Hydrocarbon Exploration Survey Strategies for Frontier Basins and Other Under-Explored Areas*

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Editor's note: Please refer to closely related articles, Search and Discovery Article #80504 (2016) and Article #80505 (2016).

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Abstract

Frontier basins and other under-explored onshore basins are well suited for hydrocarbon detection surveys using a variety of surface geochemical and non-seismic geophysical hydrocarbon-detection methods. These methods can reliably detect surface or near-surface occurrences of hydrocarbons and their alteration products. The noninvasive, low-impact nature of these techniques makes them ideally suited for use in an early-stage evaluation of remote and sometimes logistically challenging or environmentally sensitive regions, such as jungles, deserts, or culturally sensitive areas. Properly designed surveys can document the presence of an active petroleum system and quickly identify those parts of the area possessing the highest petroleum potential. Use of such an exploration strategy protects the greater part of the area from more costly and more invasive exploration methods by focusing attention and resources on a relatively small number of high-potential sites. Geochemical exploration techniques can be direct or indirect, and measurements can be instantaneous or integrative. Direct techniques analyze small quantities of hydrocarbons that occur in the pore space of soil, are adsorbed onto clay minerals, or incorporated in soil cements. Indirect methods detect seepage-induced changes to soil, sediment, or vegetation. Non-seismic geophysical methods for detection of hydrocarbons or their alteration products include satellite image analysis for seep-induced alteration, high-resolution aeromagnetic data to identify sedimentary magnetic anomalies that form in the seepage environment, radiometric surveys, radar and laser detection of hydrocarbon gases in atmosphere, and passive electromagnetic and telluric measurements. Onshore hydrocarbon microseepage surveys in frontier basins require careful planning and implementation. Microseepage data are inherently noisy data and require adequate sample density to distinguish between anomalous and background areas. Defining background values adequately is an essential part of hydrocarbon anomaly recognition and

delineation. This presentation illustrated examples from North America, North Africa, the Middle East, Asia, and South America.

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Hydrocarbon Exploration Survey Strategies for Frontier Basins

and Other Under-Explored Areas

Collecting Soil Gas Samples

Collecting Microbial Samples

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OUTLINE

- Why Hydrocarbon Detection Surveys
- Early Identification of High Potential Areas
- Survey Methods for Frontier Basins
- Survey Objectives and Design Considerations
- Selected Exploration Examples
- New or Underutilized Technologies
- Conclusions

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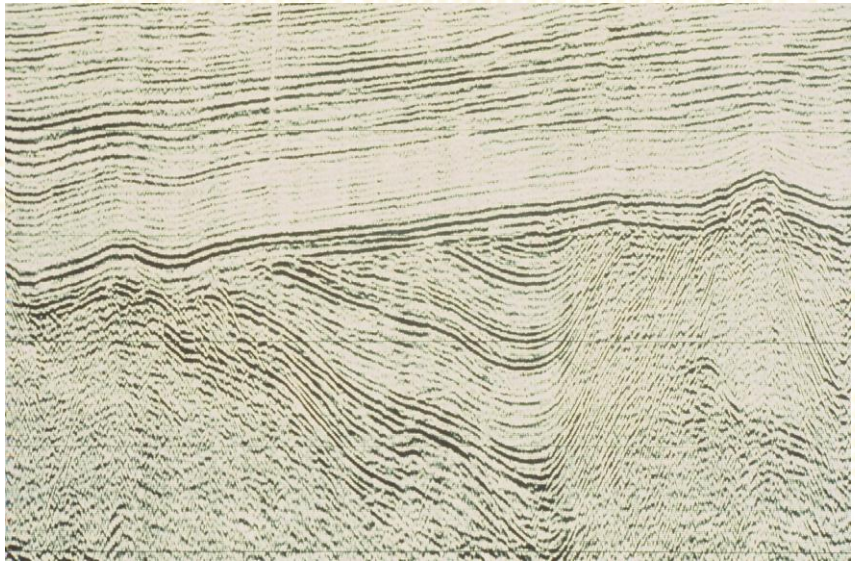
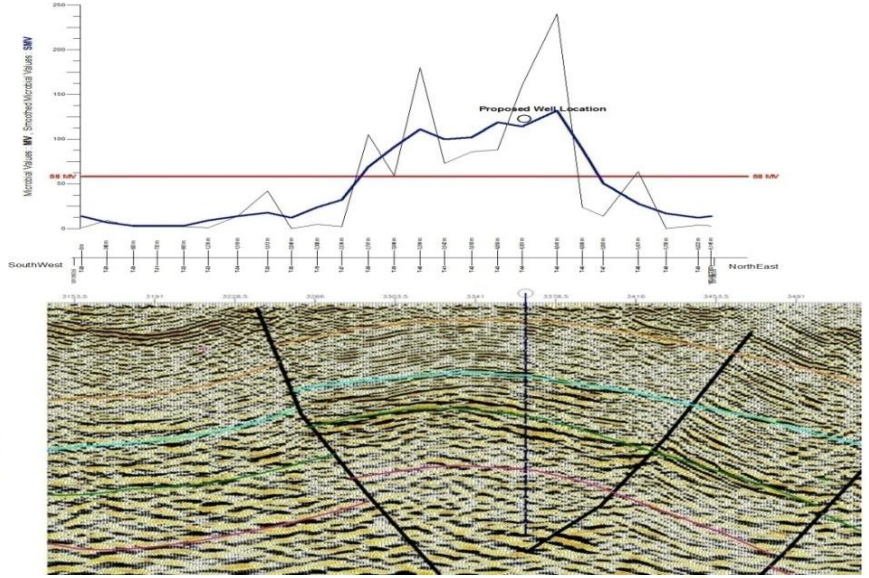
Conventional versus Geochemical Exploration

Finding Traps versus Finding Hydrocarbons





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RECONNAISSANCE SURVEY OBJECTIVES

In frontier basins, the objective of reconnaissance surveys is to find seeps and microseeps that provide direct evidence that thermogenic hydrocarbons have been generated. In other words, they document **the presence of a working petroleum system**.

Additionally, the composition of these seeps can indicate whether a basin or play is **oil-prone or gas-prone**. Detailed analysis of these hydrocarbons enables correlation with known source rocks, oils, or gases; they may also identify specific petroleum system(s).

EARLY IDENTIFICATION OF HIGH POTENTIAL AREAS

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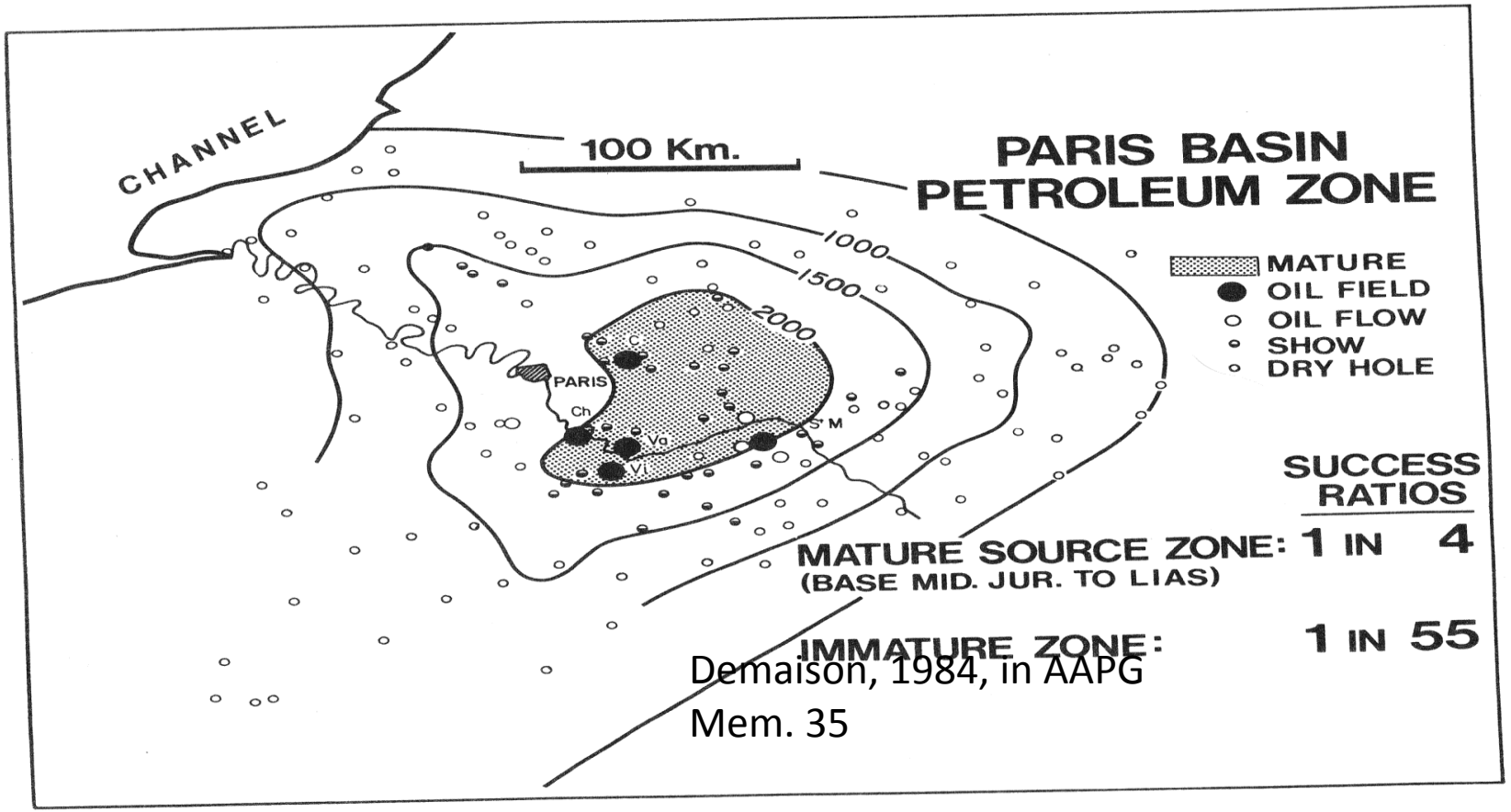
80% of the oil/gas occurs in 20% of the basin.

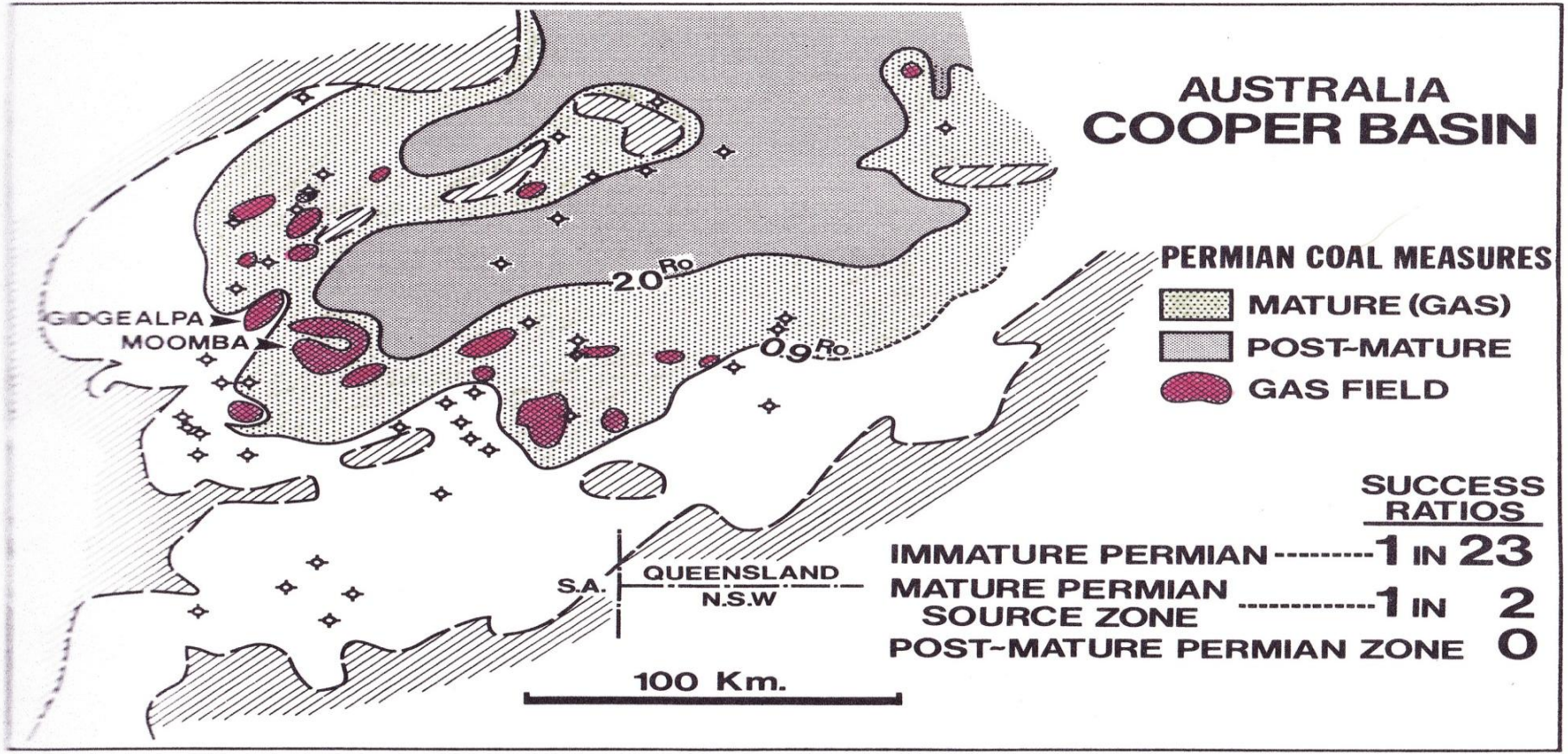
A highly cost-effective strategy in the early evaluation of a frontier basin is to identify the basin depocenter(s) and the hydrocarbon cooking pot, and then use the available hydrocarbon detection technologies to focus more costly exploration in these areas.

Success rates for exploration wells drilled in and near the cooking pot are orders of magnitude greater than for wells drilled elsewhere.



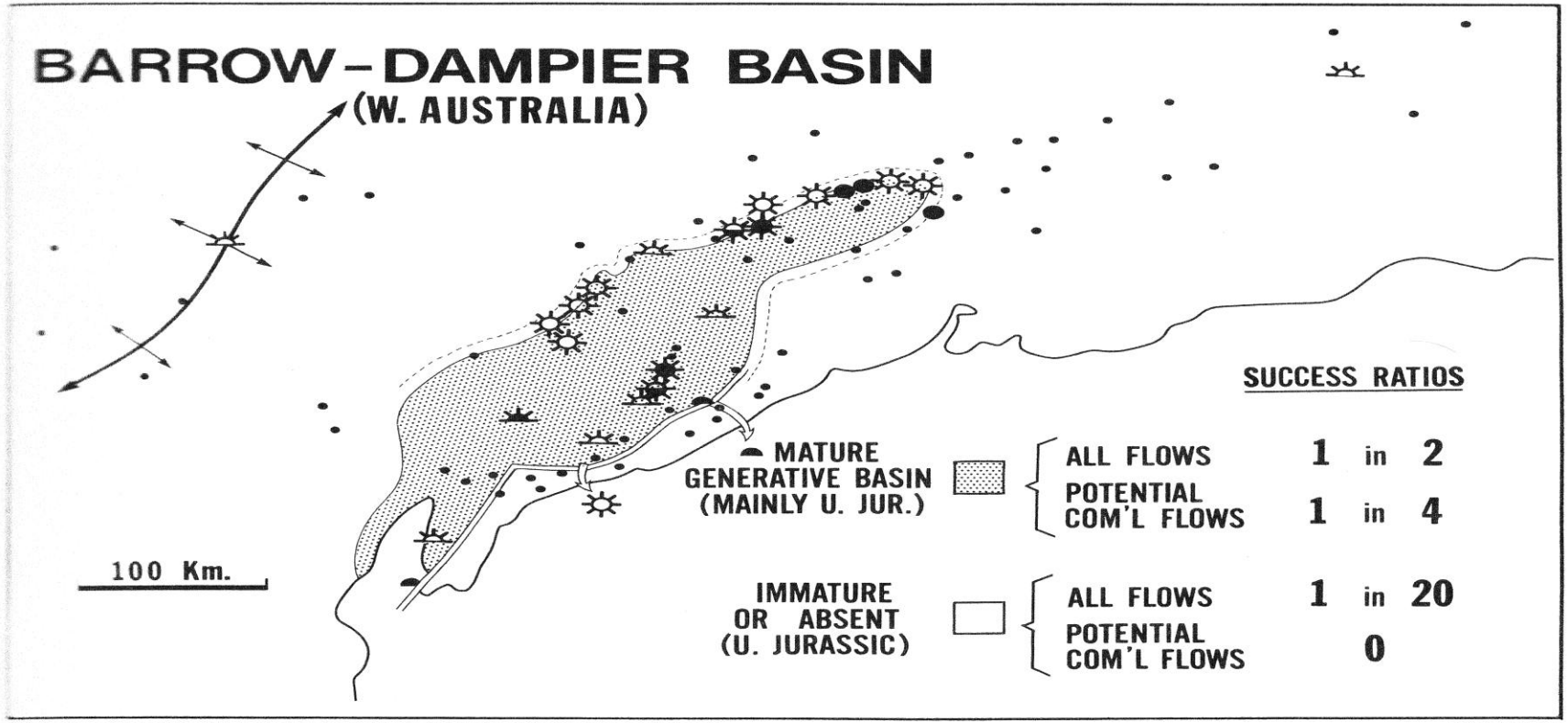
Demaison, 1984, in AAPG Mem. 35

Tissot and Welte, 1978



(Kantsler et al, 1983).

Demaison, 1984, in AAPG Mem. 35



Demaison, 1984, in AAPG Mem. 35

Why Hydrocarbon Detection Surveys ?

Most accumulations leak

Discriminate between oil versus gas

Leakage is predominantly vertical

Identify and map HC-induced alteration

Direct indicator of hydrocarbons

Minimal environmental impact

Prospects with an associated hydrocarbon anomaly are 4-6 times more likely to result in a commercial discovery than prospects without such an anomaly

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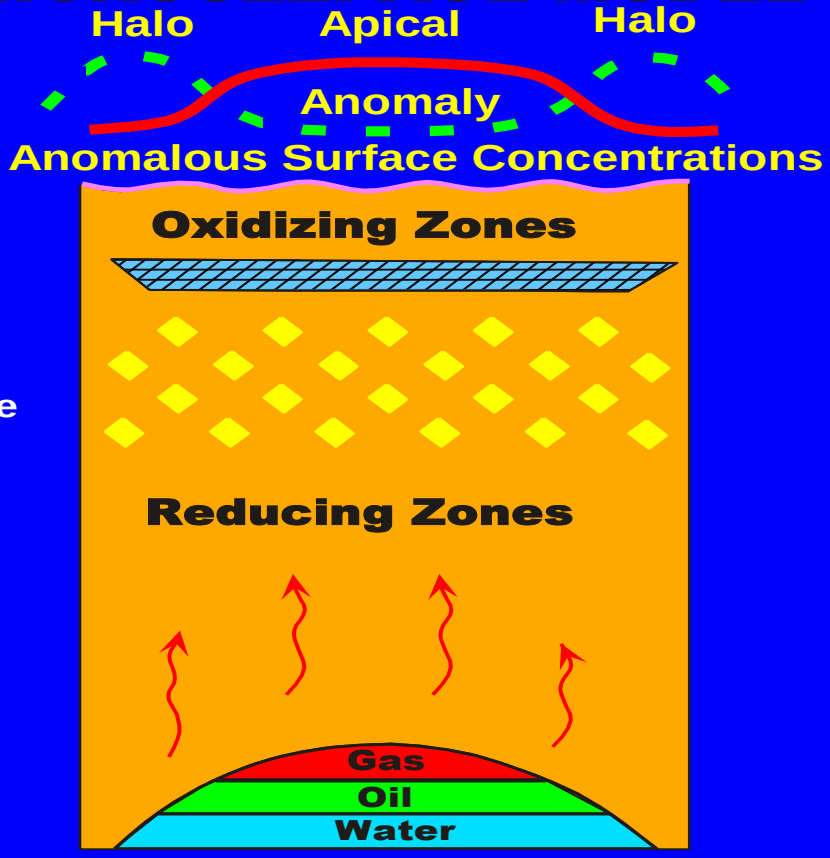
MACROSEEPAGE -- visible oil and gas seeps; located at faults, fractures, and outcrops

MICROSEEPAGE – not visible but detectible; occurs above mature source rocks and over accumulations

MICROSEEPAGE MODEL



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

EXPLORATION METHODS FOR FRONTIER BASINS

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- 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


ARCTIC CAT

WHAT AND WHERE TO SAMPLE

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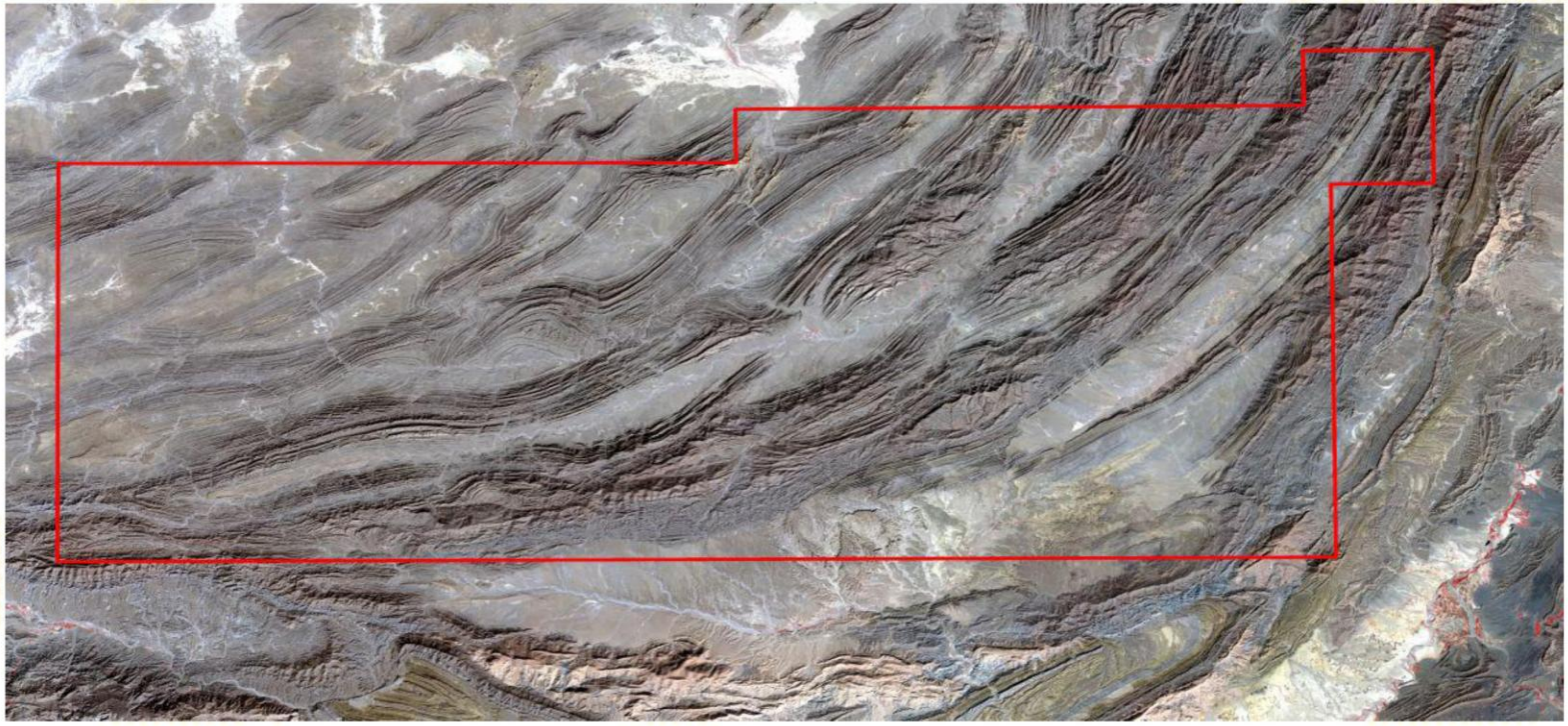
- Oil and Gas Seeps, if present
- Along & Across Faults and Fracture Zones
- Gravity Lows (Basin Depocenter?)
- Structural Highs
- Possible Seep-Induced Soil/Sediment Alteration
- Along Regional Seismic Lines, if available
- Geologic Analogs (both productive and dry)
- Regional Survey Lines or Grids, depending on terrain and logistical considerations



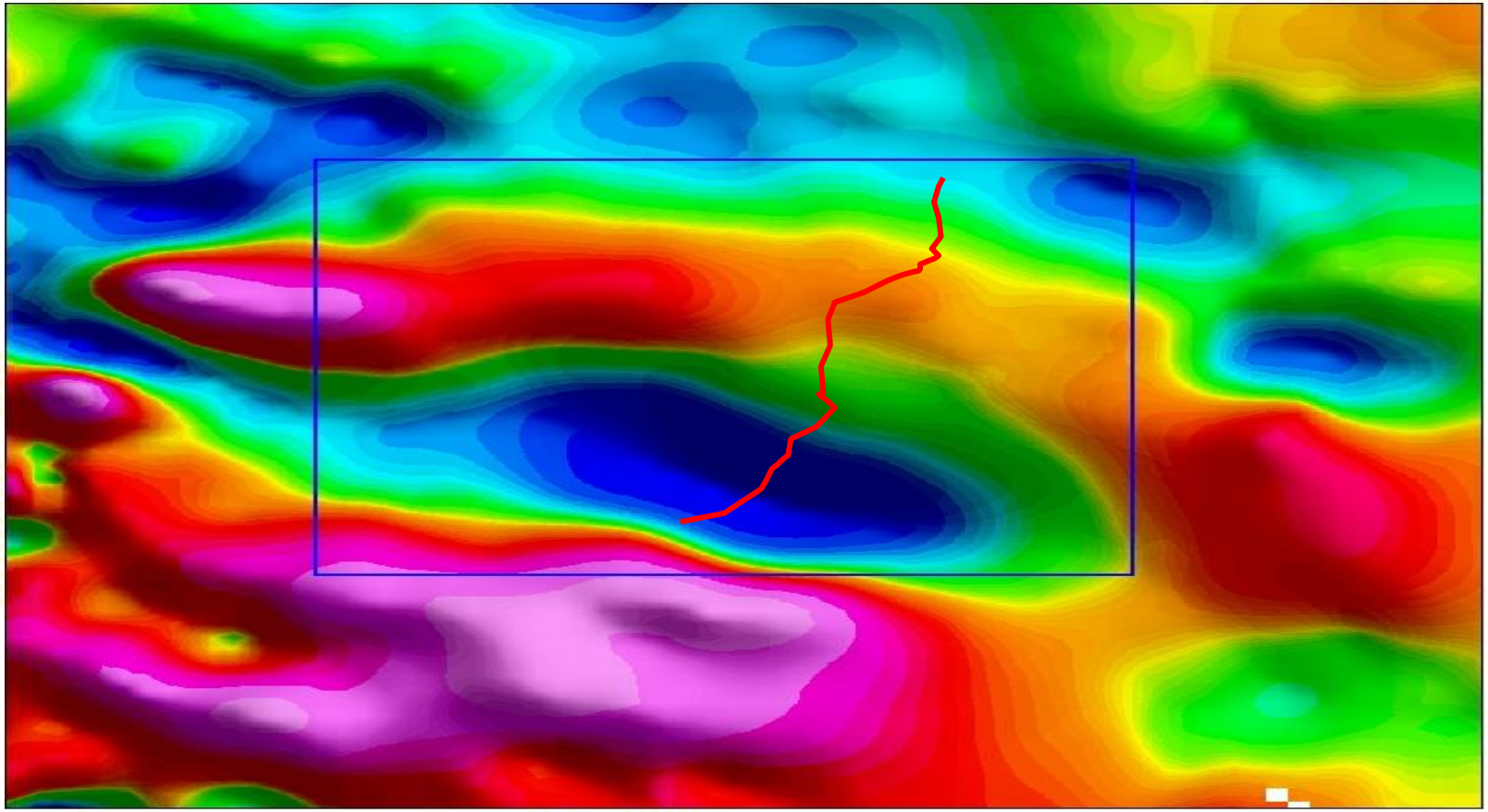


Pishin Basin, Balochistan, NW Pakistan

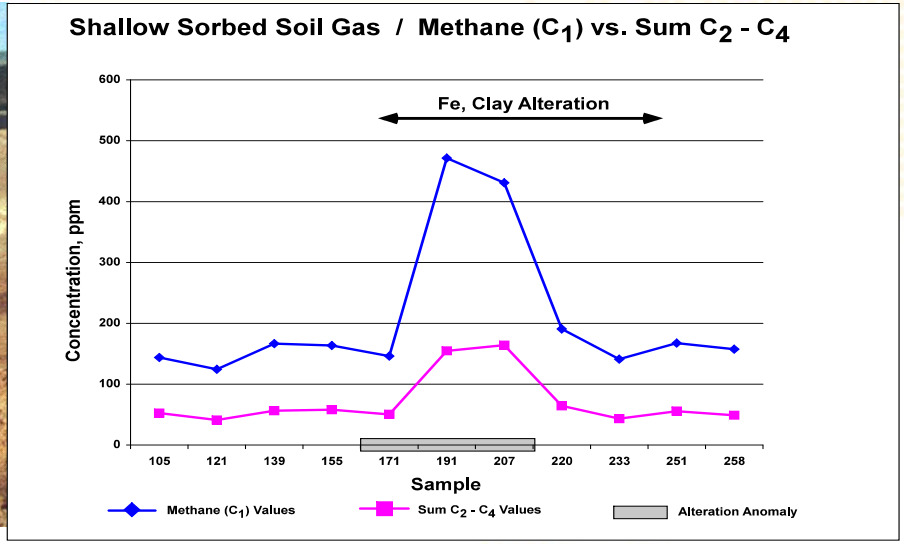
Using Remote Sensing, Geologic Mapping, and Geochemistry

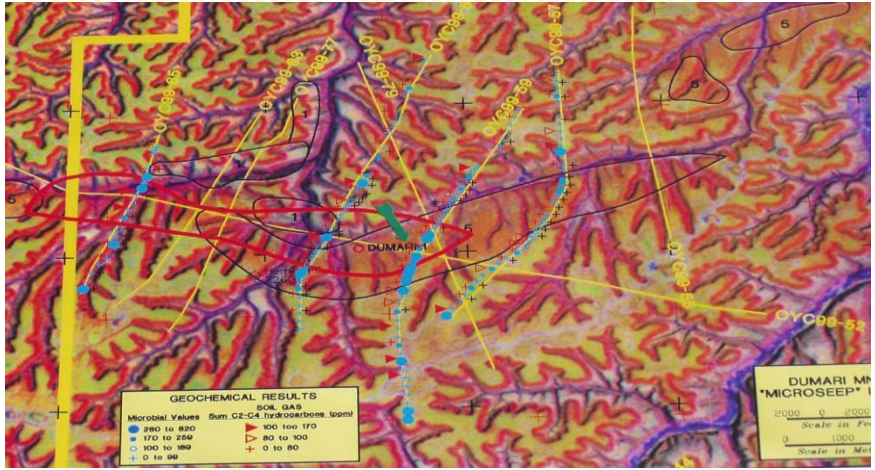
Presenter's notes: In this remote and undrilled basin, surface geochemical surveys were conducted along and across each major anticline to identify which ones were most likely to be charged and whether any was likely to yield liquids rather than dry gas. Only 3 anticlines in the east have liquid potential, and that is where seismic data were subsequently acquired.

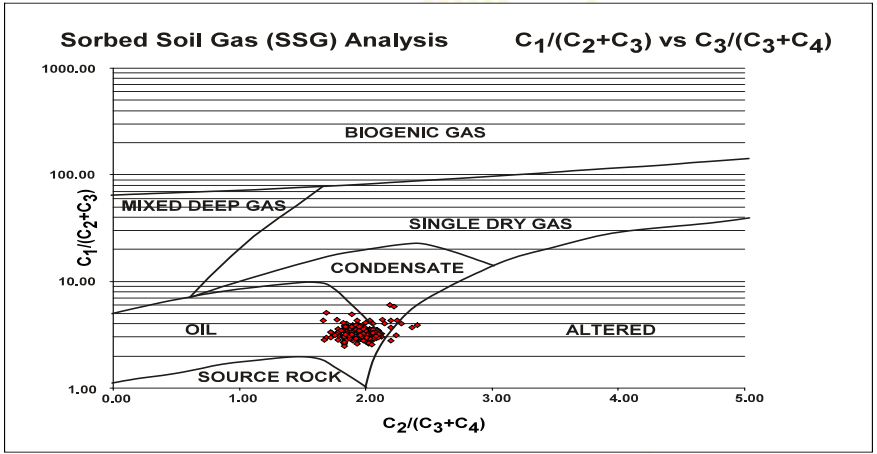


PLANNING THE SURVEY FROM GRAVITY AND MAGNETIC DATA

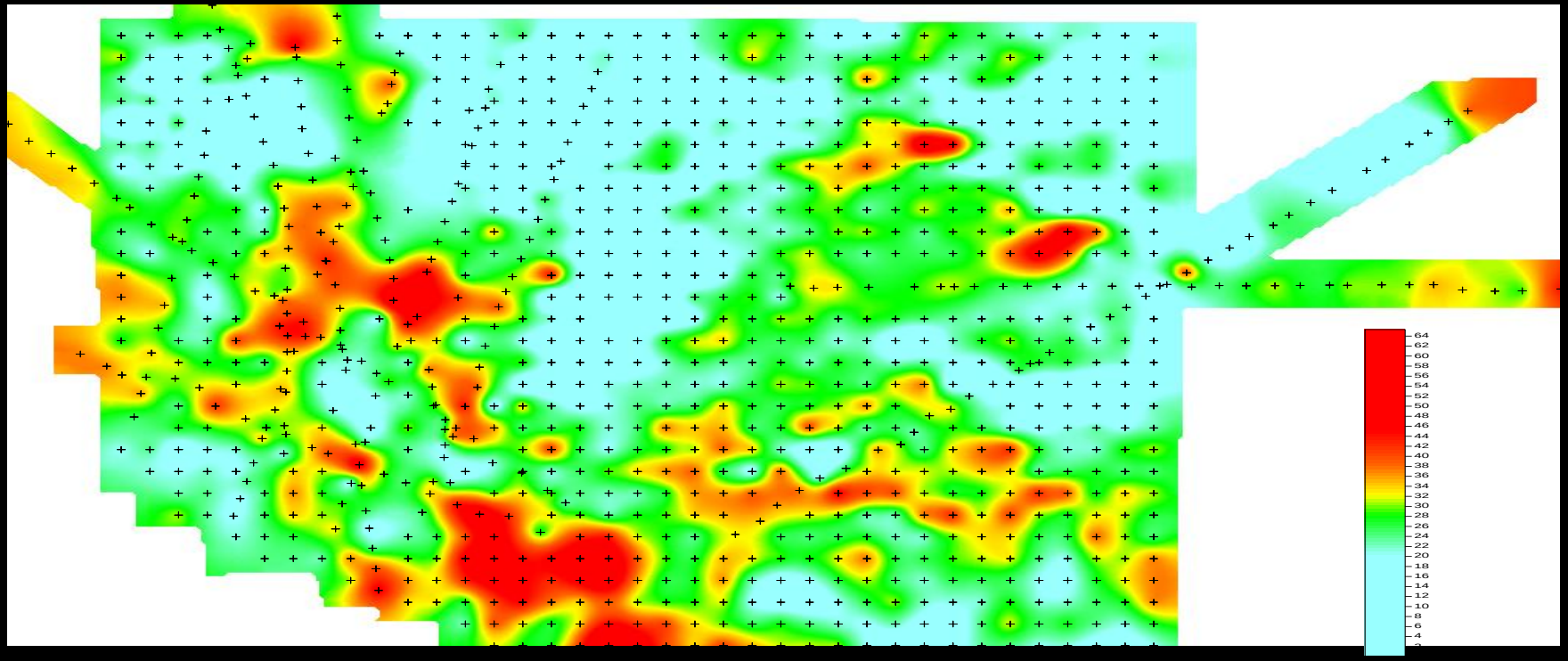
MASILA BASIN, YEMEN







Hydrocarbon Detection Surveys are also effective in basins with thick volcanic cover



Hydrocarbon Microseepage Anomalies in southwestern Armenia; south-central anomaly is an undeveloped gas field

New, Novel, or Technologies for Underutilized Frontier Basins

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Satellite Imagery for Hydrocarbon Detection

Airborne Remote Sensing – Hydrocarbon Sniffing; NXT's Stress Field Detection Surveys (SFD); NEOS array of airborne sensors and data

Seep-Induced Magnetic Anomalies

Electromagnetics, Tellurics

Surface geochemical ground-truthing

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CONCLUSIONS

Variety of remote sensing, geochemical, and non-seismic hydrocarbon detection methods

Document presence of petroleum system(s)

High-grade basin or concession based on its hydrocarbon potential

Identify priority targets or areas for seismic surveys

Focus exploration resources on areas with greatest petroleum potential

THANK YOU !

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