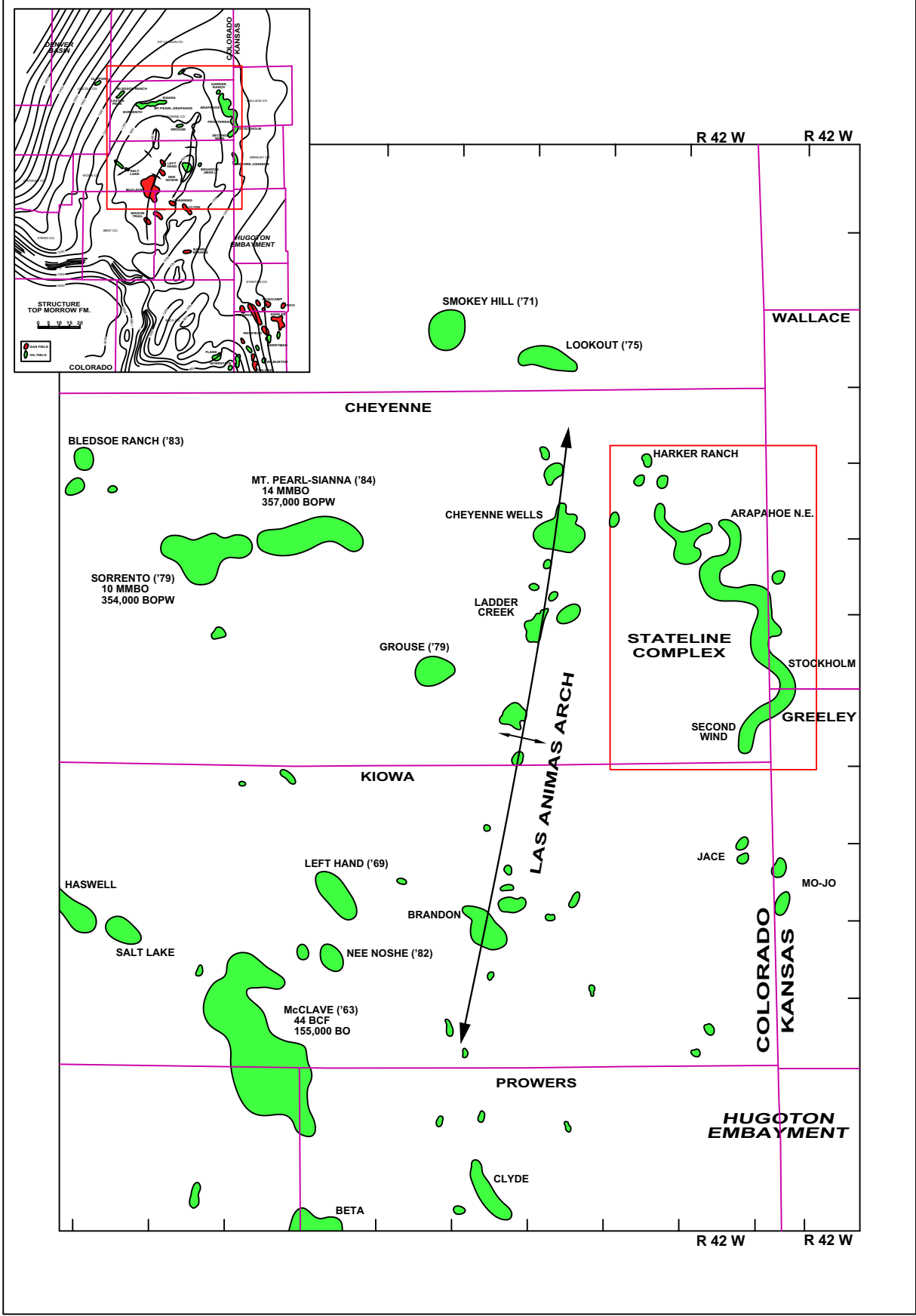
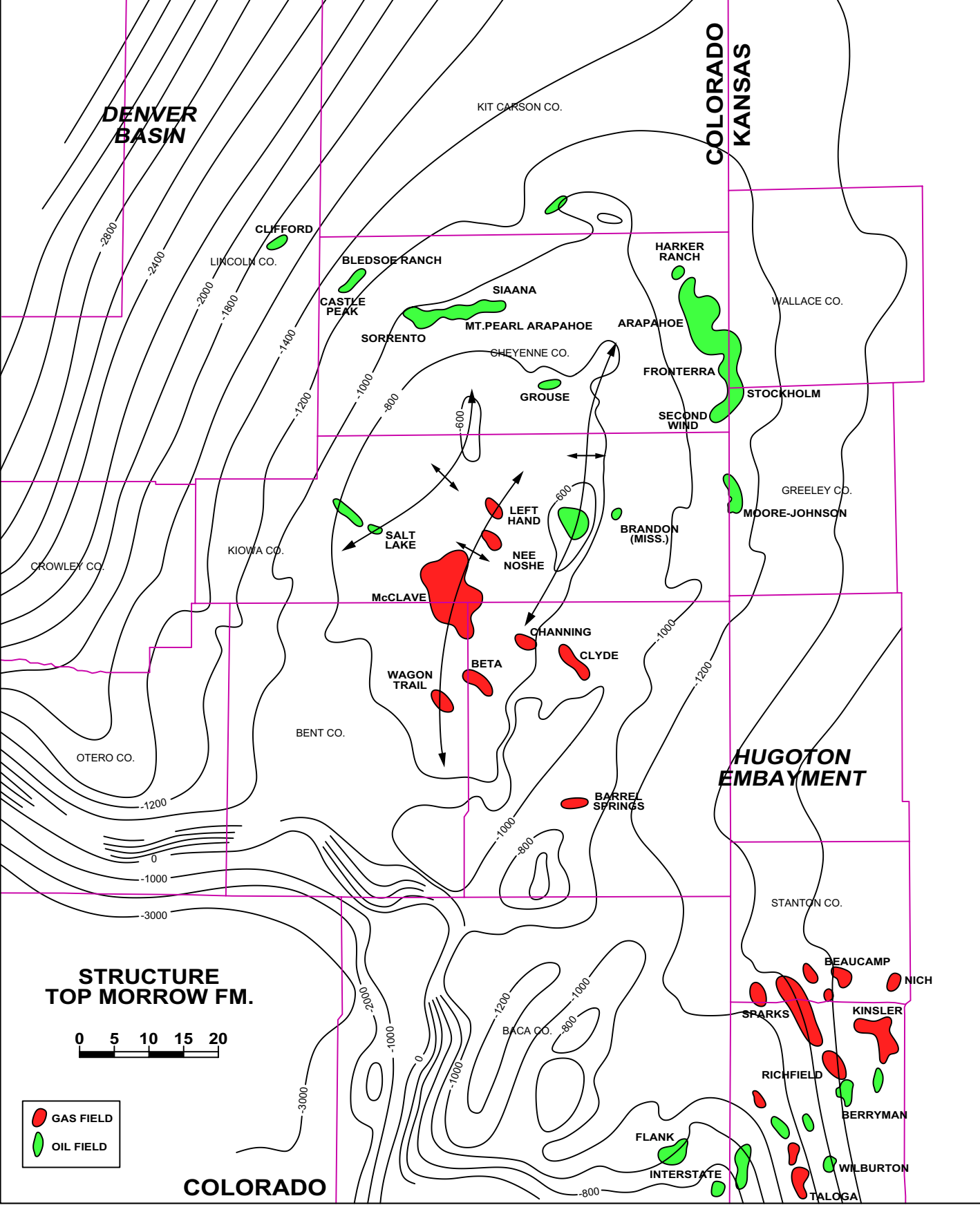


A RETROSPECTIVE ANALISYS OF A SOIL GAS SURVEY OVER A STRATIGRAPHIC TRAP TREND ON THE KANSAS-COLORADO BORDER

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AAPG Hedberg Research Conference
Near-Surface Expression of Hydrocarbon Migration
April 24-28, 1994
Vancouver, British Columbia, Canada



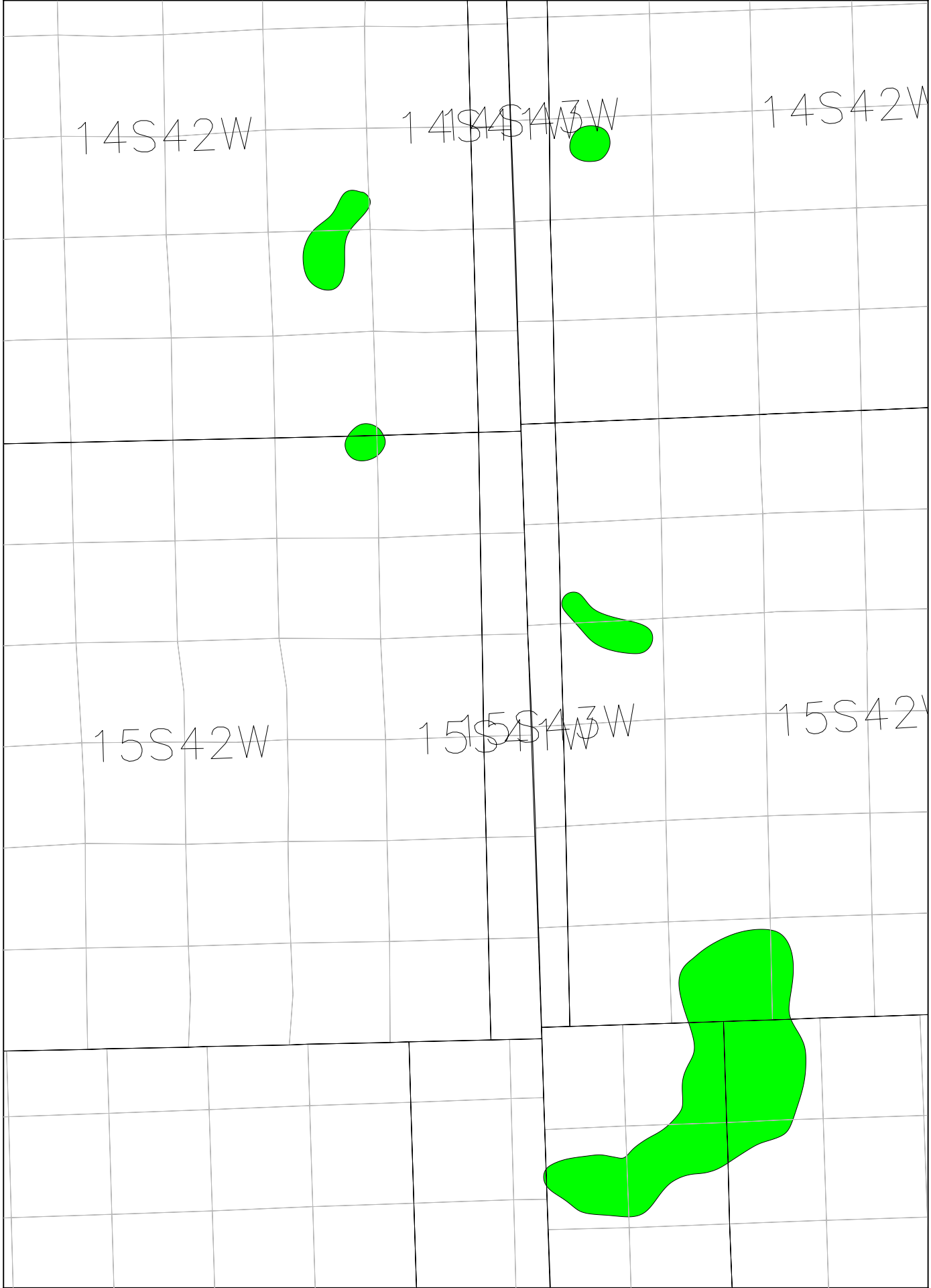
Location Map



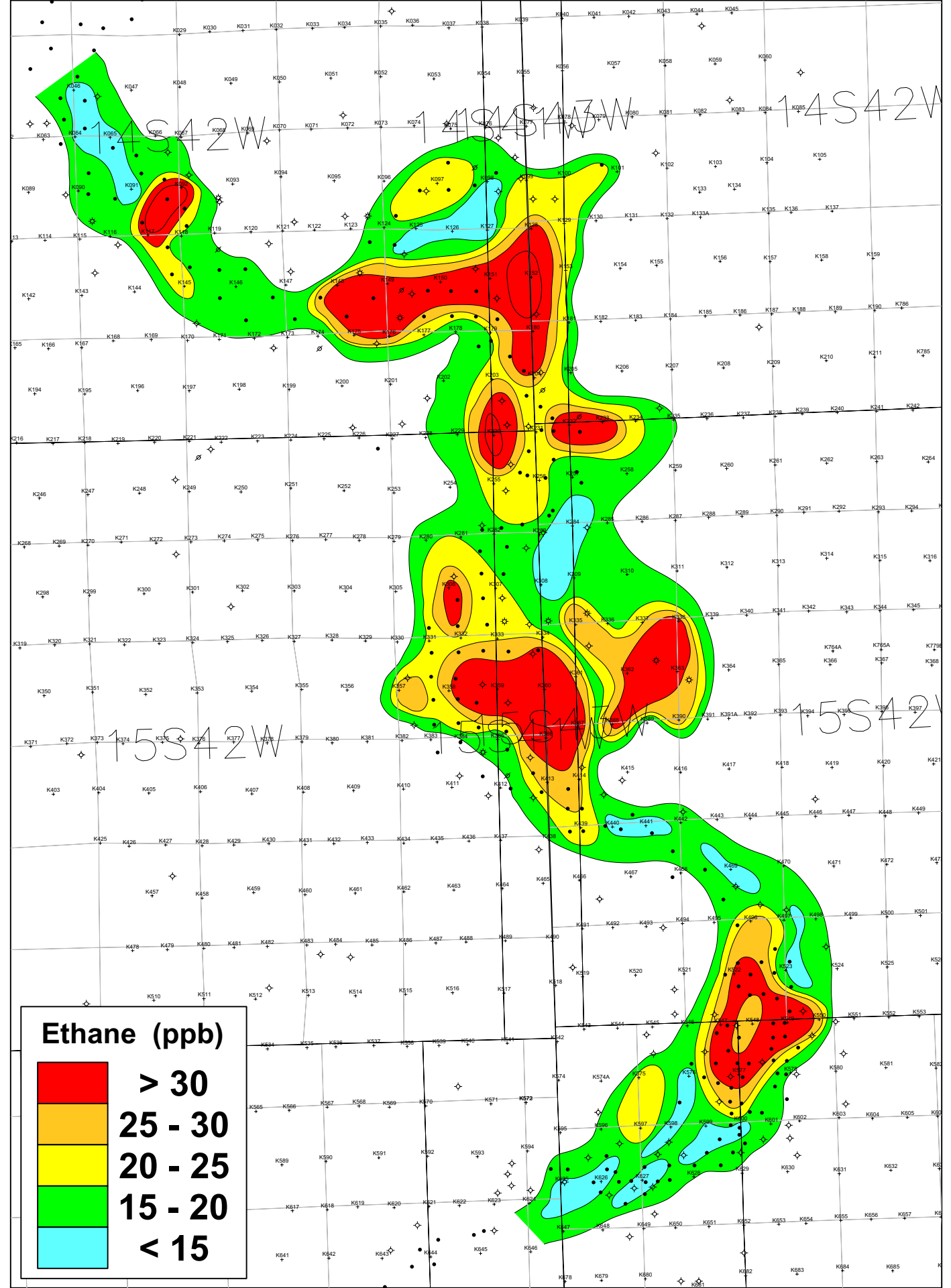
Structure Top Morrow FM.

| SYSTEM | SERIES | STAGE | FORMATION |
|---------------|--------|----------|----------------|
| PENNSYLVANIAN | UPPER | VIRGIL | WABAUNSEE |
| | | | SHAWNEE |
| | | | DOUGLAS |
| | MIDDLE | MISSOURI | LANSING |
| | | | KANSAS CITY |
| | | | MARMATON |
| | LOWER | ATOKA | ATOKA |
| MISSISSIPPIAN | UPPER | MERAMEC | MORROW SHALE |
| | | | JOHANNES S.S. |
| | | | STOCKHOLM S.S. |
| | | | KEYES |
| | | | ST. GENEVIEVE |
| | | | ST. LOUIS |
| | | | SPERGEN |
| | | | WARSAW |

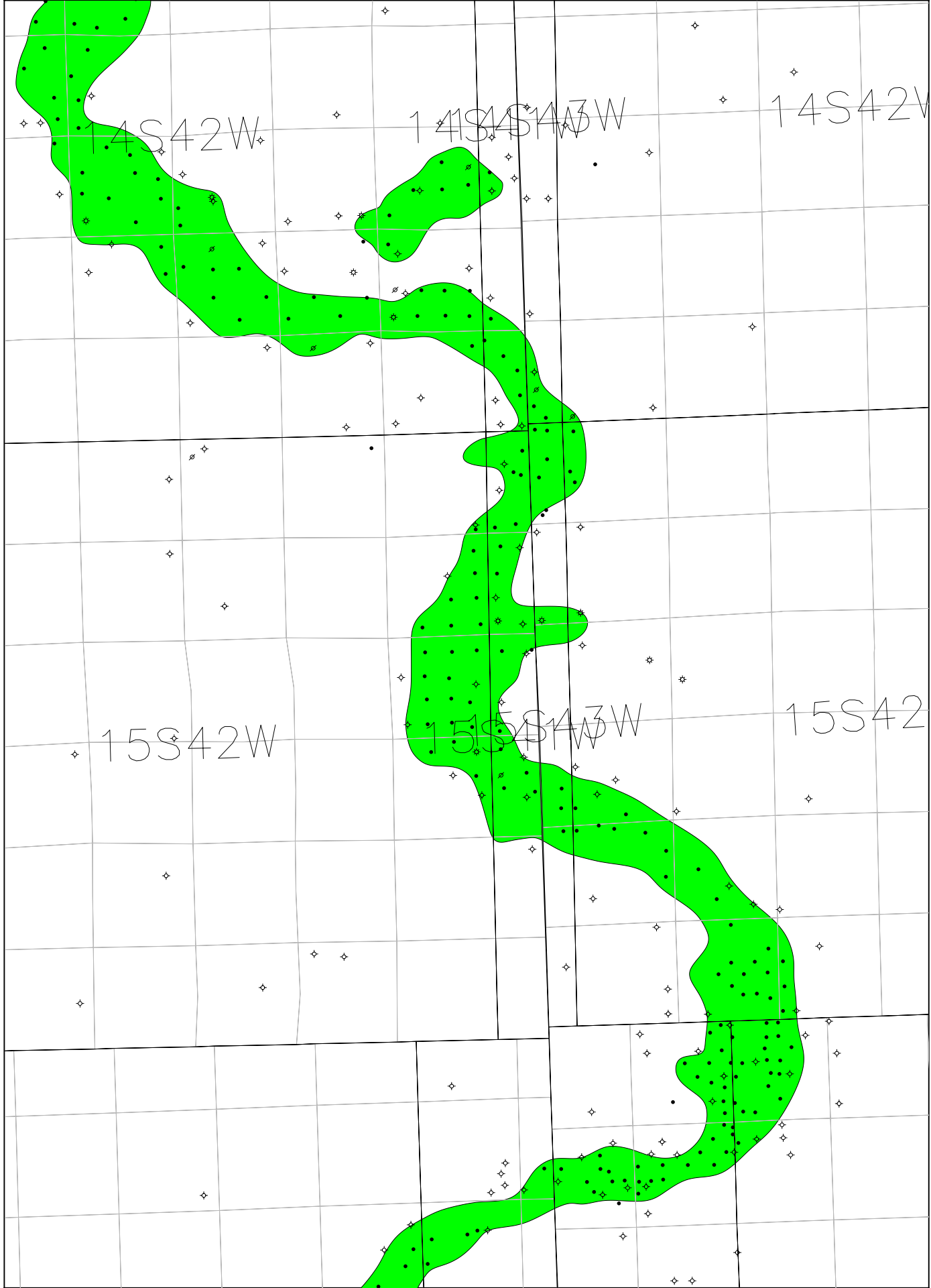
Stratigraphic Section



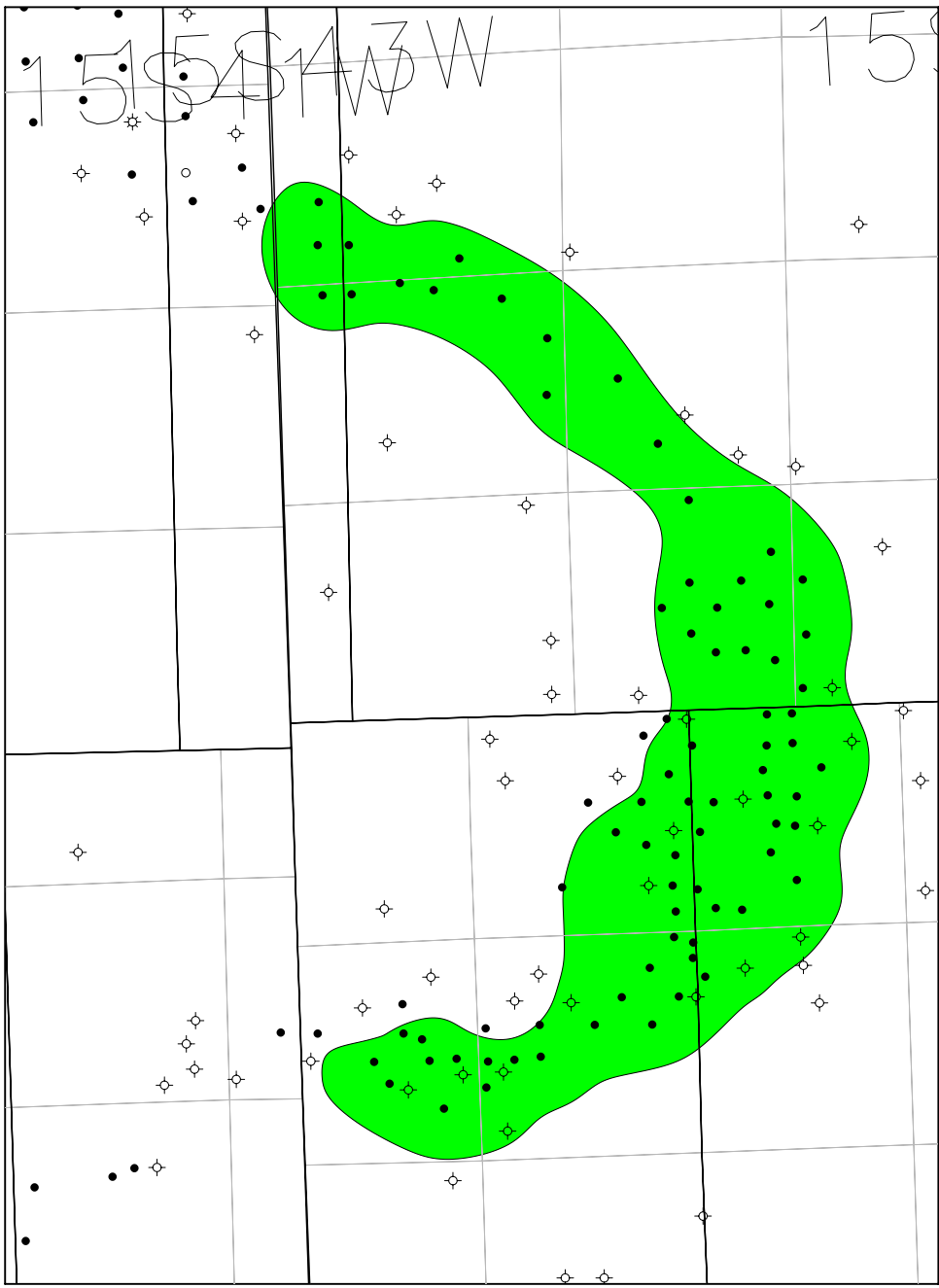
Stateline Complex Development
January 1987



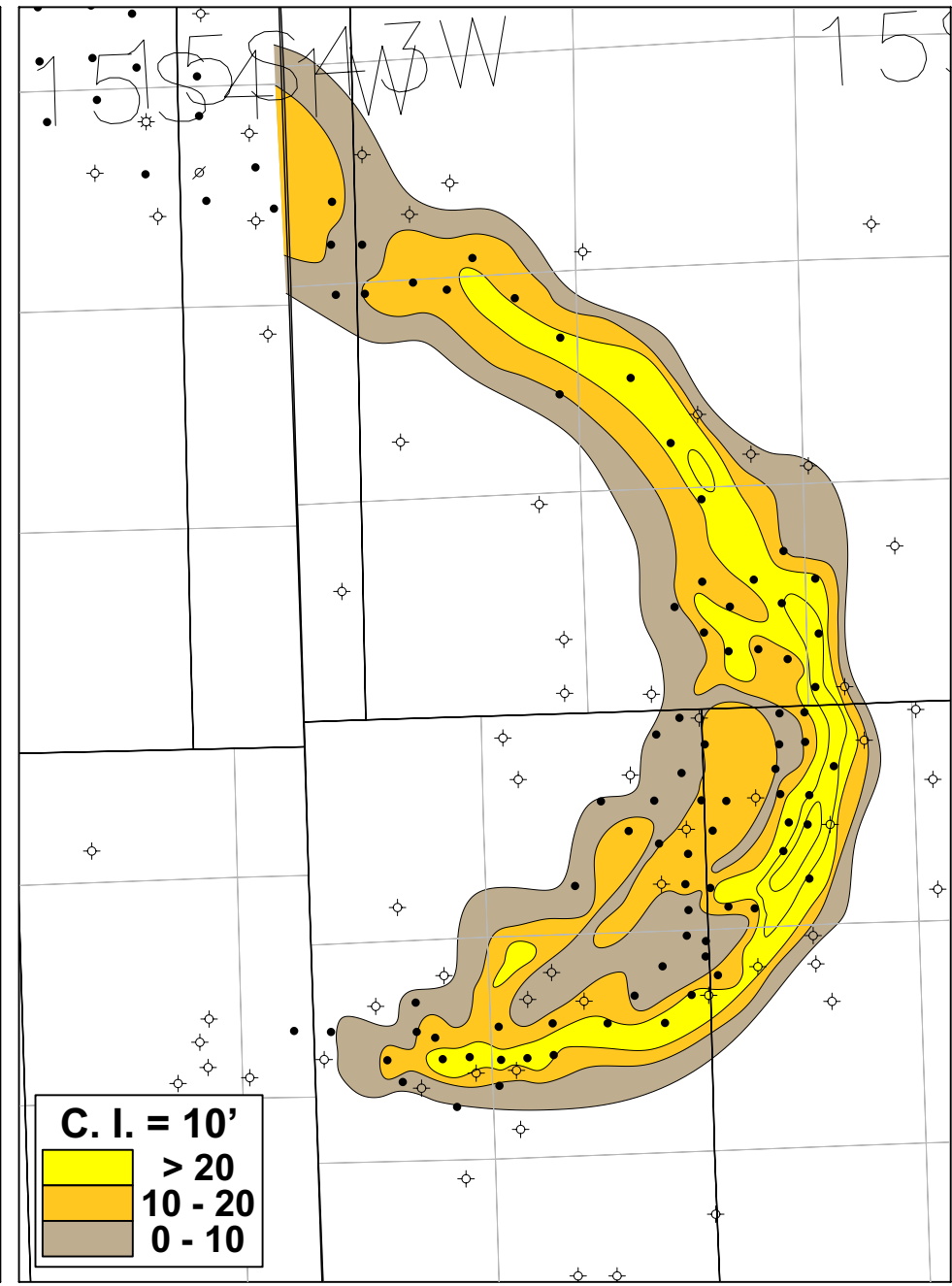
Soil Gas Survey Conducted - November 1987
Ethane Magnitude Contour Map



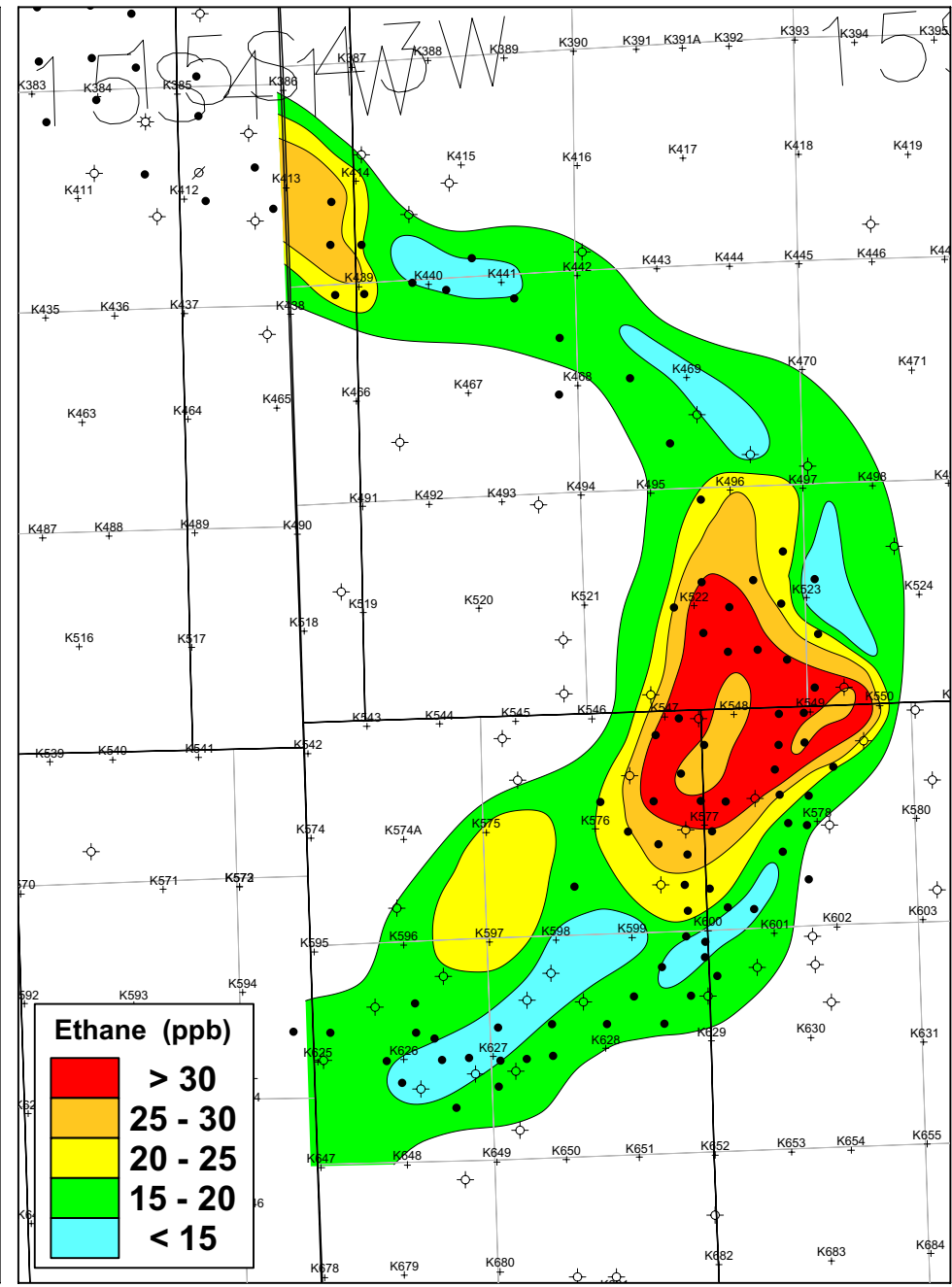
Stateline Complex Development
August 1990



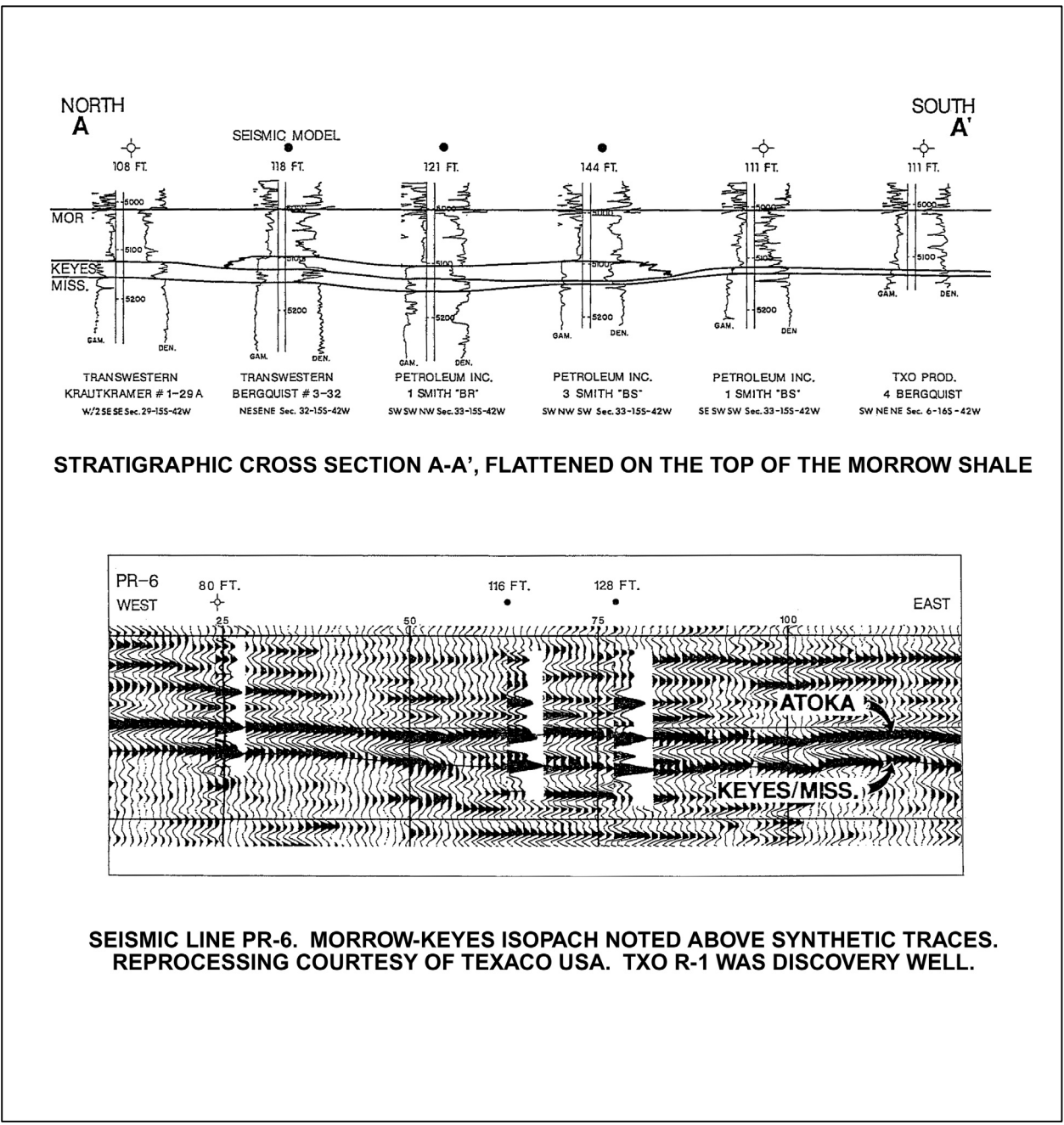
Stockholm Field
Wallace & Greeley Cos., Kansas



Stockholm Net Sand
Isopach Map



Stockholm Field
Soil Gas Map - Ethane



SEISMIC LINE PR-6. MORROW-KEYES ISOPACH NOTED ABOVE SYNTHETIC TRACES.
REPROCESSING COURTESY OF TEXACO USA. TXO R-1 WAS DISCOVERY WELL.

In 1987, Texaco collected a grid of soil gas samples over a 150 square mile area on the Kansas-Colorado border. This survey is on the northeast flank of the Las Animas Arch. Within the study area, the dominant productive horizon is the Lower Pennsylvanian Morrow Formation. The Morrow sandstones were deposited in erosional channels (valley fills) that today are found at depths ranging from 5000 to 5500 feet. The survey included what was then the Stockholm field and a few very small fields. Additional exploration and development drilling in the area has established a significant productive trend, now known as the State Line Trend. The Stockholm Field contains 82 wells, and produces from the Morrow Formation sandstones, with an average productive interval of 18 feet and a maximum of 60 feet. Porosities reach 20% and permeabilities average 217 md. The State Line Trend now contains 8 fields, is over 35 miles long, with an estimated primary recovery of 35 million barrels, and additional secondary potential.

A total of 798 samples were collected in the survey area, on a sample grid of five samples per mile. Overall hydrocarbon magnitude of the samples was low (median methane=0.749, ethane=0.013, propane=0.007 ppm) compared with world clear air (methane=1.6, with ethane and propane below 0.01 and 0.05 ppm) or other soil gas surveys. The overall low magnitudes caused a great deal of concern about the validity of the resulting anomaly patterns and the use of micro-seep techniques in an intercratonic sag basin. Additional concern was caused by the lack of any apparent agreement between the location of methane anomalies and those found on the ethane or propane maps. The samples were thought to be of low magnitude because of a lack of abundant fractures and faults to provide active migration paths to the surface. Shallow biogenic sources are thought to be contributing to the methane magnitudes over the survey area. Since the survey was conducted, the area has been developed into a significant complex of productive fields. Approximately 80 productive wells were within the survey area in 1987. At the end of 1993, there were 270 productive wells in the survey area. Re-examination of the data in the context of the post survey drilling illustrates the value the survey could have provided in (and prior to) 1987. While the ethane and propane anomalies do not predict specific prospects/drillsites, the major anomalies are closely associated with productive trends. This association indicates the value of soil gas surveys as a reconnaissance tool in and around the State Line Trend.