Improving Success of Surface Geochemical Surveys: 7 Pitfalls to Avoid*

Dietmar Schumacher¹

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¹E&P Field Services, Mora, New Mexico (deet@enp-services.com)

Abstract

The phenomenon of hydrocarbon microseepage has been well documented and forms the basis for numerous direct and indirect hydrocarbon detection methods. Over the years, these hydrocarbon exploration surveys have resulted in significant successes and some equally significant apparent failures or disappointments. How can we improve the probability of success of these geochemical and non-seismic hydrocarbon detection surveys? A review of several hundred geochemical surveys identifies seven major pitfalls that contribute to survey failure or interpretation ambiguity. These surveys were conducted in geologically and environmentally diverse settings, and used a variety of survey designs and analytical methods. The seven pitfalls to avoid are the following:

1. Survey objectives poorly defined.
2. Improper survey design.
3. Too few samples.
4. Poor data quality.
5. Interpretation errors.
6. Absence of good analogs.
7. Data integration poor or incomplete.

For a successful surface geochemical survey one must select the right analytical methods, use proper survey design, calibrate with a good geologic analog or recent discovery, and fully integrate surface and subsurface data. The discovery of a surface
geochemical anomaly does not guarantee discovery of commercially significant volumes of hydrocarbons. However, it has been well documented that prospects associated with such hydrocarbon anomalies are 4 to 6 times more likely to result in commercial discoveries than similar prospects lacking such microseepage anomalies.
Presenter’s notes: Team on left is collecting soil sample from one meter depth to be analyzed for acid-extracted soil gas; team on right is collecting soil sample from 20cm depth --to be analyzed for presence of hydrocarbon-utilizing microbes (specifically for butane-utilizers). If it is important to identify presence of liquid hydrocarbons, the shallow soil sample can also be analyzed for aromatic hydrocarbons using a fluorescence method.
• Why Hydrocarbon Detection Surveys
• Common Pitfalls to Avoid
• Survey Objectives and Survey Design
• Interpretation Failures
• Data Integration
• Summary
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.
Pitfalls to Avoid

1. Objectives poorly defined
2. Improper survey design
3. Too few samples
4. Poor data quality
5. Interpretation errors
6. Absence of good analogs
7. Data integration is poor or incomplete
SPECTRUM OF SEEPAGE STYLES

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

MICROSEEPAGE -- not visible but detectible; occurs above mature source rocks and over accumulations
Presenter’s notes: List of the main surface geochemical exploration methods; highlighted methods are the ones E&P Field Services uses for majority of its surveys. Other analytical methods are available if needed or warranted (i.e., chromatography, biomarkers, carbon isotopic analysis, etc.), as well as passive EM measurements to determine depth to hydrocarbon-bearing zones down to 5000m depth at 5-10m resolution.
SAMPLE COLLECTION and ANALYSIS
The Altiplano, Bolivia

Collecting Soil Gas Samples
Collecting Microbial Samples

USE 2 OR MORE INDEPENDENT BUT COMPLEMENTARY ANALYTICAL METHODS
Survey Design Considerations

Survey Objectives
- Target Size, Shape
- Geologic Setting
- Topography, Vegetation
- Logistical Considerations

• Ability to Sample Along & Between Seismic Lines
• Geologic Analogs for Calibration
• Permitting
• Environmental Issues
**SURVEY**

**Reconnaissance:** Document the presence of a working petroleum system; identify areas for more detailed geochem, seismic, etc.

**High-Grade Leads, Prospects** ... based on likely Hydrocarbon Charge

**Field Development, Production:** Identify by-passed pay, discriminate between charged and uncharged compartments

**Near-Field Exploration:** Identify new exploration opportunities

**OBJECTIVES**
Sampling Strategy - Survey Design

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

Sample Spacing:
- 440ft by 5280ft
- 130m by 1600m

Sample Spacing:
- 440ft by 2640ft
- 130m by 800m

Sample Spacing:
- 440ft by 440ft
- 130m by 130m

Predicted Product based on MOST
Undersampling and/or the use of improper sampling techniques is the leading cause of ambiguity which leads to interpretation failures in geochemical surveys.

PITFALLS #2, 3
East Texas Jurassic Cotton Valley Pinnacle Reefs
Reefs are 300m wide and 4500-5000 m deep
A Powerhouse Emerges: Energy for the Next Fifty Years

Area A -- Producing Reef Prospects

Sample Pattern and Spacing MUST Consider Target Shape and Size
(400m versus 100m = 16 samples versus 160 !)
Geological and geochemical analogs are valuable. What constitutes a significant geochemical anomaly? Are your survey results meaningful? Are you using the best sampling and analytical methods for the area of exploration interest, and for your objectives?

These questions can sometimes be answered by acquiring surface geochemical data from over a geologic analog or a recent discovery. Producing fields may not be good analogs unless they have only been on production a short time (the disappearance of geochemical anomalies over old fields has been well documented). Dry holes can be good analogs if they penetrate the section(s) of interest.
A Powerhouse Emerges: Energy for the Next Fifty Years

Carboniferous Channel Sands, Oklahoma – Geochem and 3D Seismic

Smoothed Microbial Values

Smoothed Microbial Values Contoured

Strongest Microbial Anomaly

Depleted 1950's Bartlesville Sand Reservoir

Layton Channel Identified by 3-D Interpretation
PITFALL #4

DATA QUALITY

Cleveland Co., Oklahoma

Menard Co., Texas
Microseepage is Predominantly Vertical

Extent of Surface Anomaly Approximates Shape and Areal Extent of Reservoir at Depth

San Jorge Basin

Morrow Channel, CO-KS

Theoretical Geochemical Anomaly associated with a fluvial channel.

600 sq km

PITFALLS #5, 7 – INTERPRETATION ERRORS, DATA INTEGRATION
3D Seismic Imaging of Silurian Reefs in Ontario
Sampled at 75m Intervals
Microseepage Anomalies, Silurian Reefs in Ontario, Sampled at 75m
Mata Magallanas Oeste Field, Argentina (Microseepage Anomalies in Blue)
Interpretation requires integration of surface and subsurface data

Understanding geology is key to using seeps and microseeps in exploration
Presenter's note: Profile of microbial values, in particular, shows the main anomaly, the effect of the river, and the anomaly due to the fault.
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Thank you!

Deet Schumacher
deet@enp-services.com