE THE BEHAVIOUR OF OIL GENERATION AND THE REST OF THE ORGANIC COMPONENTS FLAVOUR THE BIOMARKER MIXTURES.

THE IMPLICATIONS OF THIS DATA FOR EXPLORATION ESTABLISH THAT THESE COALS AND COALY SHALES INTERVALS ARE POTENTIAL SOURCES OF OIL, CONTRIBUTING TO THE TERTIARY PETROLEUM SYSTEMS OPERATING IN THE EASTERN VENEZUELA BASIN IN PLACES UNDER ADEQUATE THERMAL CONDITIONS

**REGIONAL CROSS SECTION**



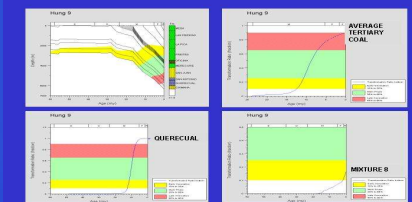
Hung, 1997

A WELL IN THE EASTERN VENEZUELA BASIN (WELL # 9 ON THE CROSS SECTION OF HUNG (1998) WAS SELECTED TO MODEL THE GENERATION OF HYDROCARBONS USING COMMERCIAL SOFTWARE (BASINMOD) AND TO COMPARE THE ACQUIRED DATA WITH OTHER PUBLISHED DATA FOR THE AREA.

THE DATA PUBLISHED BY VIVAS (1998) FROM THE QUIAMARE AREA, THAT REPRESENTS A TERTIARY TERRIGENOUS KEROGEN, WAS ALSO INCLUDED AND IS PRESENTED AS THE KEROGEN "MIXTURE 8".

A MARINE SOURCE ROCK AT THE QUERECUAL FORMATION LEVEL WAS INCLUDED TO STUDY THE BEHAVIOR OF THE ACTIVE PETROLEUM SYSTEMS

**RESULTS FROM MODELED WELL 9**



IN THE FIGURE ABOVE THE BURIAL HISTORY DIAGRAM FOR WELL HUNG #9 INDICATES THAT THE TERTIARY OFICINA FORMATION IS ACTUALLY MATURE AND BEGAN TO EXPULSE OIL, FROM OUR AVERAGE "COALY" KEROGEN, AROUND 11 MA AND STILL HAVE SOME REMNANT GENERATIVE POTENTIAL.

ON THE OTHER HAND THE MARINE QUERECUAL FORMATION WAS ACTIVE FROM AROUND 13 TO 8 MA BUT IT IS ACTUALLY EXHAUSTED, FOR THIS AREA. BUT IT MAY BE STILL ACTIVE IN OTHER PARTS OF THE BASIN.

A TERRIGENOUS MIXTURE 8, MODELED AT THE SAME OFICINA FM. LEVEL, DOES NOT ENTER THE "EXPULSION WINDOW" AT ANY TIME DURING THE BURIAL OF THE OFICINA FORMATION OR ITS EQUIVALENTS IN THE BASIN.