

Geochemical Exploration in Northern South America: Strategies and Recent Successes*

Dietmar (Deet) Schumacher¹

Search and Discovery Article #30420 (2015)**

Posted October 13, 2015

*Adapted from oral presentation given at AAPG Latin America and Caribbean Region, 20th Caribbean Geological Conference 2015, Port-of-Spain, Trinidad & Tobago, West Indies, May 17-22, 2015

**Datapages © 2015 Serial rights given by author. For all other rights contact author directly.

¹E&P Field Services, USA, France, and Malaysia (deet@enp-services.com)

Abstract

Detailed geochemical and research studies document that hydrocarbon microseepage from petroleum accumulations is common, predominantly vertical (with obvious exceptions in some geologic settings), and dynamic (responds quickly to changes in reservoir conditions). Since microseepage is nearly vertical, the extent of an anomaly at the surface can approximate the productive limits of the reservoir at depth. Furthermore, the detailed pattern of seepage can reflect reservoir heterogeneity, discriminate between charged and uncharged compartments, and identify areas of bypassed pay. Results of recent microbial and soil gas surveys in Venezuela, Colombia, and Peru establish the value of hydrocarbon microseepage data for high-grading prospects and aiding field development projects. These surveys were conducted in the Eastern Venezuela basin, the Maracaibo-Catatumba basin in western Venezuela, the Guajira and Cesar Rancheria basins in northern Colombia, the Middle Magdalena Valley basin in central Colombia, and the Lancones basin in northwestern Peru. Results from the underexplored Lancones basin identified structures that warrant additional study due to strong hydrocarbon indications. The Guajira survey documented previously unrecognized oil potential in a basin currently known only for its biogenic dry gas. Results from eastern Venezuela and Cesar Rancheria successfully discriminated prospects on basis of probably hydrocarbon charge. Surveys over two old oil fields in western Venezuela and in the Middle Magdalena Valley identified bypassed pay and several new drilling opportunities. High-resolution microseepage surveys offer a flexible, low-risk and low-cost environmentally friendly technology that not only complements traditional geologic and seismic data, but adds value to such data. Properly integrated with other exploration data, their use has led to discovery of new reservoirs.

Reference Cited

Schumacher, D., 2010, Integrating hydrocarbon microseepage data with seismic data doubles exploration success: in Proceedings 34th Annual Conference and Exhibition, May 2010, Indonesian Petroleum Association, IPA10-G-104.

Geochemical Exploration in Northern South America: Strategies and Recent Successes



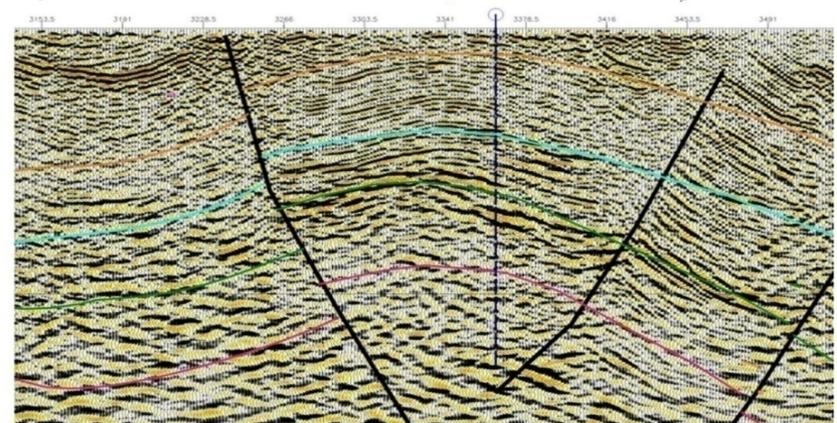
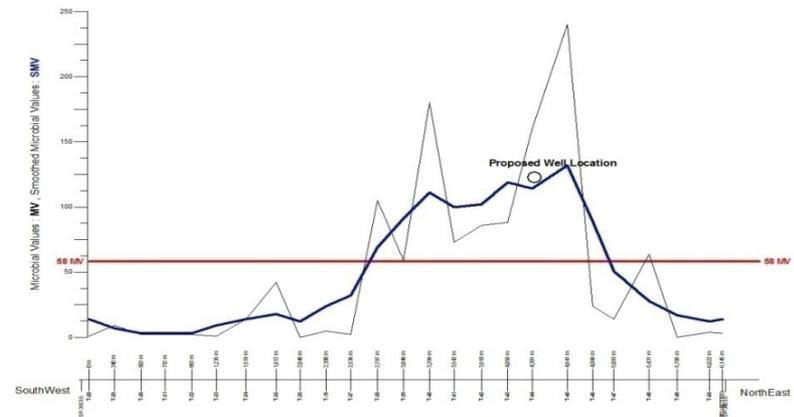
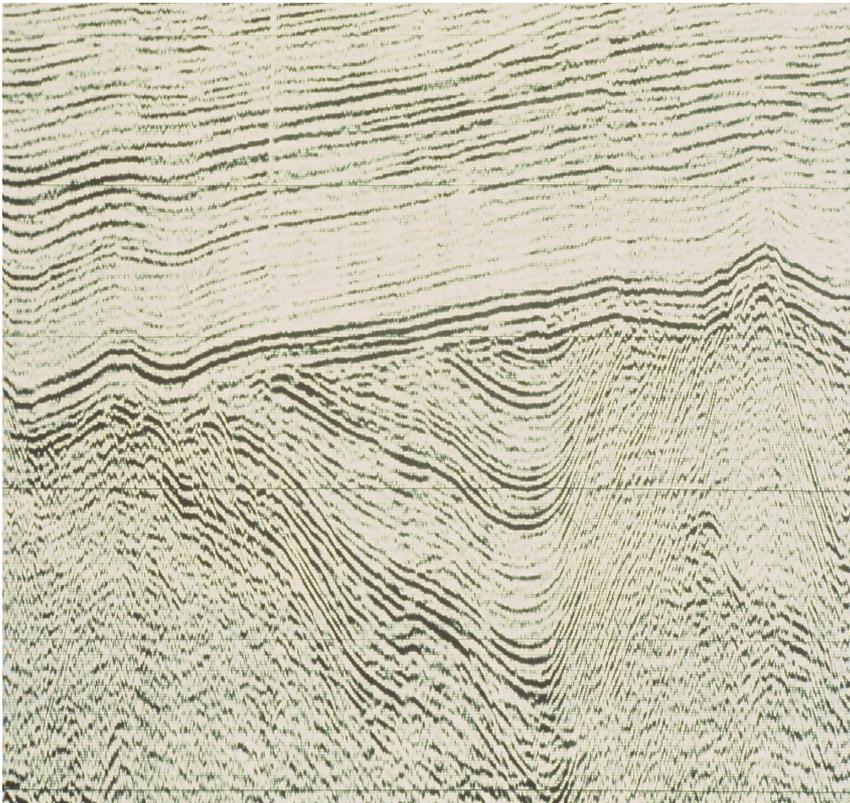
Dietmar (Deet) Schumacher
E&P Field Services, (USA, France, Malaysia)

OUTLINE

- Introduction
- Why Geochemical Exploration
- Survey Design Considerations
- Survey Objectives
- Exploration Examples
 - Venezuela, Colombia, Peru
- Summary

Conventional vs Geochemical Exploration Methods

Finding Traps vs Finding Hydrocarbons



For Success, we need Traps WITH Hydrocarbons

Why Microseepage Surveys?

- Most Productive Basins Leak Hydrocarbons
- **Most Accumulations Leak Hydrocarbons**
- Leakage is Predominantly Vertical
- Leakage is Dynamic (1-3 m/day)
- **Provides Direct Detection of Hydrocarbons**
- Methods Have Minimal Environmental Impact
- **Prospects with Seepage Anomaly are 4-6 times more likely to result in a discovery**

MICROSEEPAGE MODEL

Halo Apical Halo



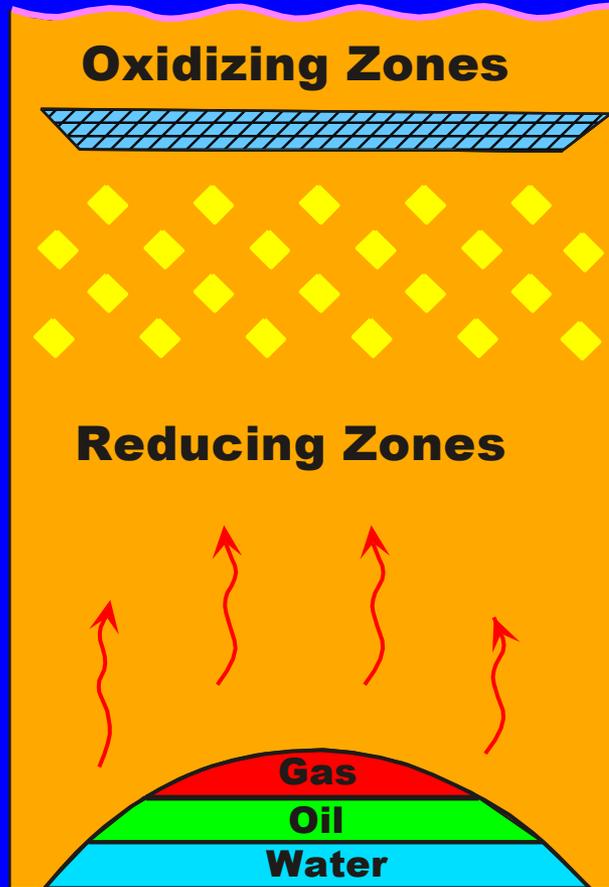
GEOCHEMICAL

Carbonate Precipitation

Pyrite Precipitation
also sulphur, pyrrhotite
greigite, uranium, etc.

Bacterial Degradation
of Hydrocarbons

Light Hydrocarbons
Seep Upward from
Trap Creating a
Reducing Zone



GEOPHYSICAL

High Resistivity
Anomaly

High Polarization
Anomaly

Magnetic
Anomaly

Low Resistivity
Anomaly

Seismic Velocity
Anomaly

Hydrocarbon Detection Methods

- **REMOTE SENSING, SATELLITE IMAGERY**
 - detects hydrocarbon-induced alteration, oil slicks
- **AEROMAGNETICS, MICROMAGNETICS**
 - detects hydrocarbon-induced alteration
- **SOIL GAS, FLUORESCENCE**
 - hydrocarbon concentration and composition
- **MICROBIOLOGICAL**
 - measures HC-oxidizing bacteria
- **PASSIVE ELECTROMAGNETICS, TELLURICS**
 - depth to hydrocarbon-bearing zones

Survey Design Considerations



- Survey Objectives
- Target Size, Shape
- Geologic Setting
- Topography, Vegetation
- Logistical Considerations
- Data Integration
- Ability to Sample Along & Between Seismic Lines
- Geologic Analogs for Calibration
- Permitting
- Environmental Issues
- Prior Experience

Survey Objectives

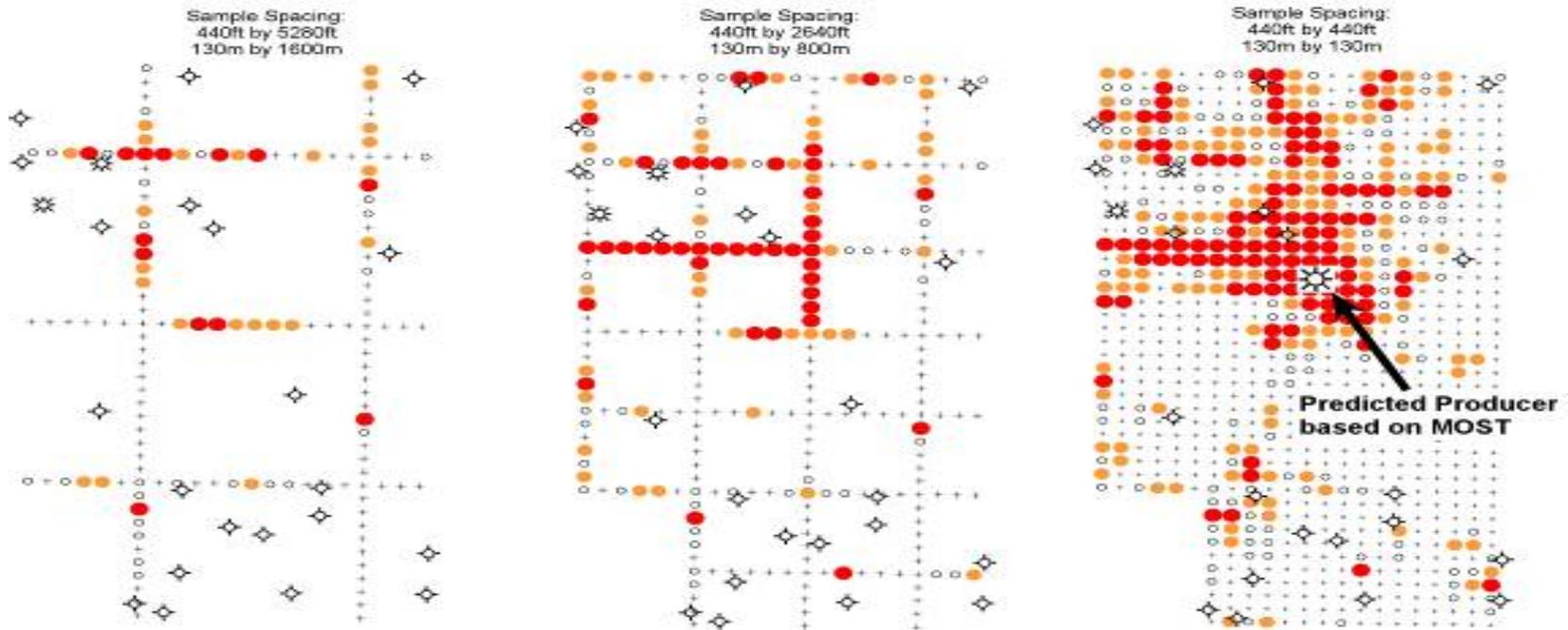
- Reconnaissance Surveys
- Prospect Generation, Prospect Evaluation
- Field Development
- Production Monitoring

Geo-Microbial
Technologies, Inc.
Ochelata, Oklahoma USA

Sampling Strategy - Survey Design



The value of sample grids over line surveys is illustrated in this example from Oklahoma.



Note: Abandoned / depleted oil field in south part of survey area demonstrates Microbial Reservoir Characterization (MRC) principle of pressure withdrawal and microseepage shutdown.

Exploration Examples

Reconnaissance Surveys

- Guajira Basin, Colombia
- Lancones Basin, Peru

Prospect Evaluation

- QLC Block, Venezuela
- Cesar Rancheria Basin, Colombia

Field Development and Production

- Los Manueles Field, Venezuela
- Santa Lucia Field, Colombia

Reconnaissance Survey Objectives

Document Presence of Petroleum System(s)

Characteristics of the Petroleum System(s)

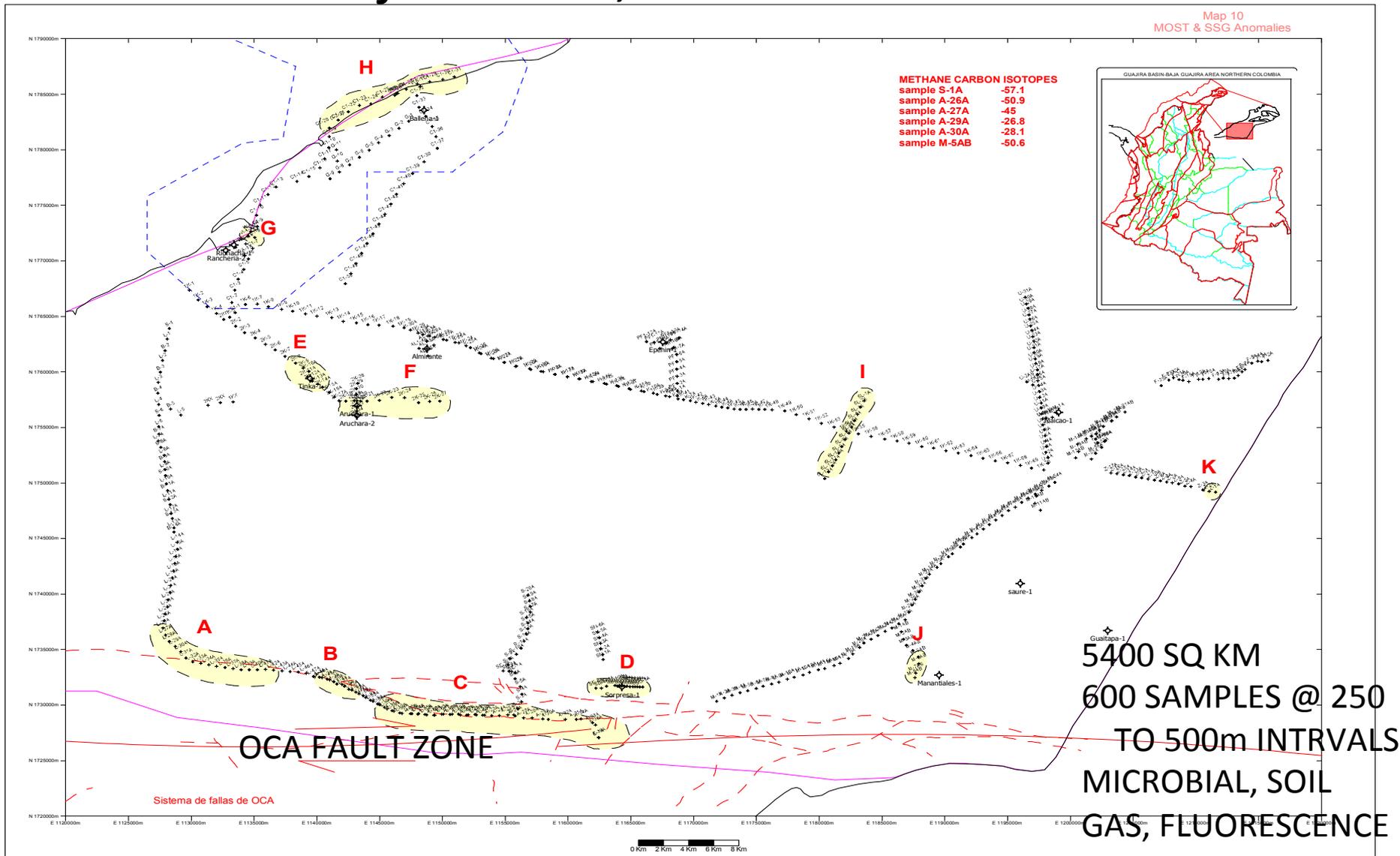
Age, Facies, Maturity, Oil vs Gas, etc.

High-Grade Basin on Basis of Hydrocarbons

Guide Location of Future Seismic Surveys

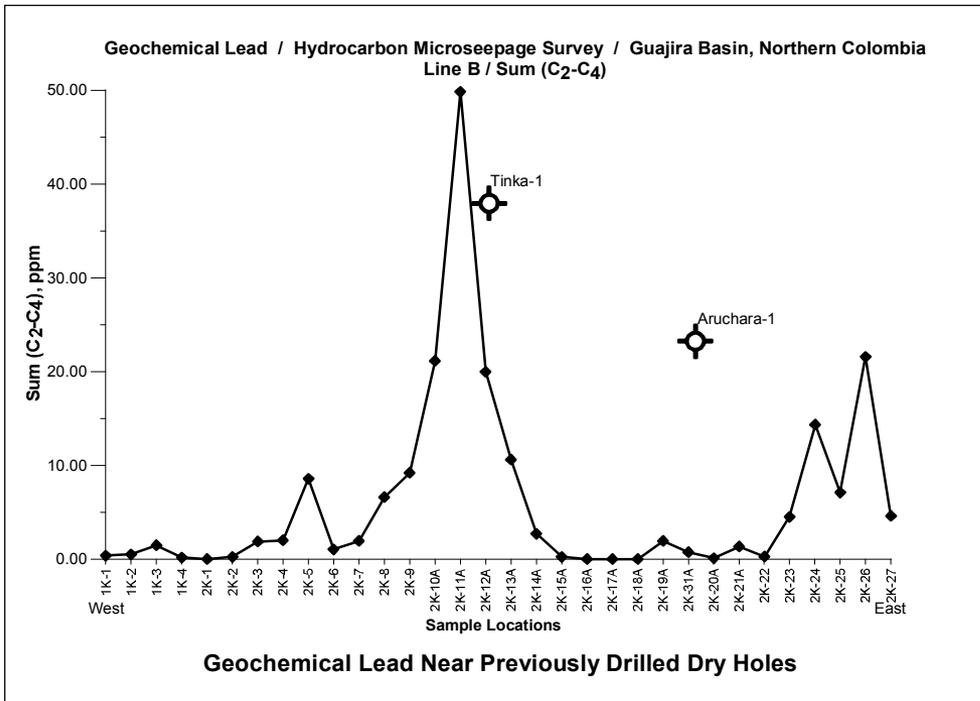
FRONTIER OR UNDEREXPLORED BASINS

Guajira Basin, Northeast Colombia

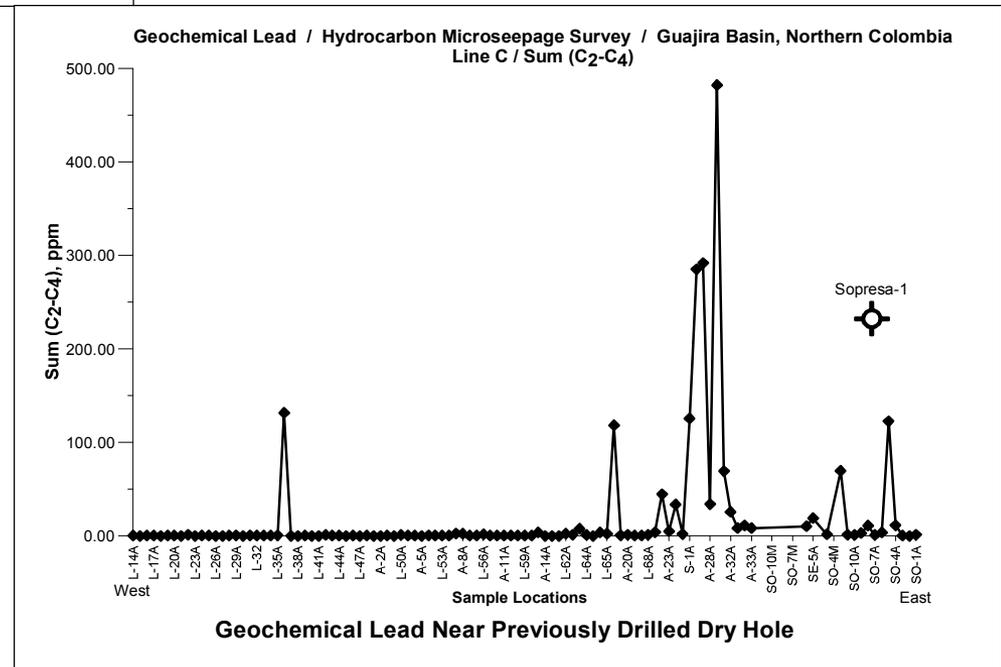


Guajira Basin, Colombia

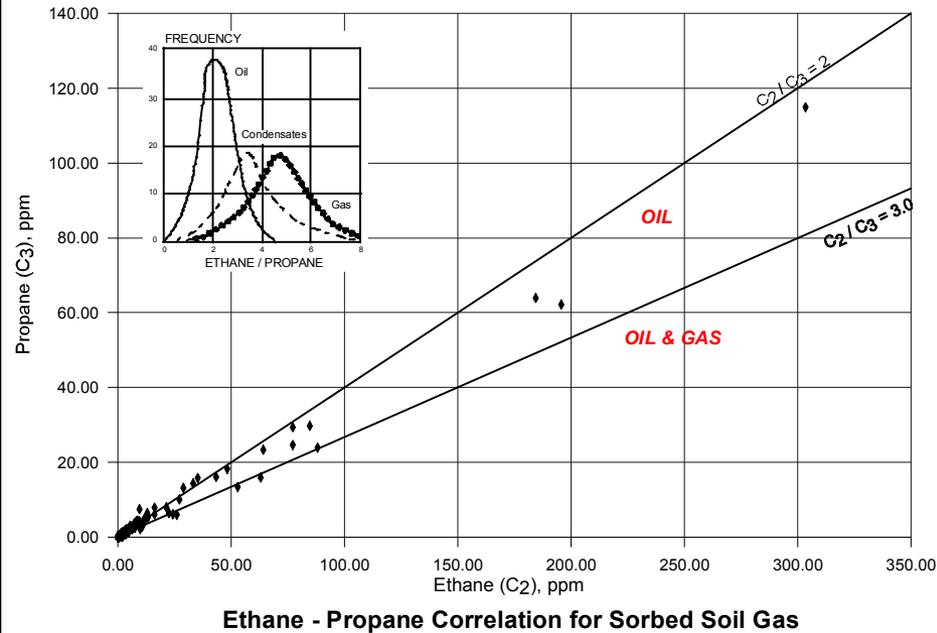
Geochemical Traverses



Acid Extracted Soil Gas Data ----- Sum (C₂-C₄)



Guajira Basin, Northern Colombia
Ethane (C₂) vs. Propane (C₃) / Sorbed Soil Gas Composition

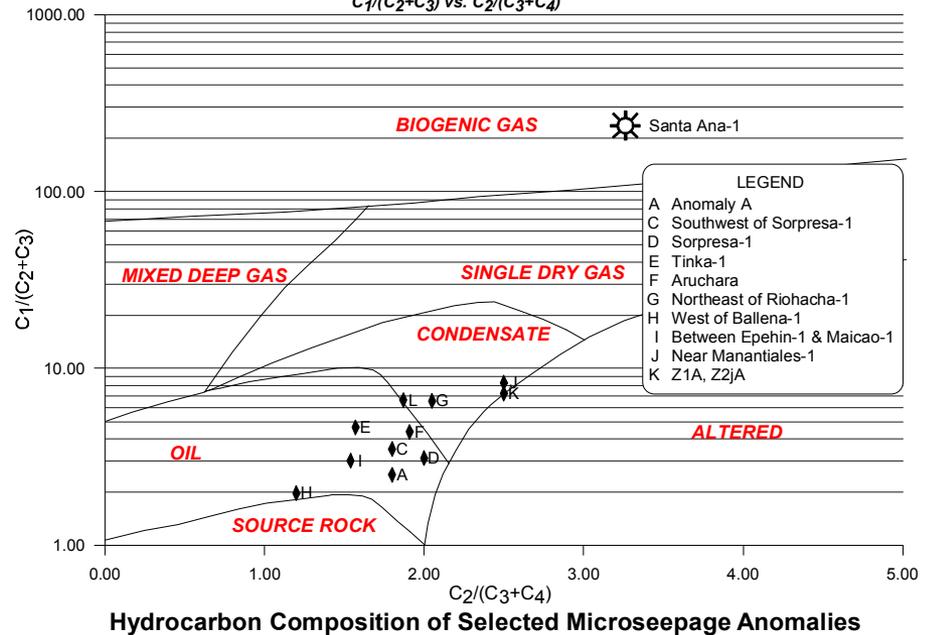


Guajira Basin, Colombia

Adsorbed Soil Gas Hydrocarbon Crossplots

Presence of oil-associated gases document presence of thermogenic petroleum system in a basin which at present only produces biogenic gas

Guajira Basin, Northern Colombia
Hydrocarbon Composition, Sorbed Soil Gas
C₁/(C₂+C₃) vs. C₂/(C₃+C₄)



Frontier Basin Exploration

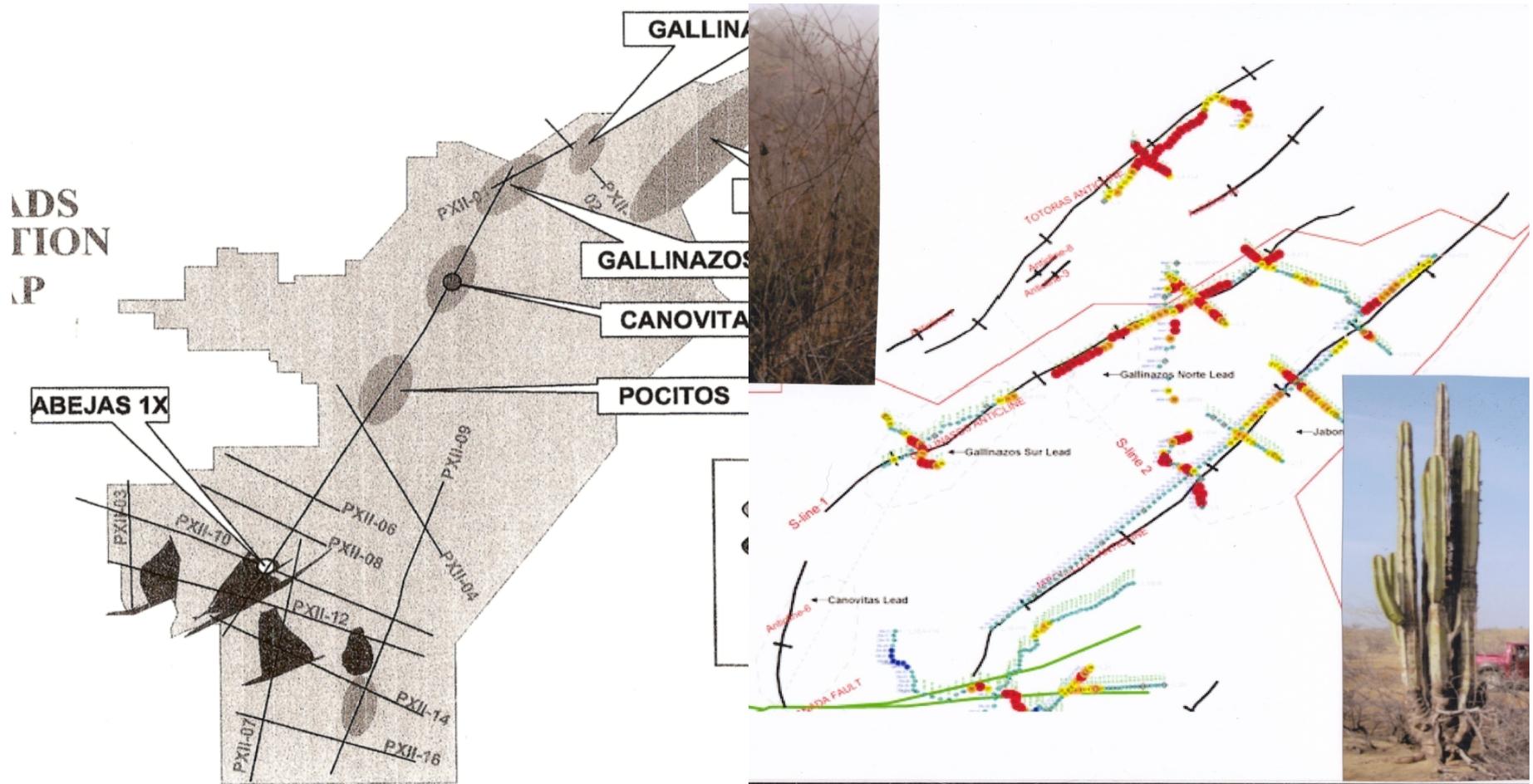
Lancones Block, Northwest Peru

LANCONES
BASIN



Frontier or Underexplored Basins

Lancones Basin, Northwest Peru



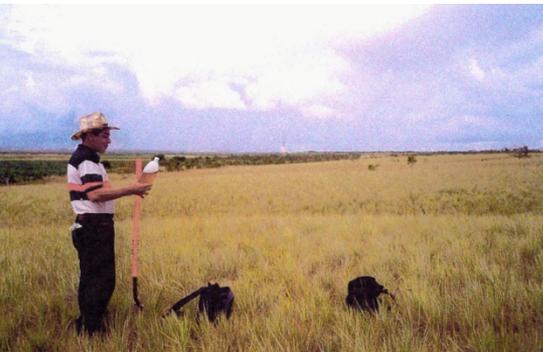
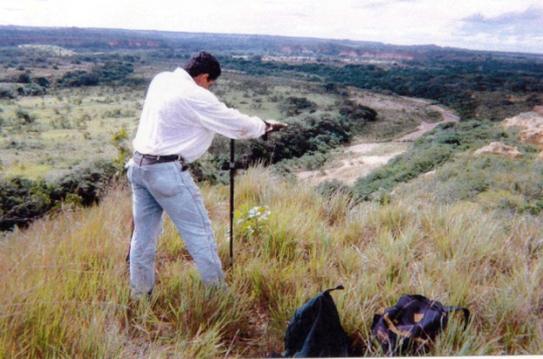
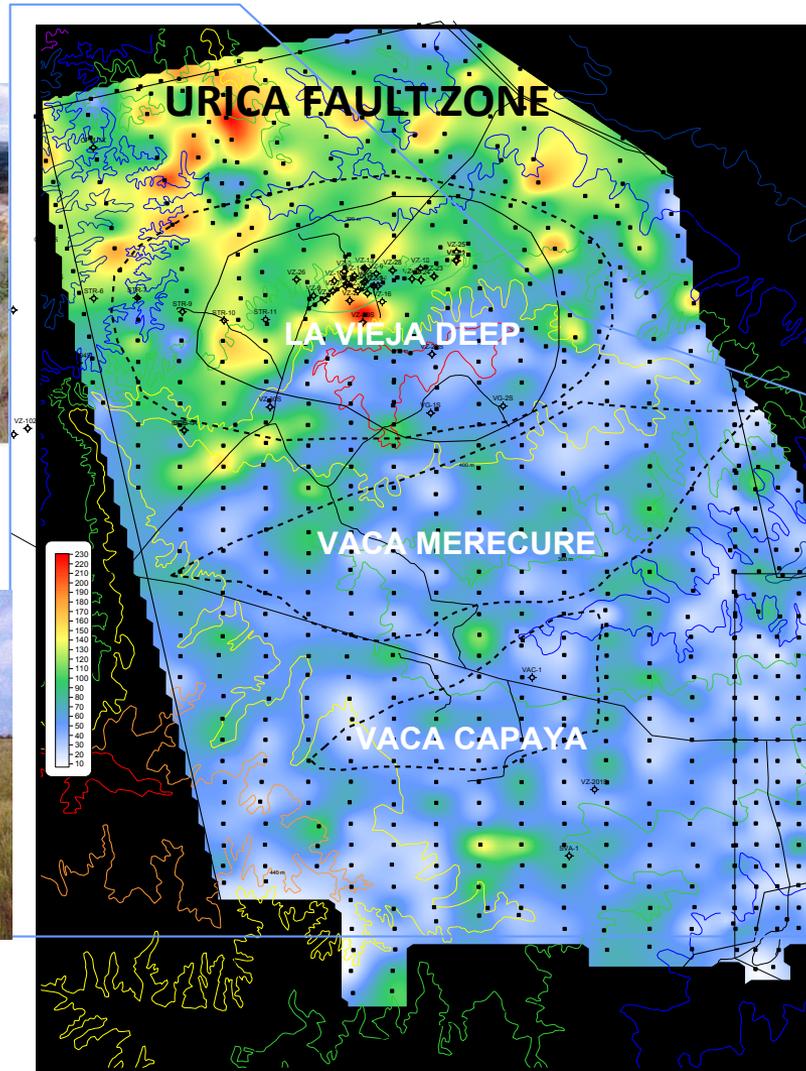
Samples collected along and across surface anticlines

Prospect Generation and Prospect Evaluation: Survey Objectives

1. High-grade existing leads and prospects on the basis of their probable hydrocarbon charge
2. Generate geochemical leads for future geologic and seismic evaluation
3. Determine hydrocarbon composition (oil vs gas)
4. Aid in selection of drilling sites
5. Evaluate leases and concessions prior to their renewal or relinquishment

Eastern Venezuela Basin

QLC Block, Prospect Evaluation

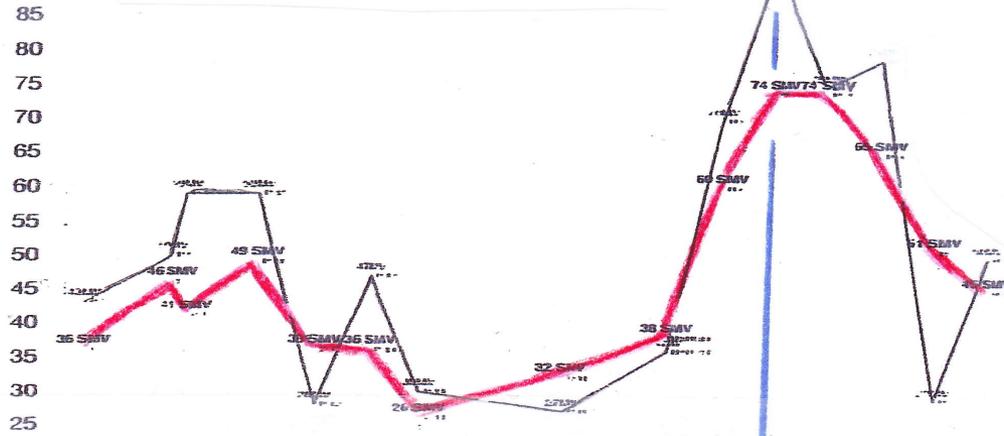


PRINCIPAL RESERVOIRS
ARE MIOCENE OFICINA &
EOCENE MEREURE FMS

575 SQ KM
1600 SAMPLES
SOIL GAS, MICROBIAL

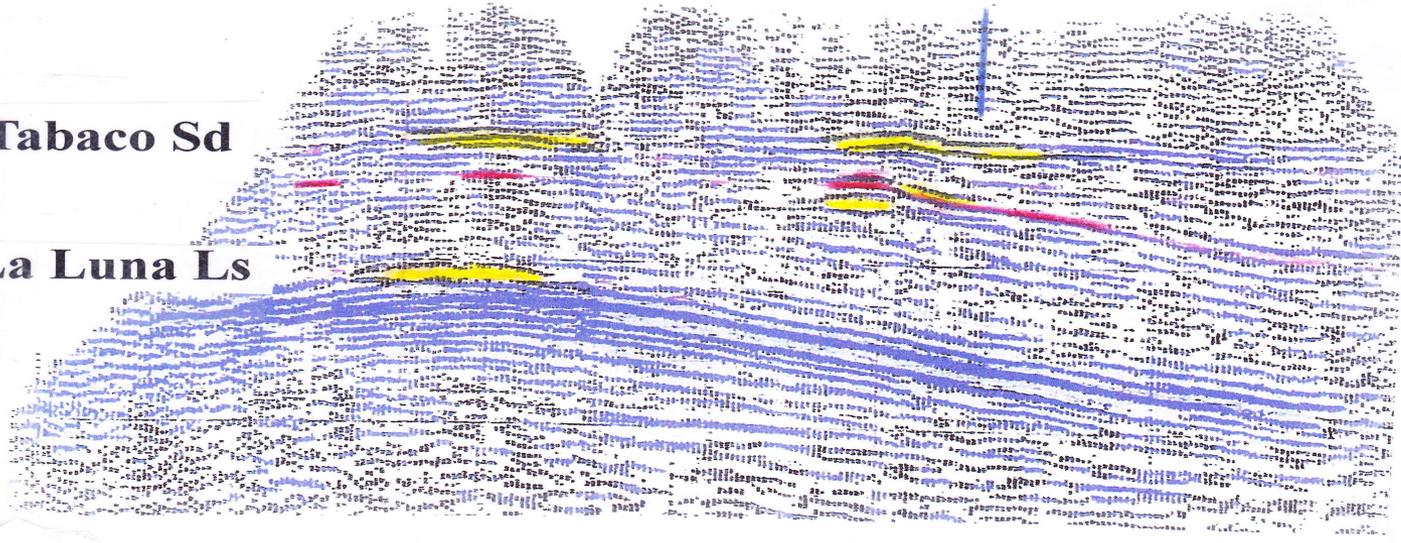
Cesar Rancheria Basin, Colombia

Hydrocarbon Microseepage Profile



Tabaco Sd

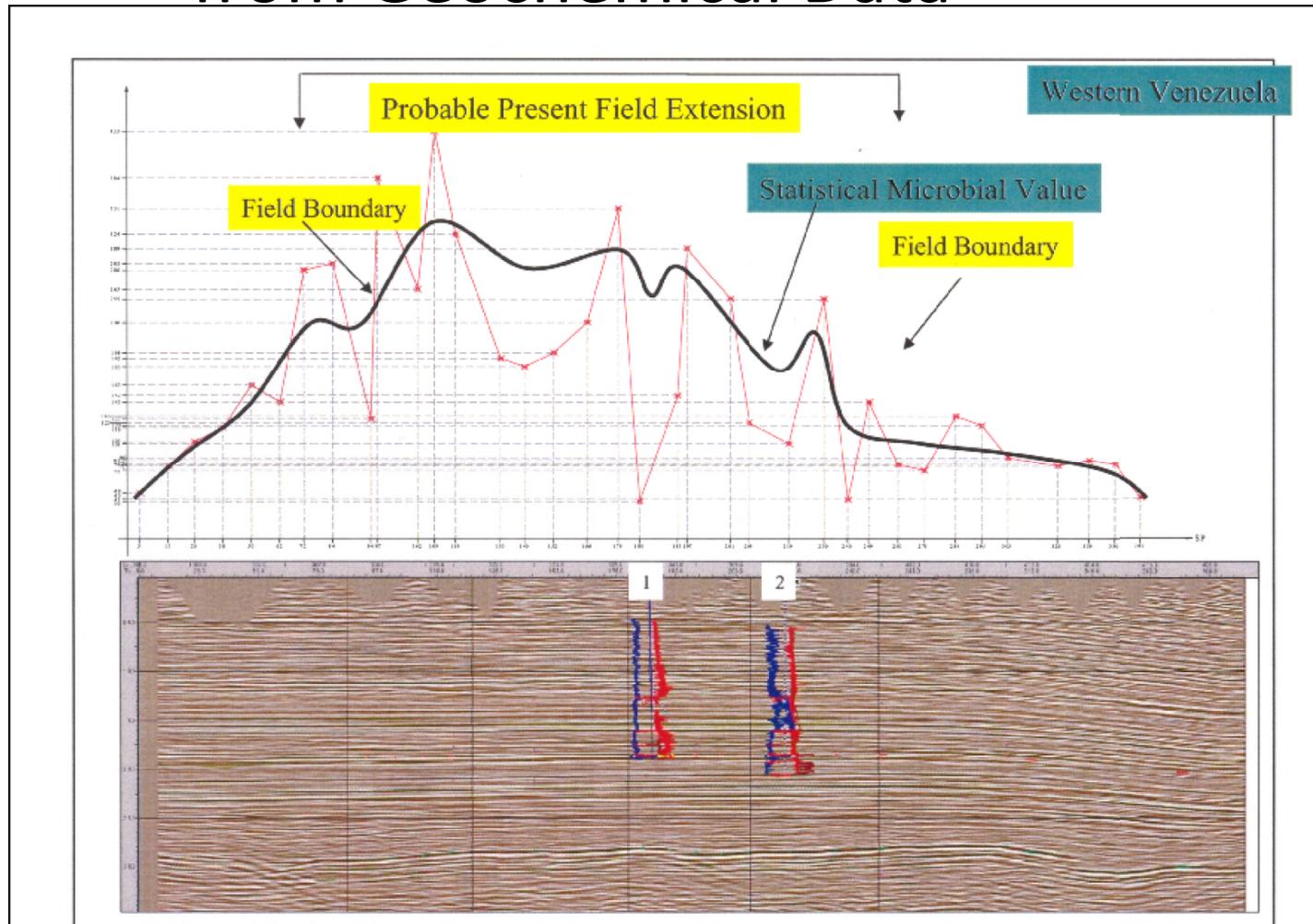
La Luna Ls



Mature Basins and Field Development: Survey Objectives

1. Early delineation of field limits
2. Identify by-passed pay or undrained reservoir compartments
3. Identify near-field opportunities
4. Document hydrocarbon drainage over time with repeat surveys

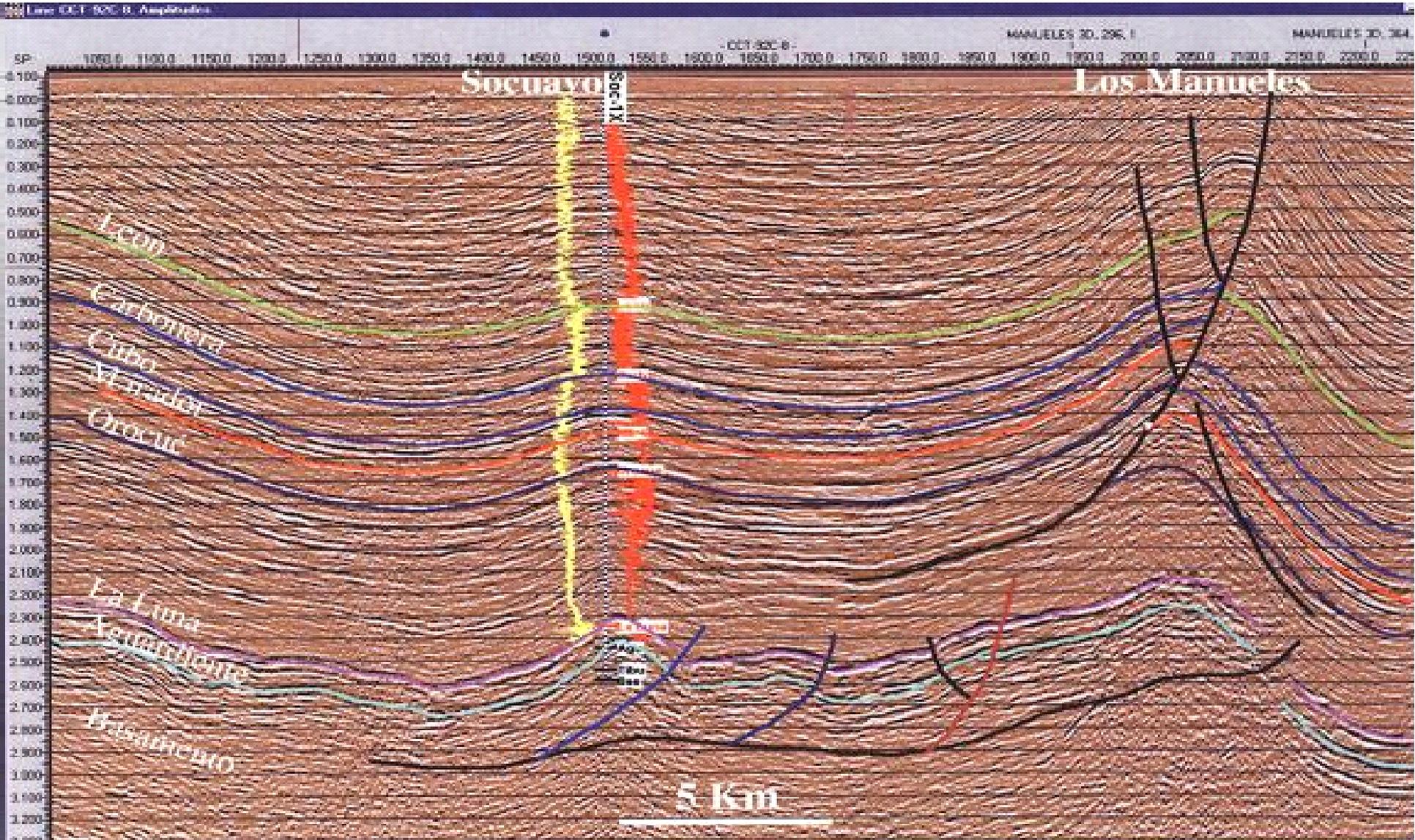
Venezuela – Early Delineation of Field Limits from Geochemical Data



La Palma
Field

Example of a geochemical anomaly associated with a recent discovery in western Venezuela. Microbial samples were collected at 300m intervals along seismic lines to identify the probable limits of the oil/gas field. The most prospective area occurs west of the wells. Also note the low seepage values in the immediate vicinity of the two producing wells; this is due to depressurization of the reservoir due to production.

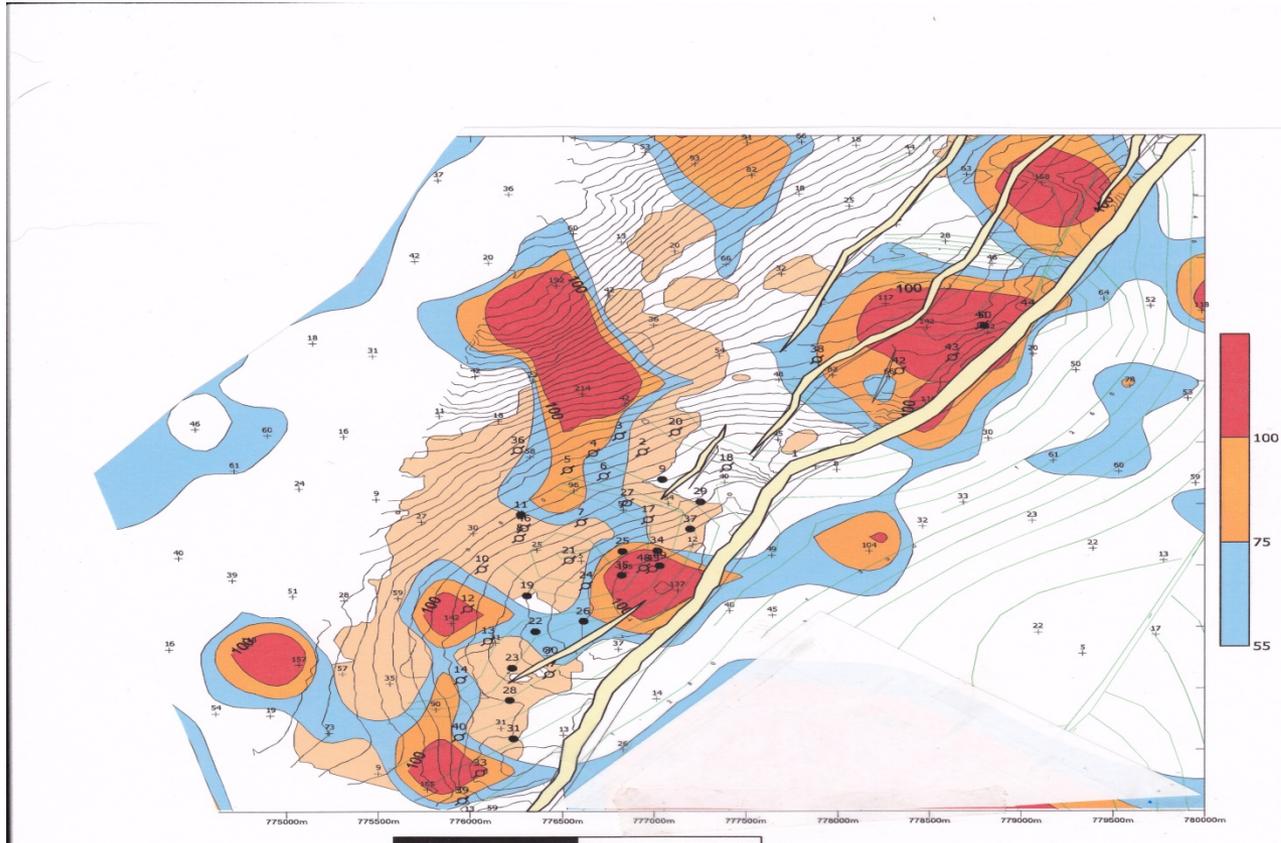
Los Manueles Field, Western Venezuela



SOUTHWESTERN MARACAIBO – CATATUMBO BASIN

Los Manueles Field, Venezuela

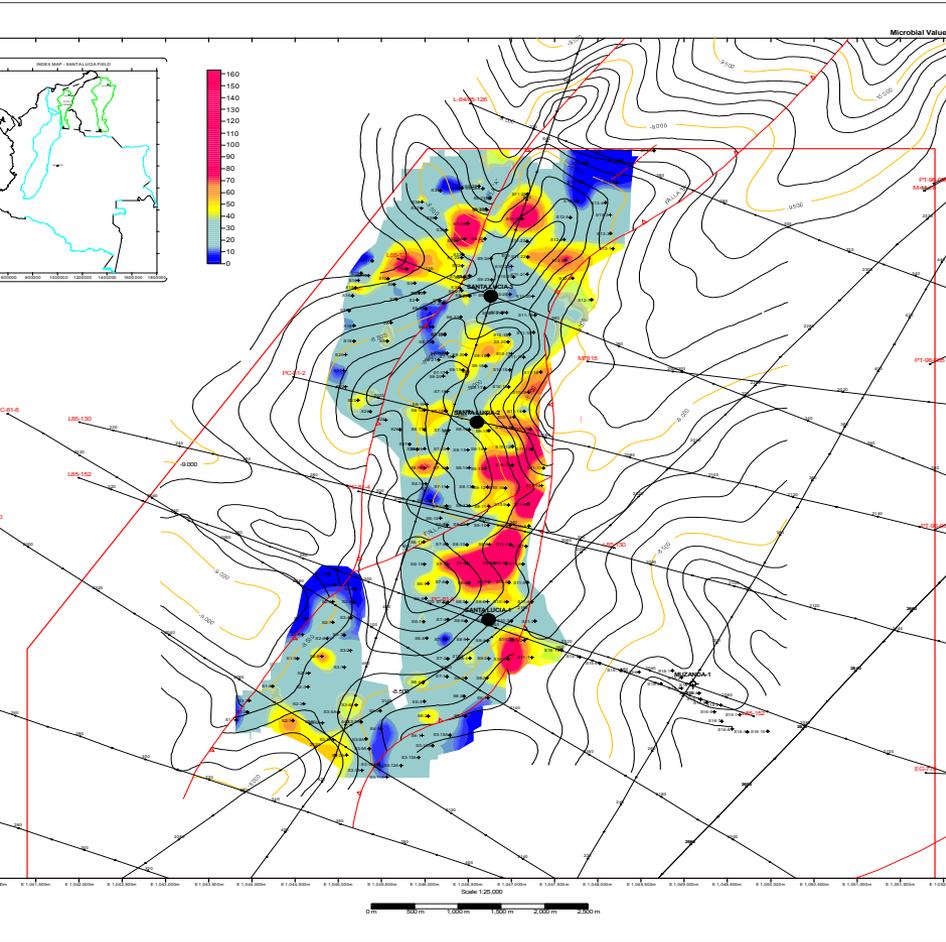
Maracaibo-Catatumbo Basin



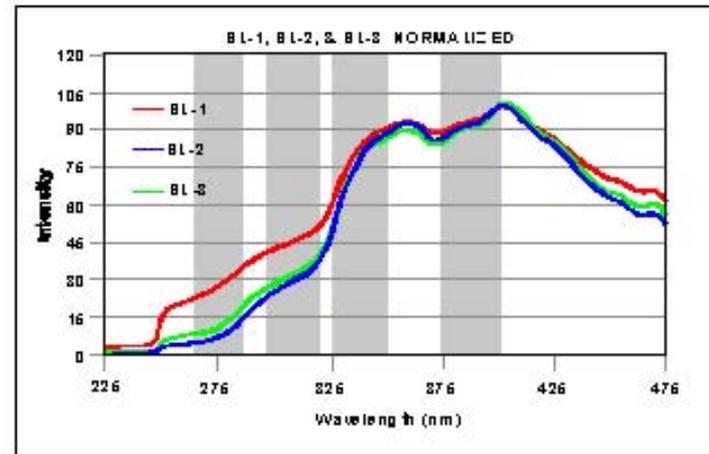
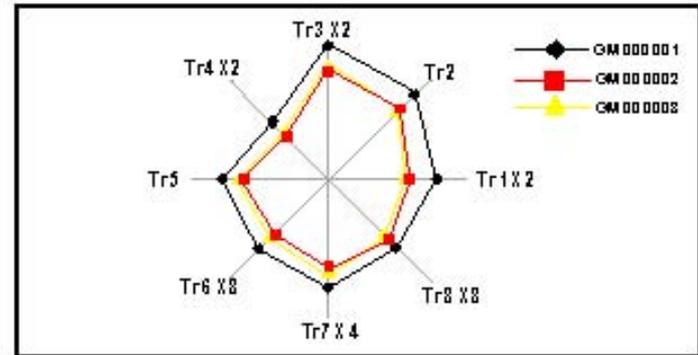
After the survey, 2 oil discoveries were drilled within the geochem anomalies northeast of old field

Hydrocarbon Microseepage anomalies in this old oil field may represent areas of by-passed pay, undrained reservoir compartments, or possible deeper pay zones. Main producing reservoir is Eocene Mirador.

Field Development: Santa Lucia Field, Middle Magdalena Valley, Colombia



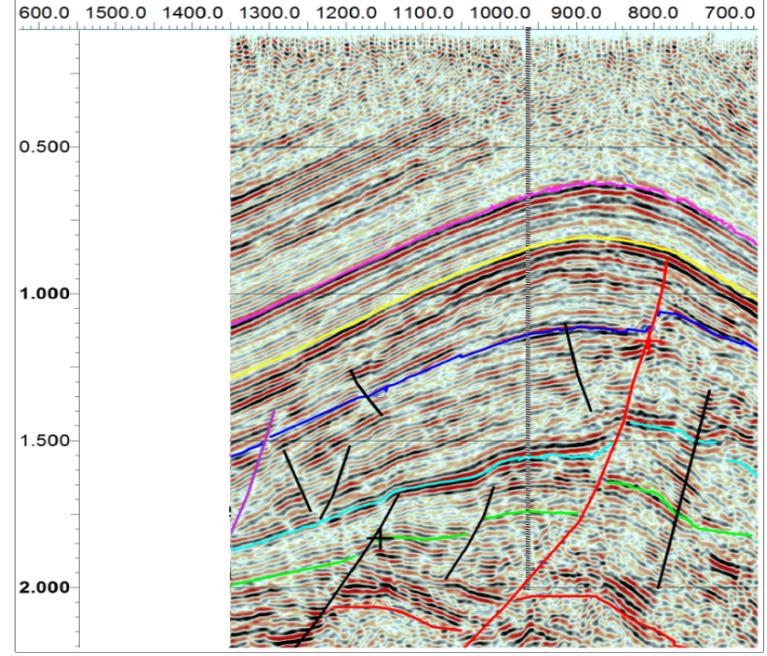
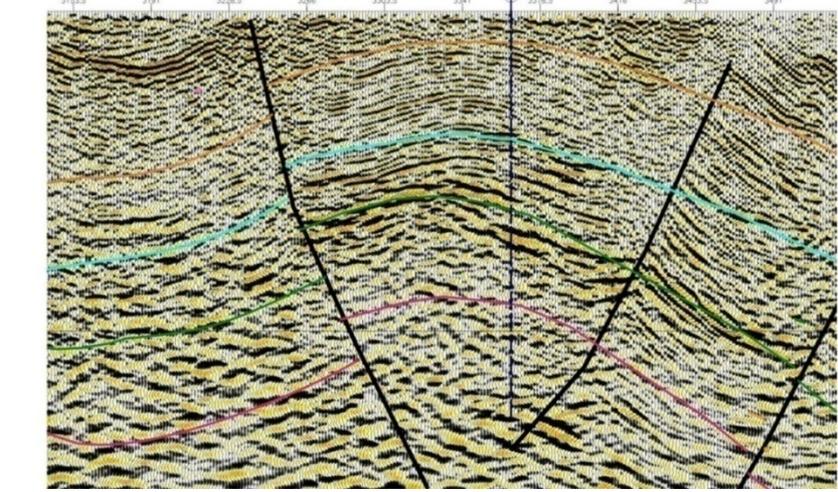
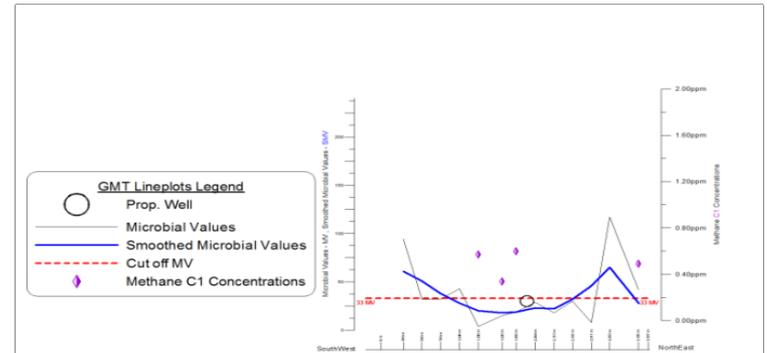
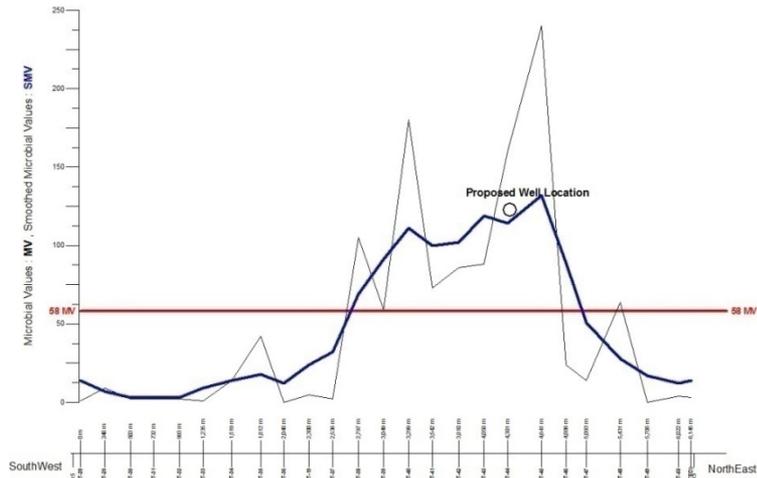
Reservoir Oil Fingerprinting



Fingerprinting of Santa Lucia oils suggests SL1 oil not in fluid communication with SL2 and SL3 oils. Upper figure represents a C7 Oil Transformation Star Diagram. Lower figure shows Fluorescence Data.

Production from Lower Tertiary Esmeralda-La Paz Fm at 2500-2600m

HOW DO WE MEASURE SUCCESS of Hydrocarbon Microseepage Surveys?



Compare prediction with post-survey drilling results

Reducing Exploration Risk

Post-Survey Drilling Results

SUMMARY

2774 Wells, Various Companies,
Various Methods, Various Basins

In Negative Anomalies

- 1430 Wells Drilled
- 1267 Wells Dry (**89%**)
- 163 Discoveries (**11%**)

In Positive Anomalies

- **1344 Wells Drilled**
- **247 Wells Dry (18%)**
- **1097 Discoveries (82%)**

For all wells drilled, the success rate based only on geology and seismic alone was 42% (Schumacher, 2010)

For a Successful Hydrocarbon Detection Survey(s) -

Select the right method(s)

Use proper survey design

Calibrate with analog field or recent
discovery

Integrate surface and subsurface data

Thank you !

Deet Schumacher
deetschumacher@gmail.com