Integrated Approach Using Subsurface Geology, Aeromagnetics, Surface Geochemistry and 3-D Seismic in Discovering New Conventional Reservoirs*

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Search and Discovery Article #41494 (2014)**
Posted November 30, 2014

*Adapted from oral presentation given at AAPG International Conference & Exhibition, Istanbul, Turkey, September 14-17, 2014

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Abstract

An integrated approach is used by many companies in the industry that is restricted to subsurface geology and 3D seismic. By adding aeromagnetics and surface geochemistry allows a more definitive approach. In many producing areas aeromagnetics can be used to determine faulting that can be related to potential structural and stratigraphic traps and to delineate potential migration pathways. In some basins such as the Forest City, isolated structures are the norm but not all structures are productive. Aeromagnetics can help determine likely areas of oil migration. Surface geochemistry provides a tool to determine if micro-seepage is present at the surface. Historically an area of no anomalous surface geochemical readings typically implies a reservoir with no petroleum of significance present. By using a group of complimentary exploration tools this helps reduce but not always eliminate risk in drilling. The Arikaree Creek and Bolero fields in the Denver Basin and several Bartlesville sand producing fields in the Cherokee Basin using this integrated approach will be discussed.

Reference Cited

Dickinson, R., D.A Uhl, M.D. Matthews, R.J. LeBlanc, Jr., and V.T Jones, 1994, A retrospective analysis of a soil gas survey over a stratigraphic trap trend on the Kansas-Colorado border: AAPG Hedberg Research Conference, Near-Surface Expression of Hydrocarbon Migration, April 24-28, 1994, Vancouver, British Columbia, Canada. Poster Session IV, April 27, 1994.

INTEGRATED APPROACH USING SUBSURFACE GEOLOGY, AEROMAGNETICS, SURFACE GEOCHEMISTRY AND 3-D SEISMIC IN DISCOVERING NEW CONVENTIONAL RESERVOIRS

Presented By: Dr. Steven A. Tedesco

Running Foxes Petroleum Inc.

GOALS OF THIS PRESENTATION

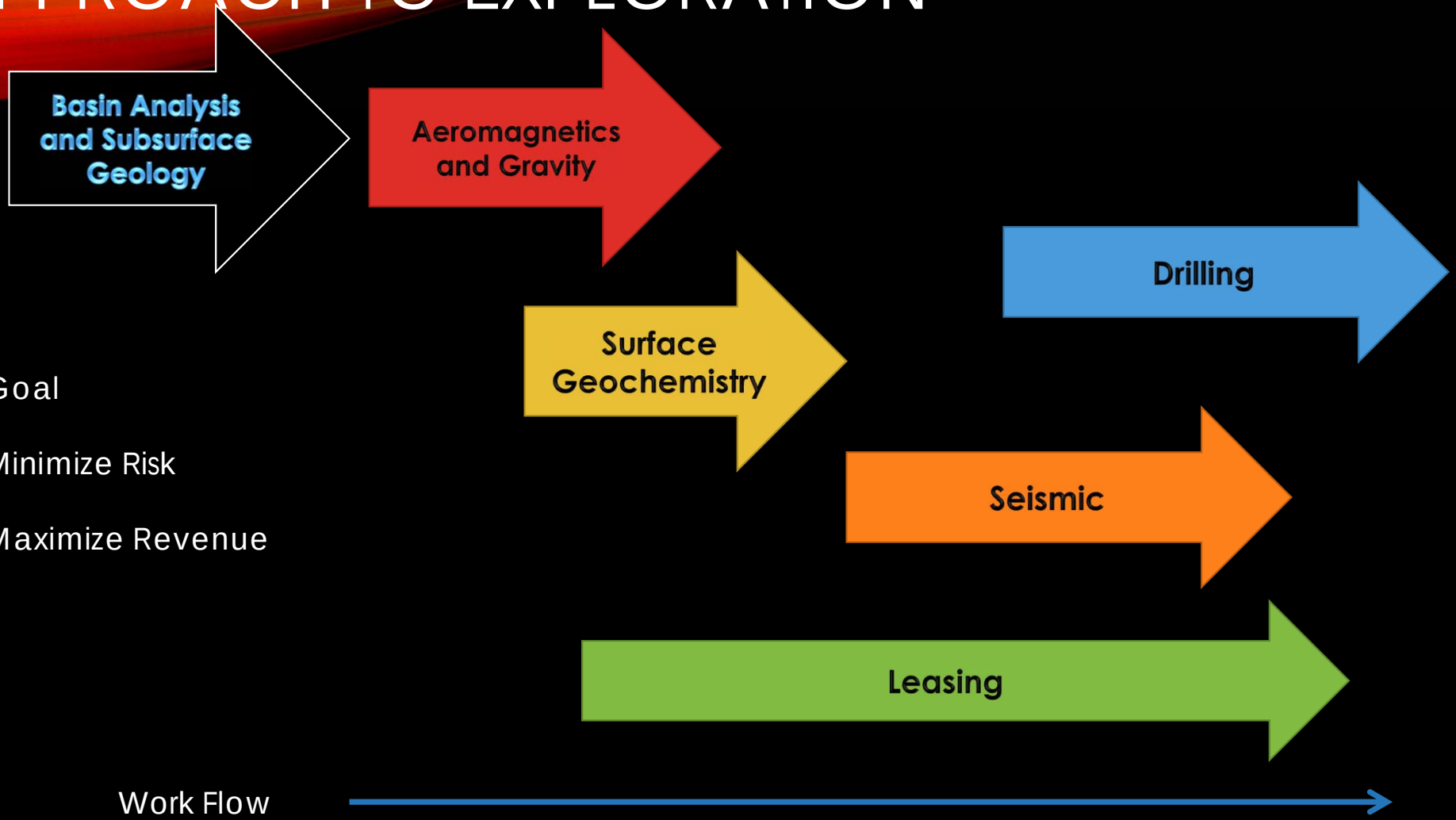
- Reduce rick through an integrated approach;
- Minimize overall finding costs;
- Repeatable methodologies;
- Able to modify approach when one or more tools are not applicable.

STRATEGY FOR EXPLORING IN HIGH RISK AREAS

Technology Available :

- Subsurface geology (define an area of exploration);
- Basin modeling for timing of oil generation, expulsion and migration (confirm the potential for hydrocarbons);
- Aeromagnetics and gravity (determine areas of structural activity);
- Surface geochemistry (define areas of hydrocarbon leakage for 3D);
- 3D Seismic (define target).
- Drill

APPROACH TO EXPLORATION



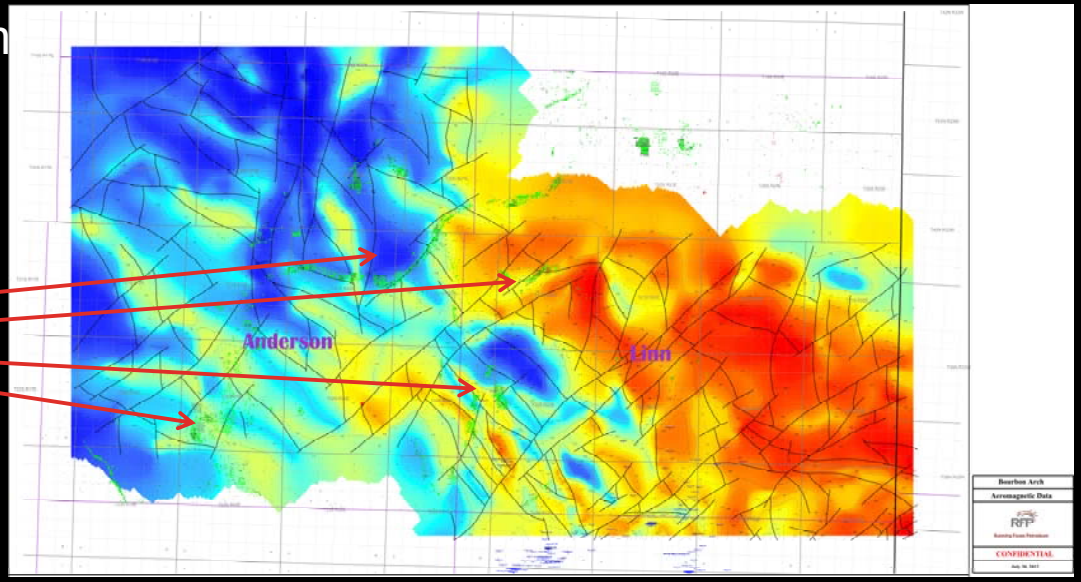
SUBSURFACE GEOLOGY AND BASIN MODELING

- Use existing wellbore data;
- Use existing cores and outcrops for source rock and reservoir analysis;
- Projecting potential reservoir trends through an unexplored or lightly unexplored area.

AEROMAGNETICS

- Provides a way to map potential areas of fracturing and structural changes in the basin;
- Depth to basement important in defin of basement features and overlying structure;
- Intensity of data critical to defining basement.

Oil Fields

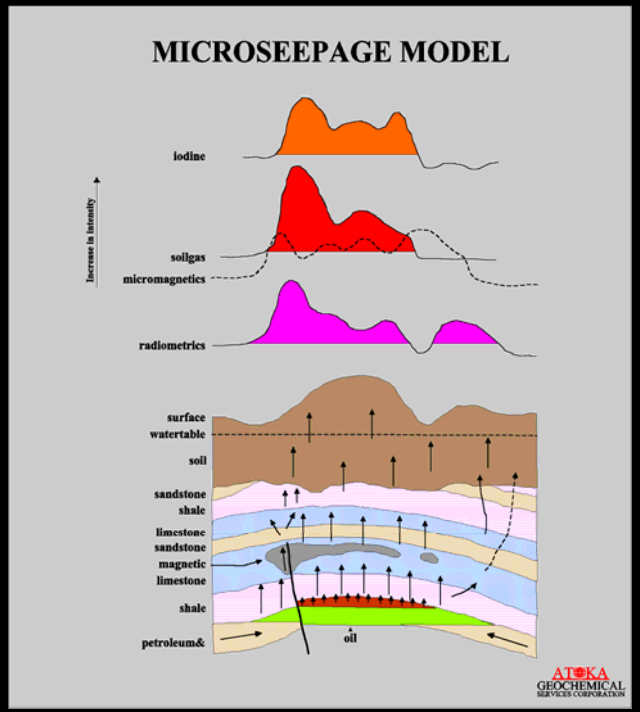


Survey in Forest City Basin, Kansas Mid-Continent USA
Interpretation by Earthfield Technologies, flown by CGG

All aeromagnetic data presented here acquired by CGG and processed by Earthfield Technologies

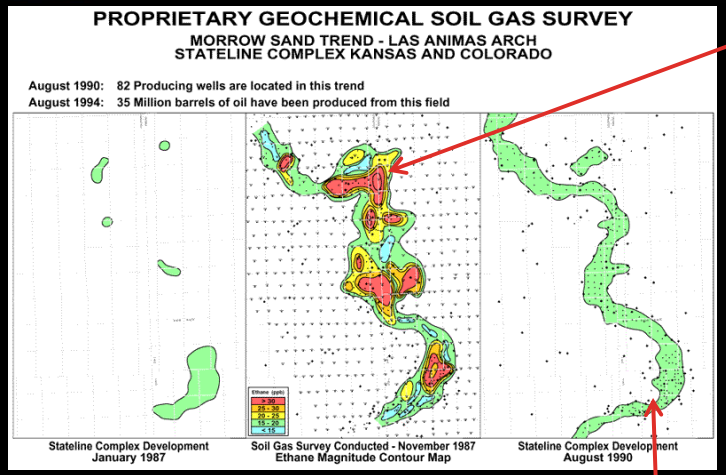
SURFACE GEOCHEMISTRY

- Concept of Surface Geochemistry;
- Hydrocarbons migrate through the earth;
- Presence of hydrocarbons and changes they cause can be measured;
- Actually mechanisms little understood.



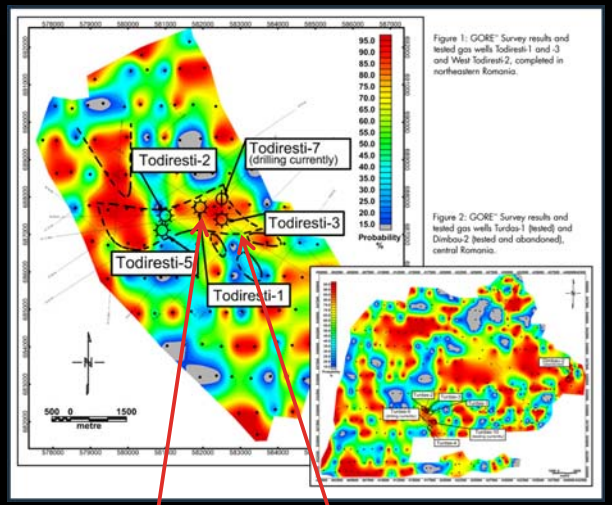
EXAMPLES OF SURFACE GEOCHEMISTRY

Anomalies

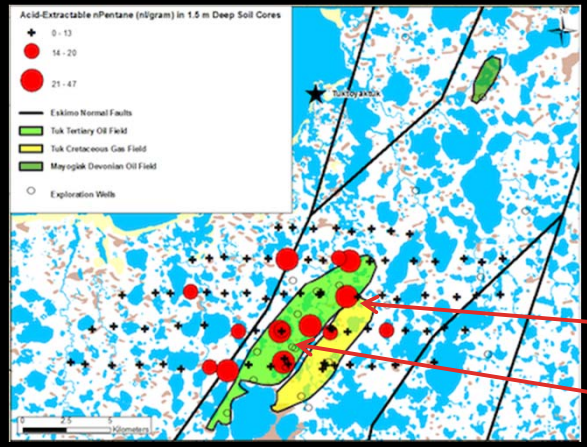


Dickinson et al., 1994

These examples are on the Internet



Anomalies



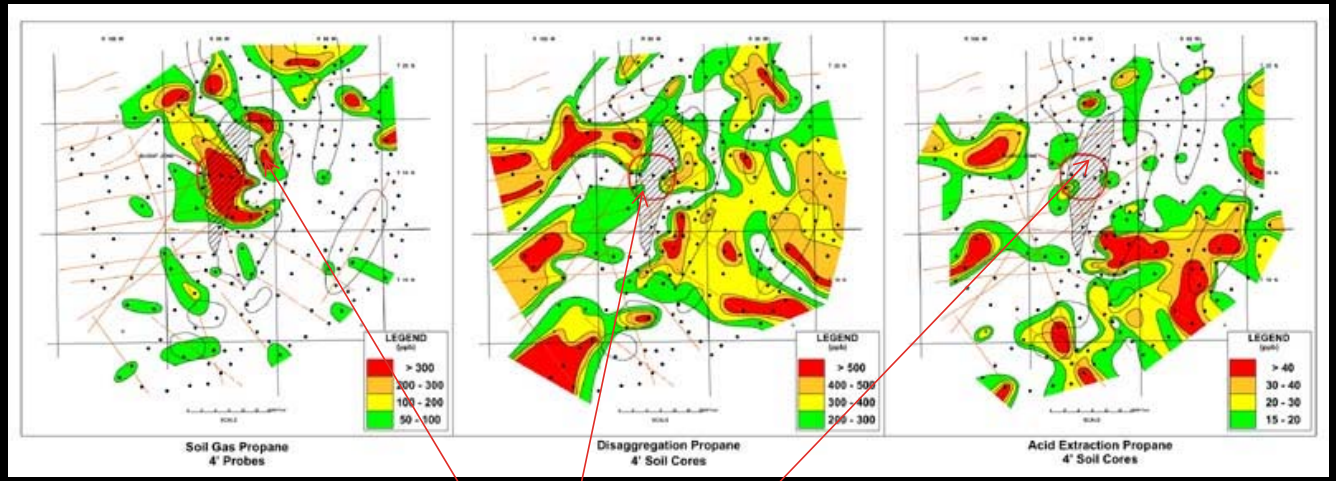
Gas Field

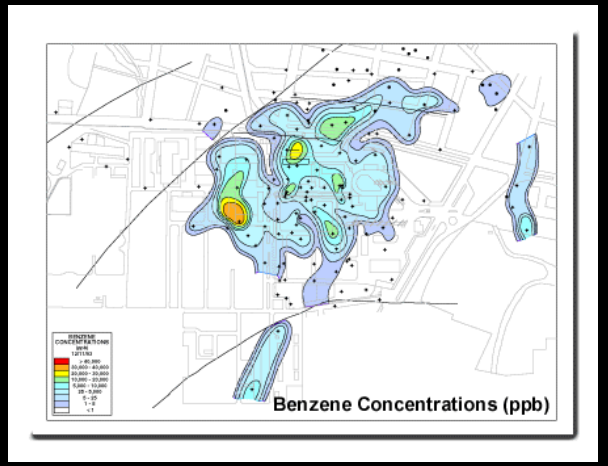
Oil Field

Stateline Oil Field
Pennsylvanian Morrow Channel
1,700 meters

EXAMPLES OF SURFACE GEOCHEMISTRY

Different types of soil gas

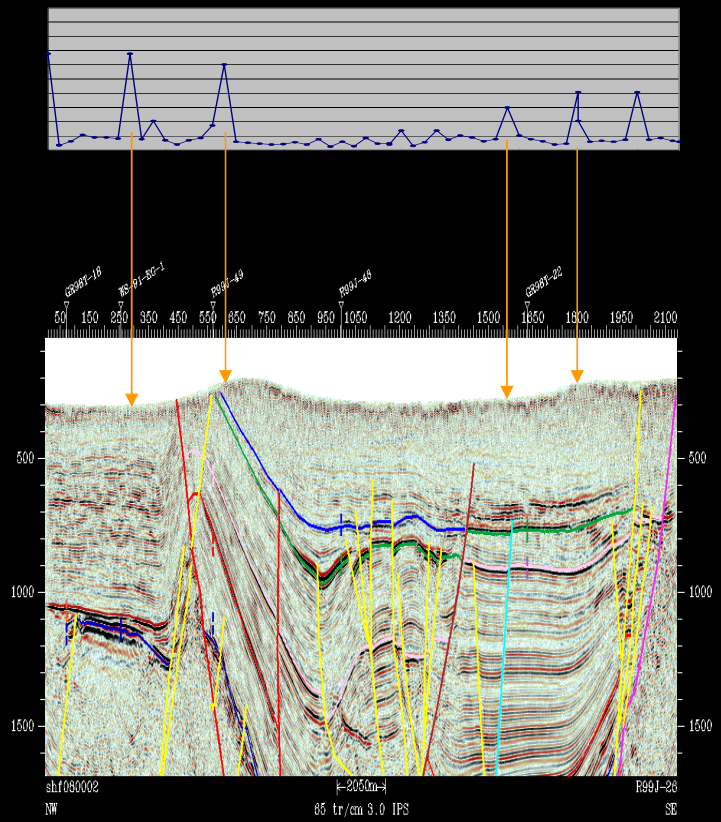


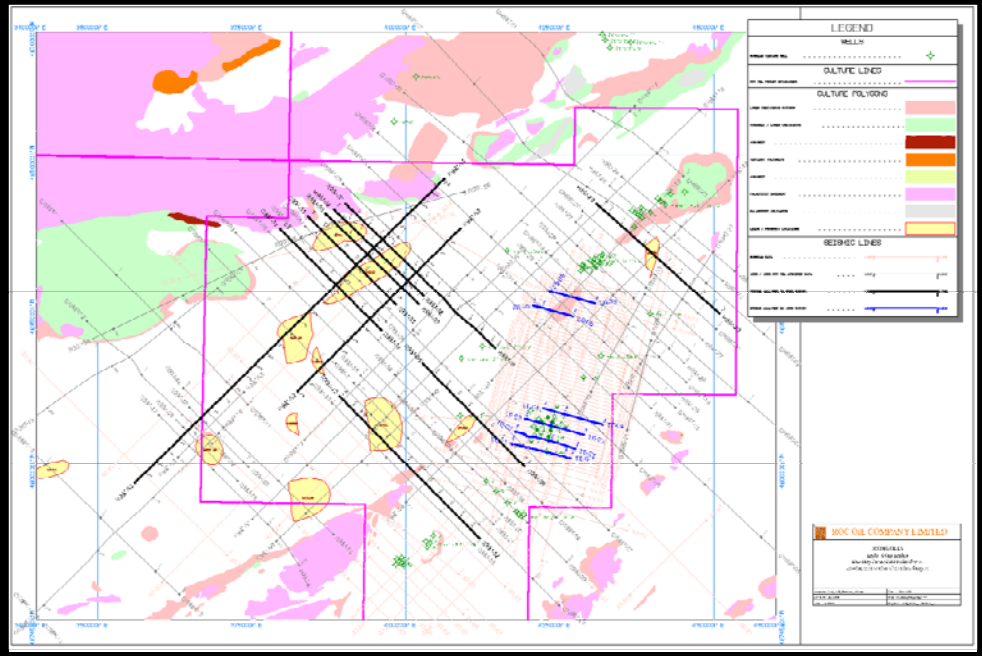


Environmental

Producing field

EXAMPLES OF IODINE SURFACE GEOCHEMISTRY

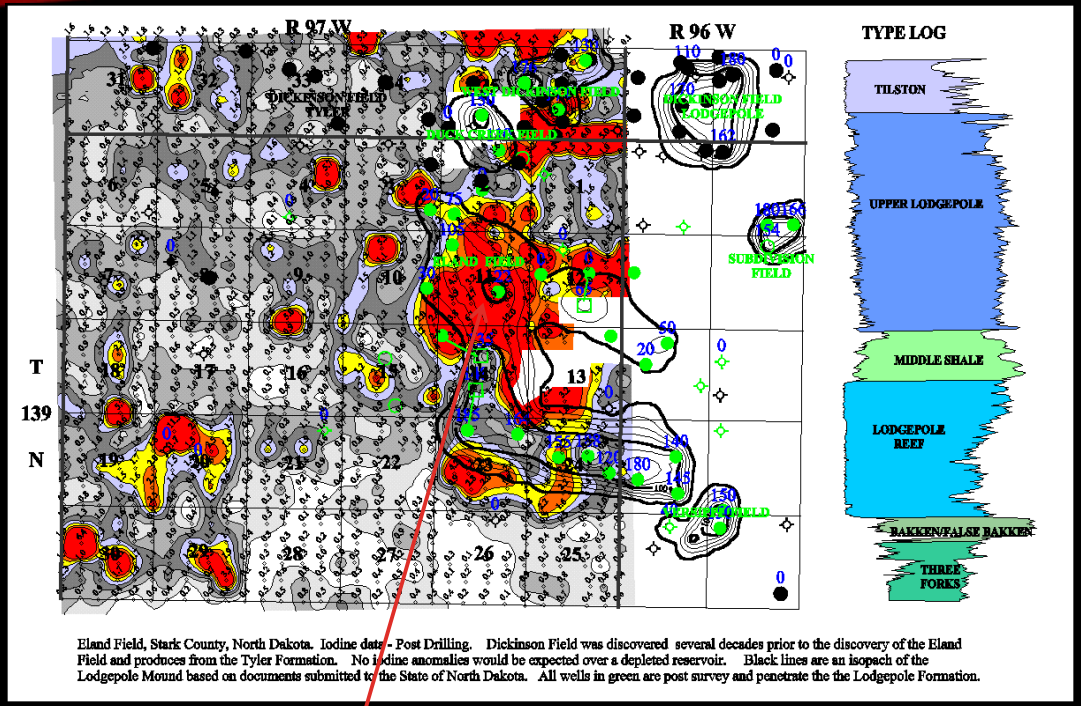




Work done for Roc Oil in 2000 in the Unegt Basin

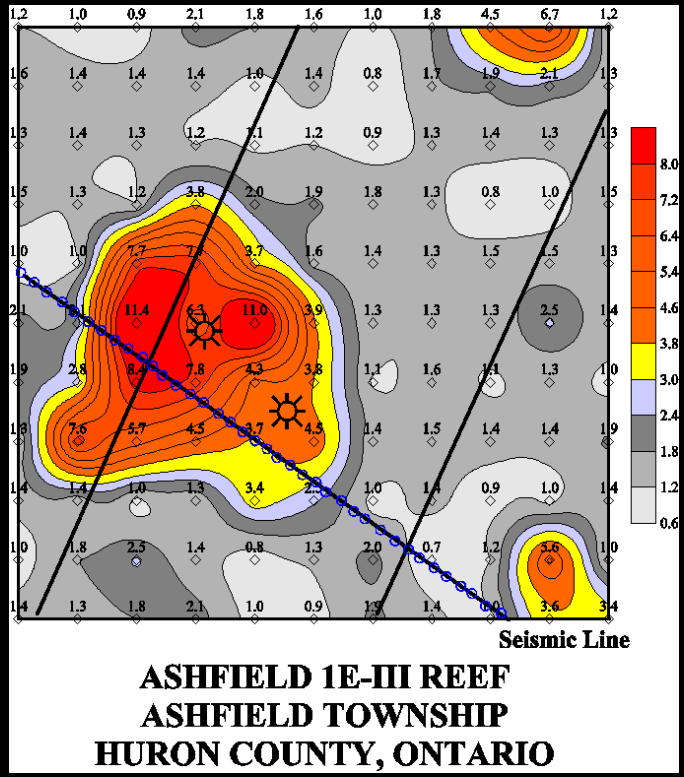
Surveyed determine all leakage was along fault systems and not being trapped. Iodine survey was done by Atoka Inc.

EXAMPLES OF IODINE SURFACE GEOCHEMISTRY



Eland Field, Stark County, North Dakota. Iodine data - Post Drilling. Dickinson Field was discovered several decades prior to the discovery of the Eland Field and produces from the Tyler Formation. No iodine anomalies would be expected over a depleted reservoir. Black lines are an isopach of the Lodgepole Mound based on documents submitted to the State of North Dakota. All wells in green are post survey and penetrate the the Lodgepole Formation.

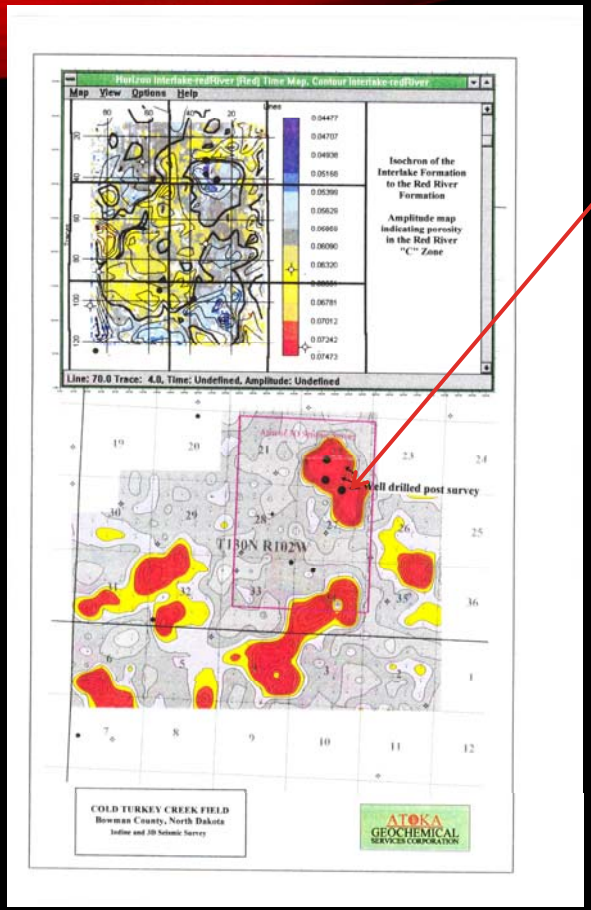
Eland Field – 20 MMBO at 3,000 meters
Mississippian Waulsortian Mound



Silurian Reef

Iodine surveys done by Atoka Inc.

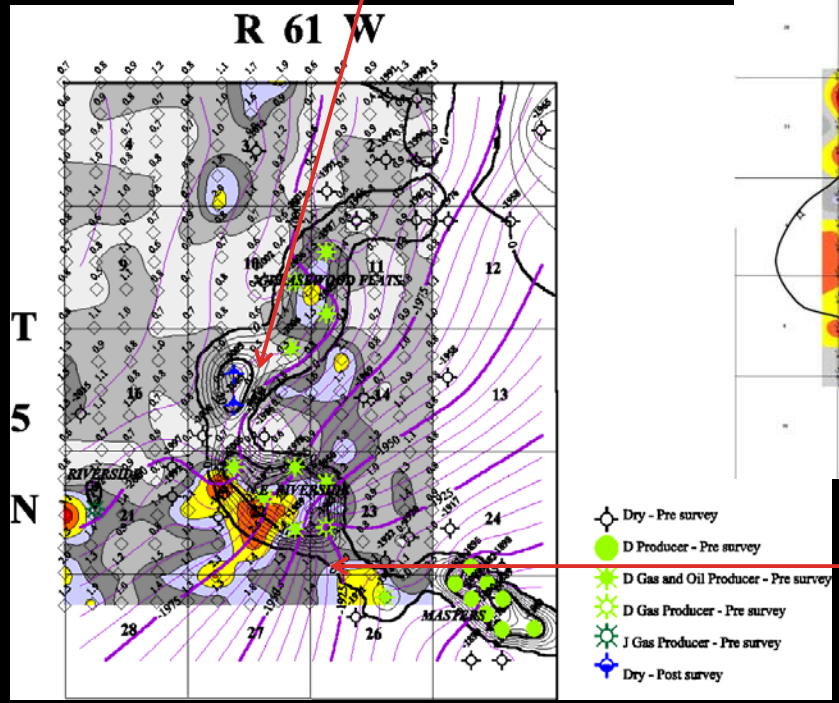
EXAMPLES OF IODINE SURFACE GEOCHEMISTRY



Structural bump in Red River, Ordovician - 3,000 meters

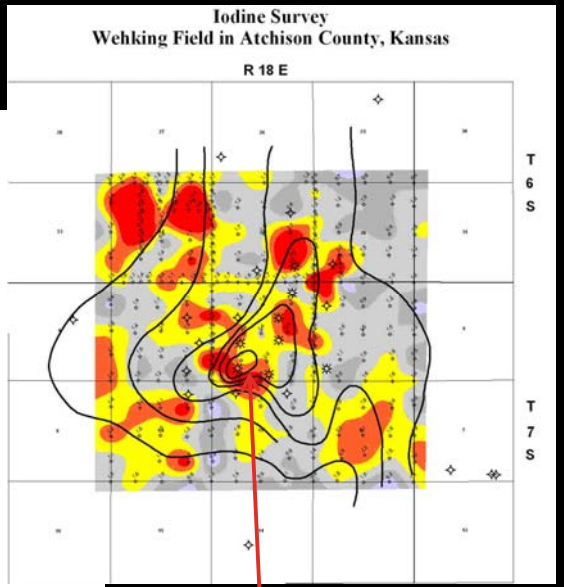
Anomalies

Predicted Dry Hole



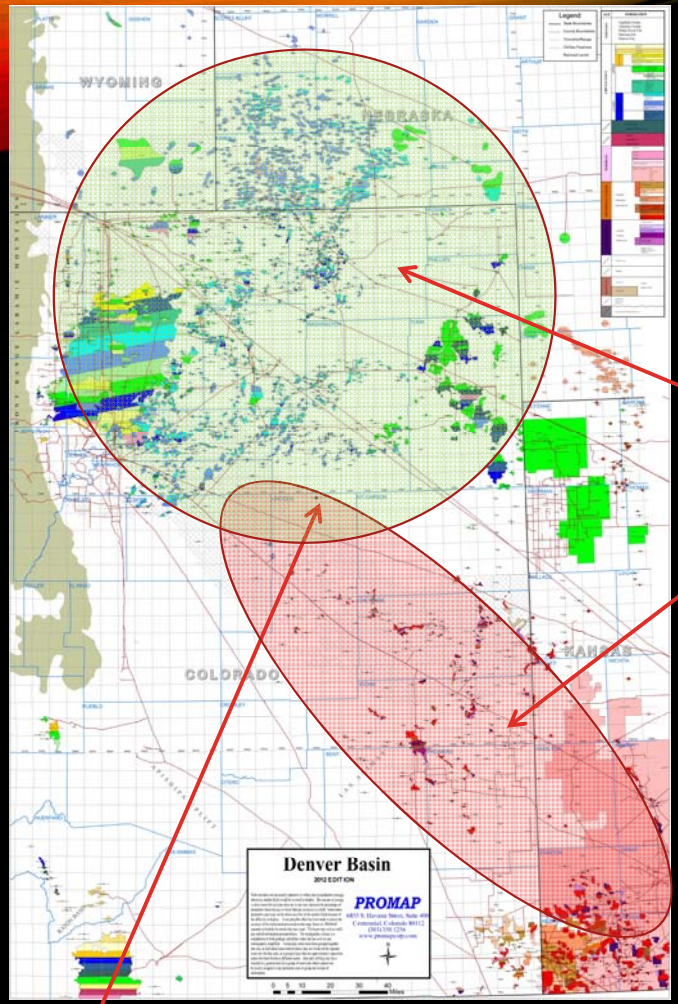
Cretaceous D Sand at 2,100 meters
Iodine surveys done by Atoka Inc.

Pennsylvanian Cherokee Sands
400 meters



Anomalies

INTEGRATED APPROACH EXAMPLE: DENVER BASIN



Arikaree Creek Field

Denver Basin – Colorado, Mid-Continent USA
Foreland Basin

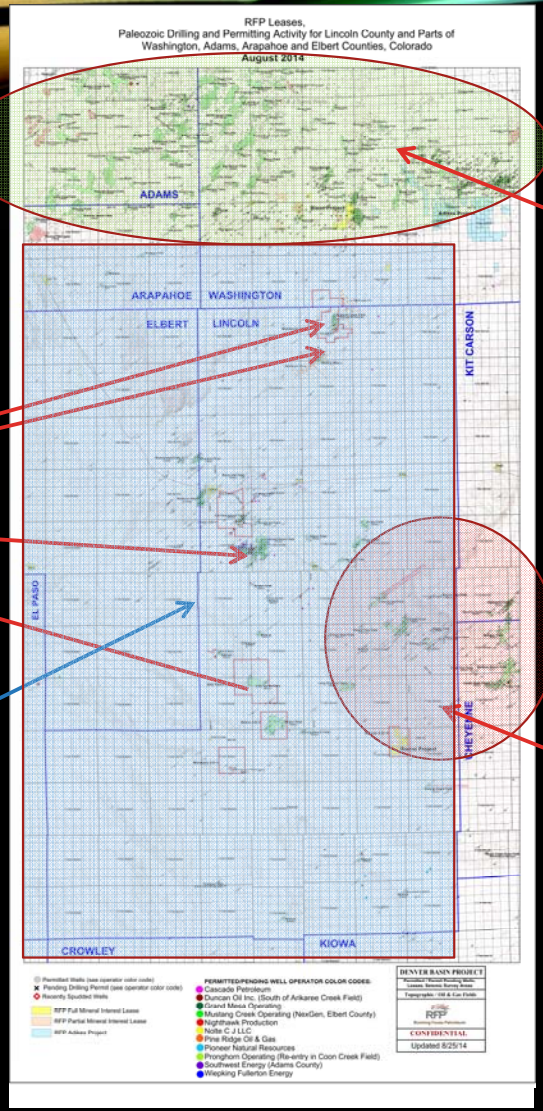
Reservoir Types:

Cretaceous: D and J channel sands

Paleozoic:

Depths - 1,606 – 3,500 meters;
Mississippian carbonates – 3 to 20 meters thick;
Morrow sandstone channels – 2 to 20 meters thick;
Cherokee A and C shoals or secondary dolomite features - 0.5 to 3 meters thick;
Marmaton B carbonate shoal – 1 to 3 meters thick.

SOUTHEAST DENVER BASIN



Cretaceous Fields – pre-1980

- Generally unexplored prior to 2009 for over 20 years;
- No productive Cretaceous sands present;
- Paleozoic reservoirs are discrete;
- Low oil prices

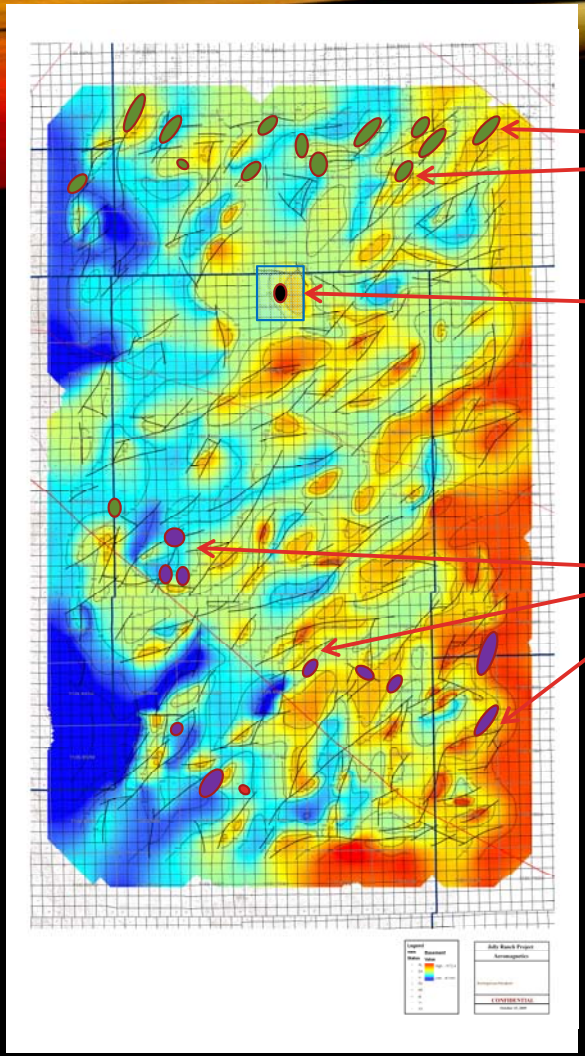
New Paleozoic Fields Post 2010

Large area significantly under explored

Limited Seismic Data

Paleozoic Fields – pre-1985

AEROMAGNETICS IN NORTHERN LINCOLN COUNTY



Cretaceous Oil Fields

Arikaree Creek

Survey 2009

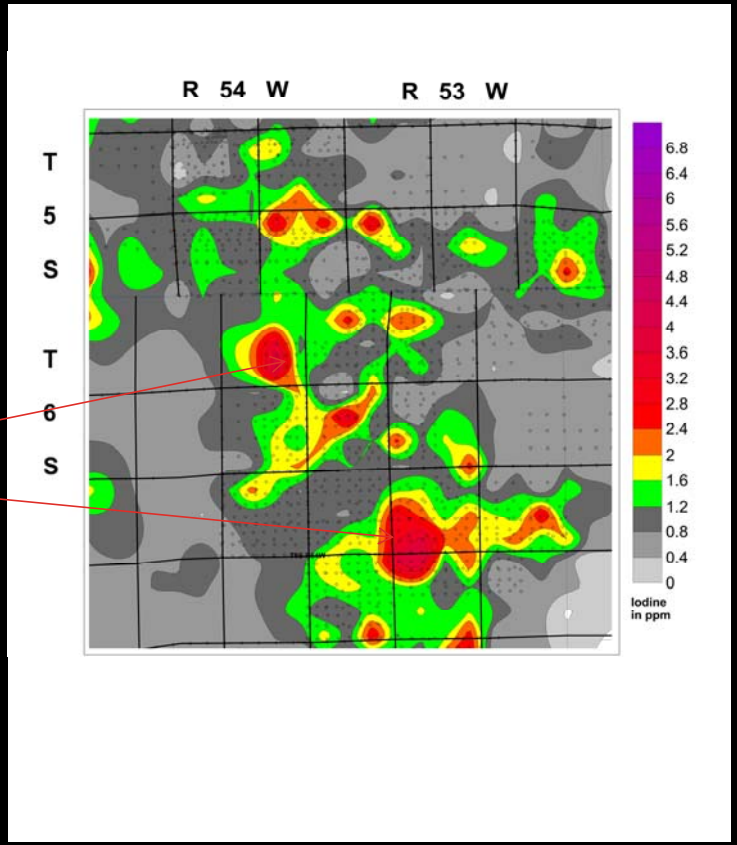
Pennsylvanian – Mississippian Oil Fields

Flown by CCG and interpreted by Earthfield Technology

ARIKAREE CREEK OIL FIELD

- Discovered in 2012;
- Project developed by Running Foxes, partner bought out part of Company interest prior to drilling;
- Field found using:
    - Projection of productive reservoirs deeper into Denver Basin toward source of generated hydrocarbons;
    - Detail surface geochemistry;
    - 3D seismic survey;
    - Identification of structure with associated wrench faulting.

IODINE SURFACE GEOCHEMISTRY IN NORTHERN LINCOLN COUNTY



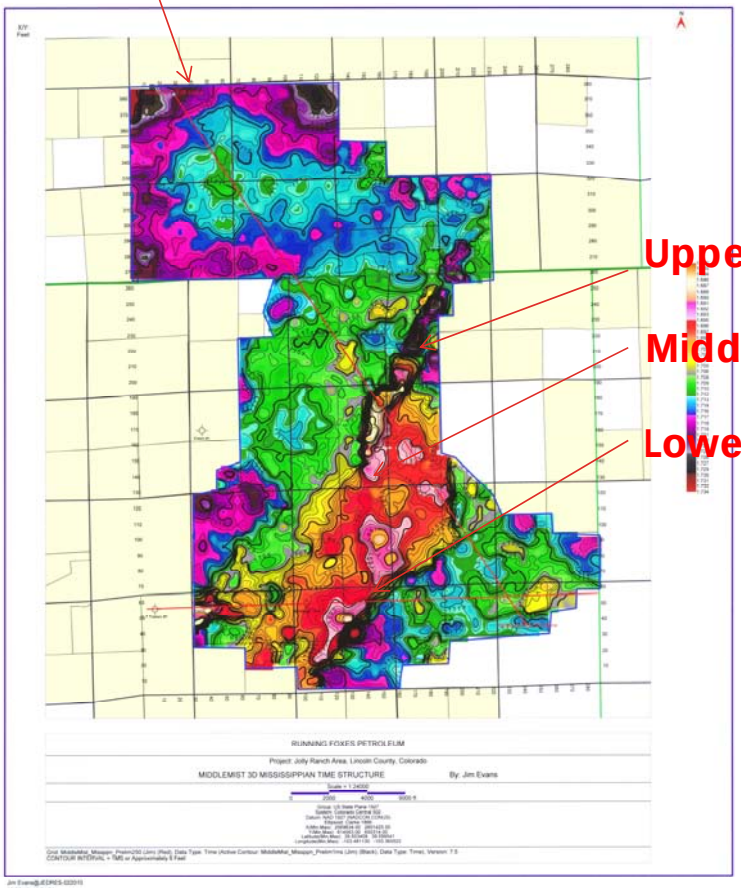
Anomalies

Small area of the overall iodine survey in Lincoln County

Iodine surveys done by Atoka Inc.

3D Outline

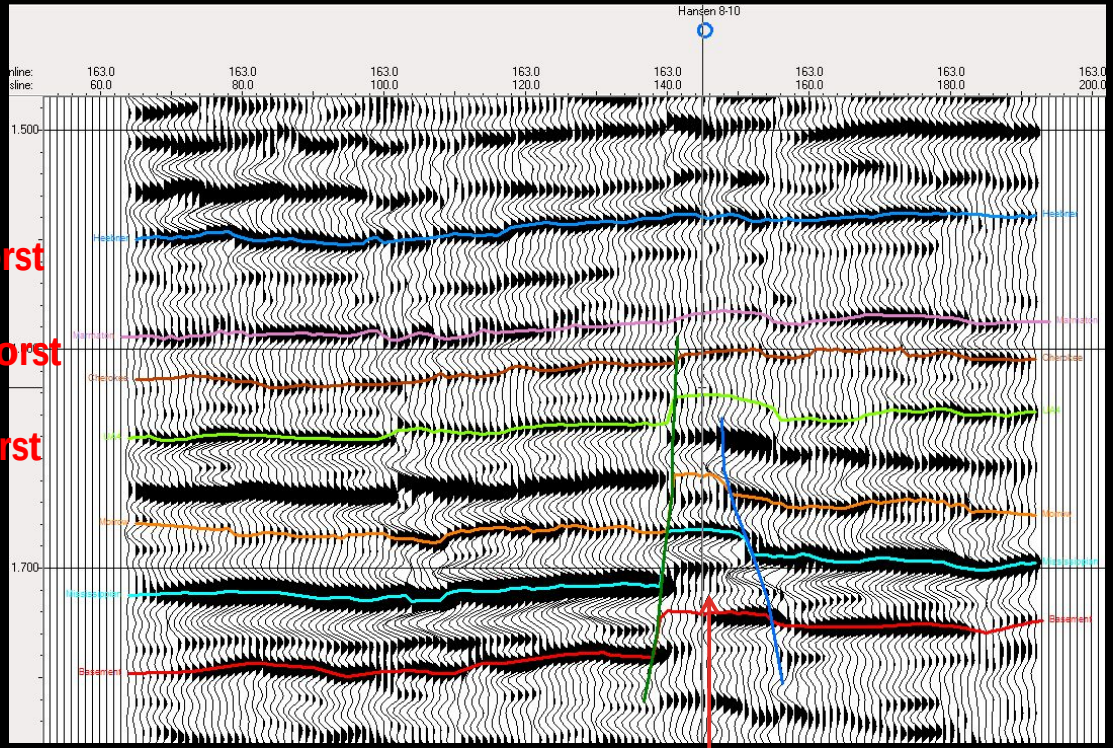
PRE-DRILLING 3D SEISMIC SURVEY



Upper Horst

Middle Horst

Lower Horst

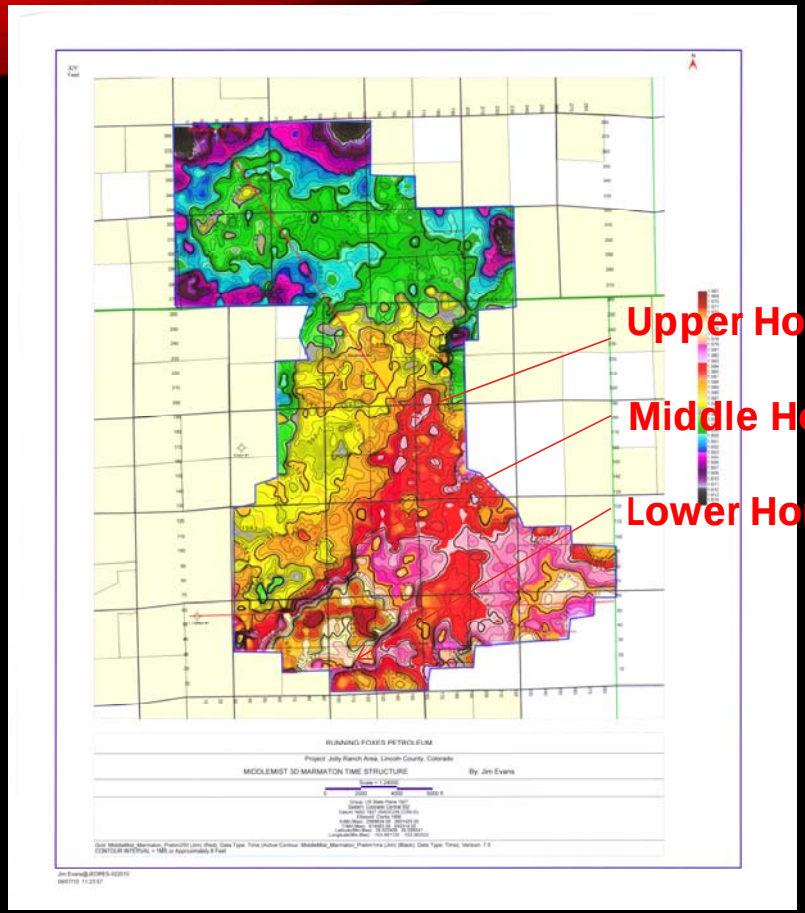


Mississippian Structure

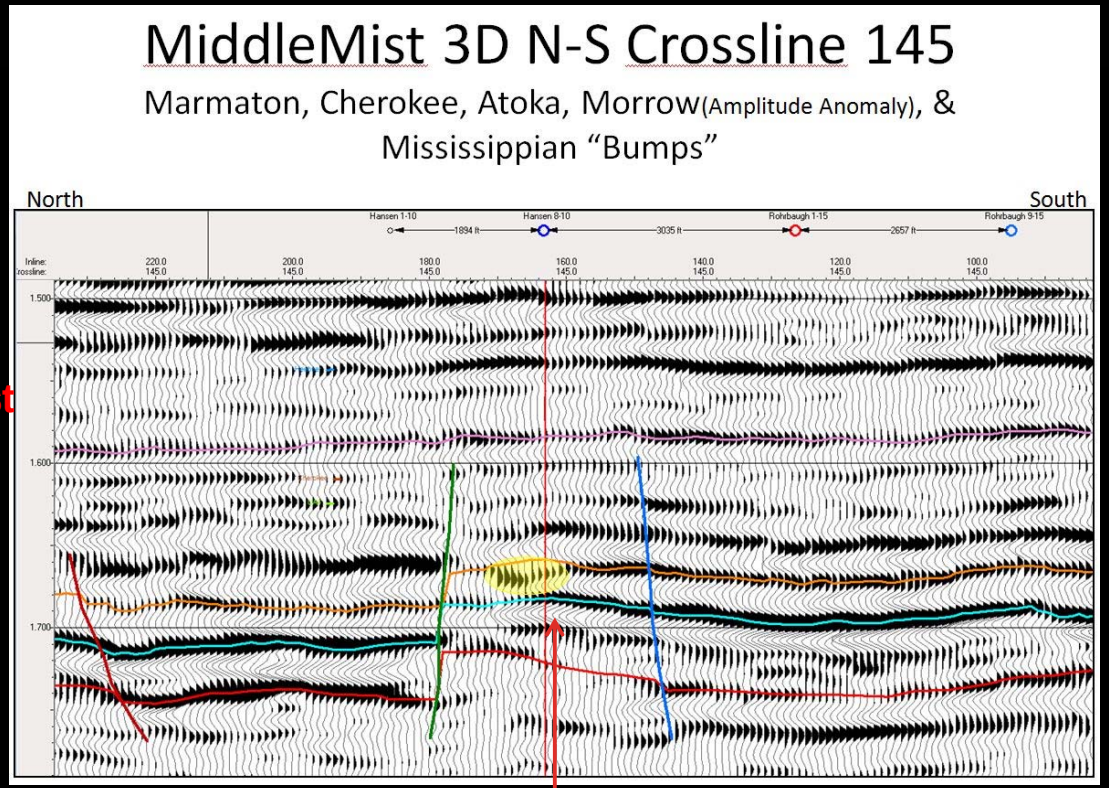
Pop up structure

Data Processed by Excel Geophysical
Interpreted by JED Resources

PRE-DRILLING 3D SEISMIC SURVEY



Note the diminishing relief
Compared to previous slide

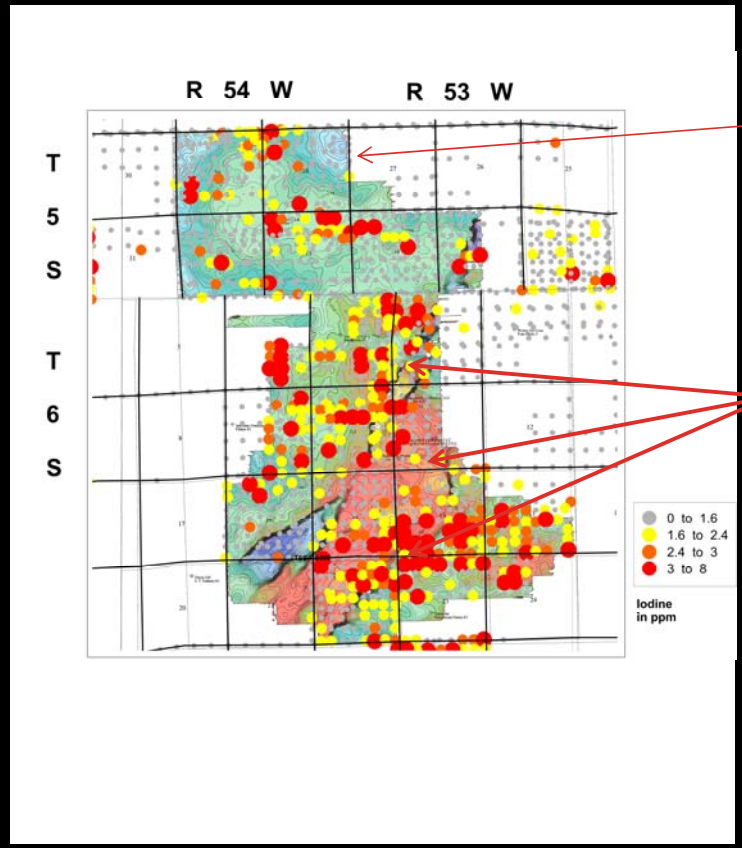


Top of the Marmaton

Data Processed by Excel Geophysical
Interpreted by JED Resources

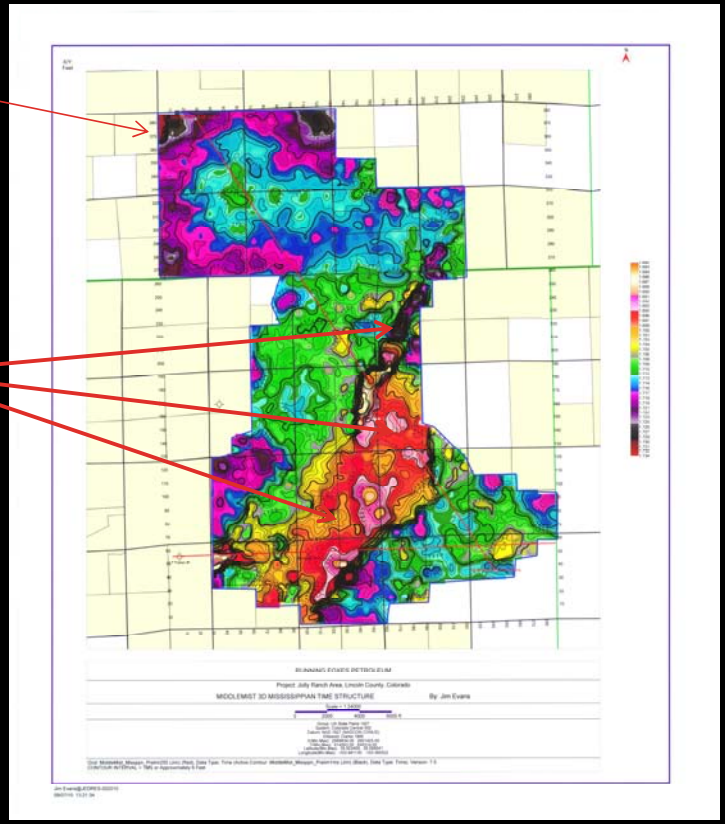
Pop up structure – different view
from previous slide

IODINE AND 3D SEISMIC SURVEY



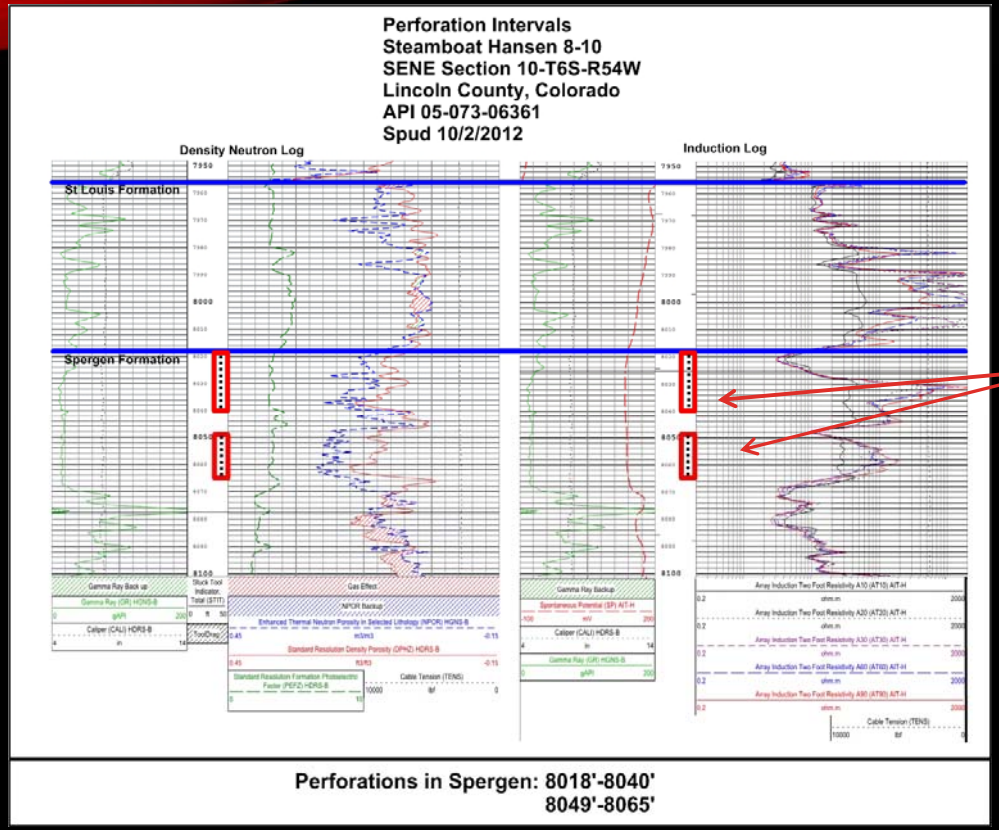
3D Outline

Horst



Bubble or Classed Post Map
Seismic structure on Mississippian

DISCOVERY WELL



Hanson 8-10

Completed in the Mississippian Spergen

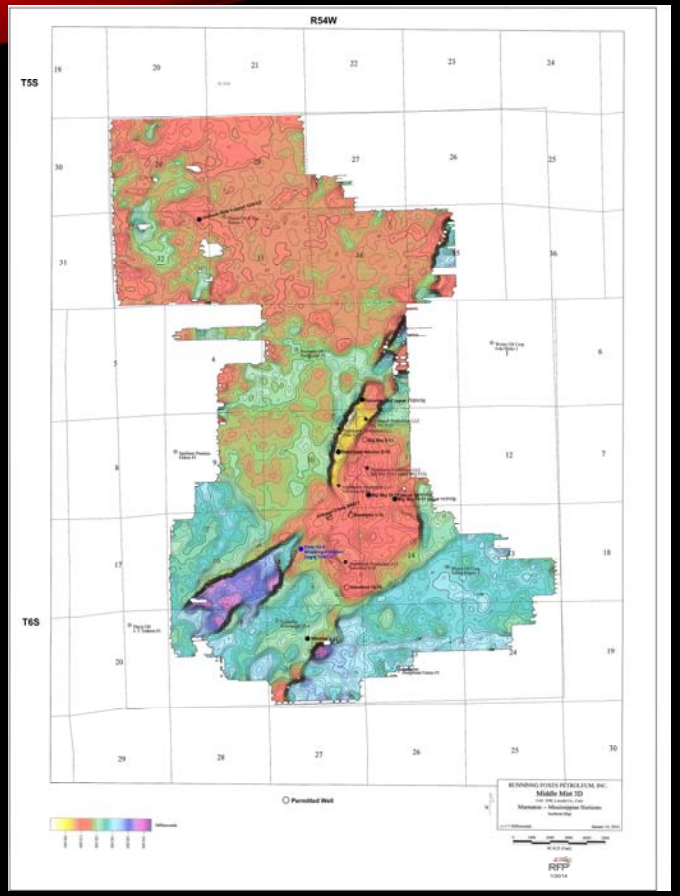
400+ BOPD

Reservoir is low temperature dolomite

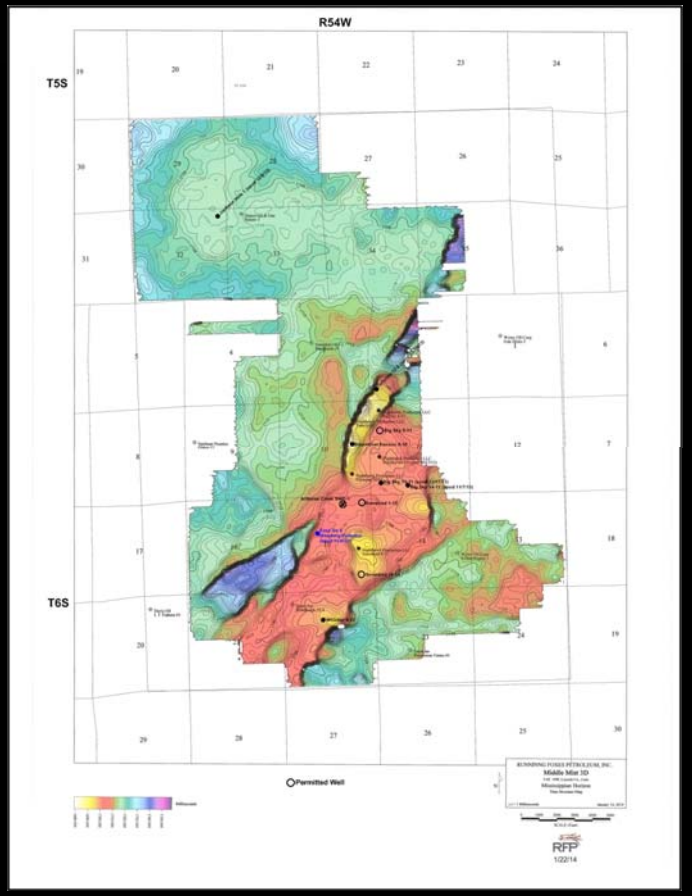
No water

Middle Horst, oil and water zone

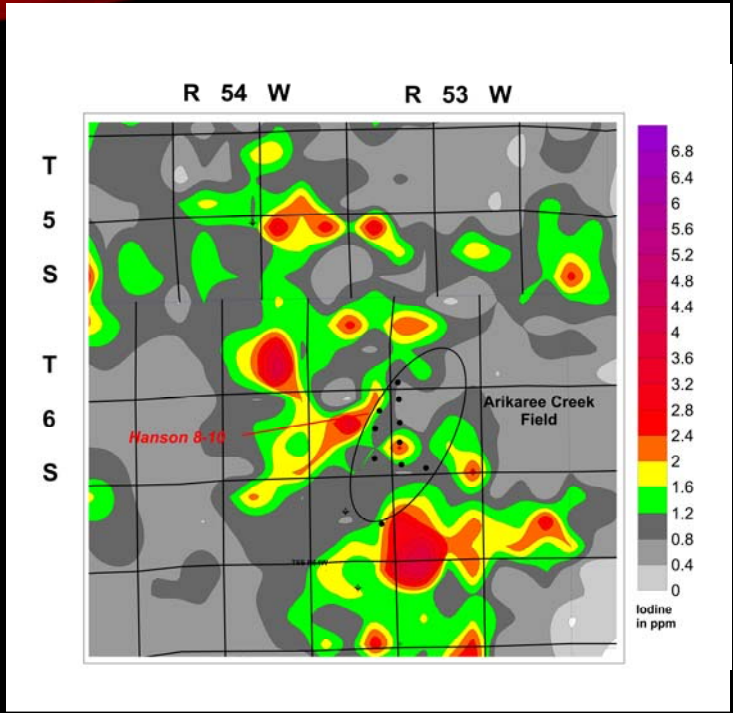
MISSISSIPPIAN STRUCTURE AND ISOCHRON

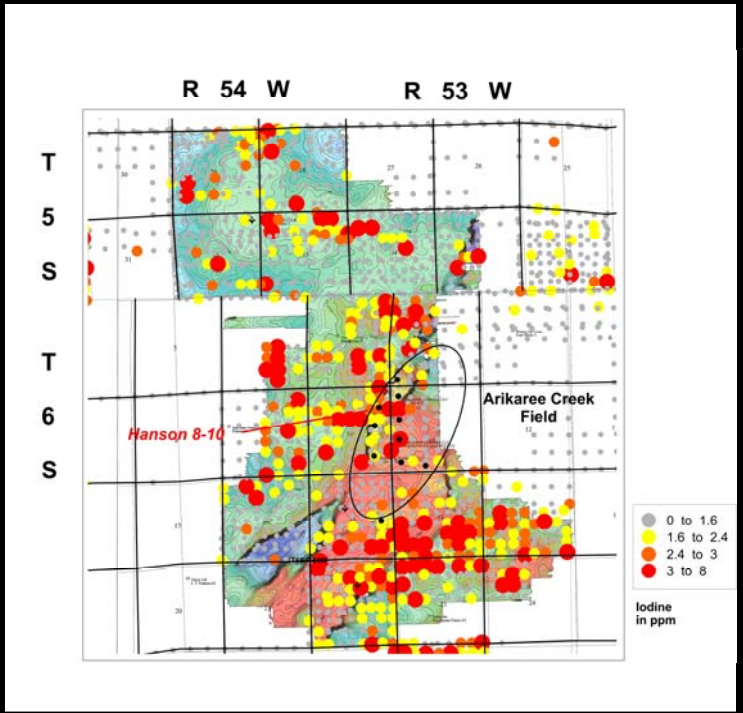


Post Drilling Results



IODINE SURVEY AND 3D SEISMIC

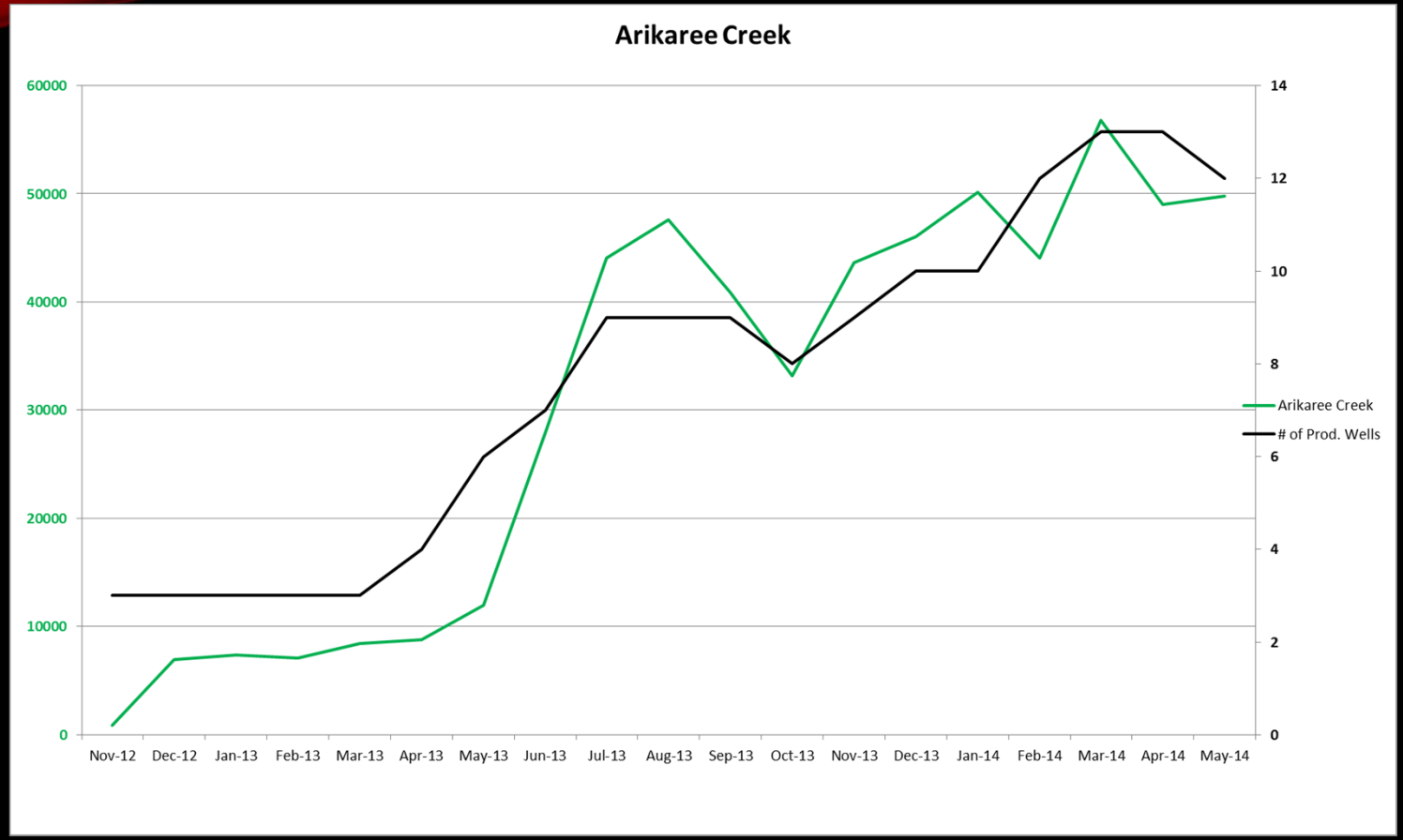




Anomalies related to fault leakage creating a halo anomaly

Iodine surveys done by Atoka Inc.

PRODUCTION



Field will make 1 MMBO by end of the year

SUMMARY

- Using an integrated approach lowers risk;
- Tools that provide a variety of approaches that lead to the same goal are:
    - Regional geology
    - Basin and source rock analysis
    - Aeromagnetics and gravity
    - Surface geochemistry
    - 3D Seismic

This approach was successful in finding the Arikaree Field for the Company. It has been used successful elsewhere resulting in other new field discoveries.

THE END

Exploration – leaping into the unknown for fun and profit based on limited understanding of the subsurface