

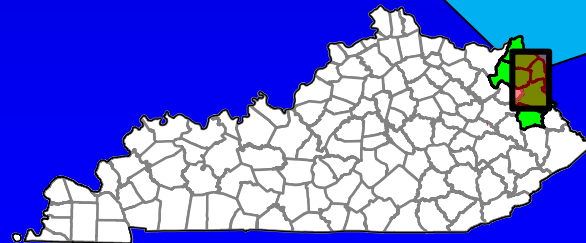
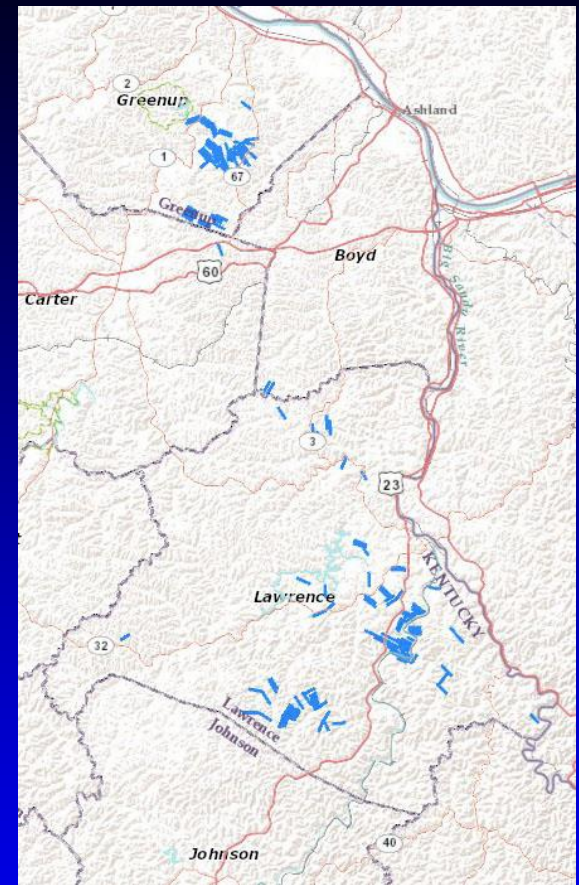
Update on the Berea Sandstone Oil Play in Kentucky

Stephen F. Greb, David C. Harris,
Thomas M. (Marty) Parris, and Cortland F. Eble

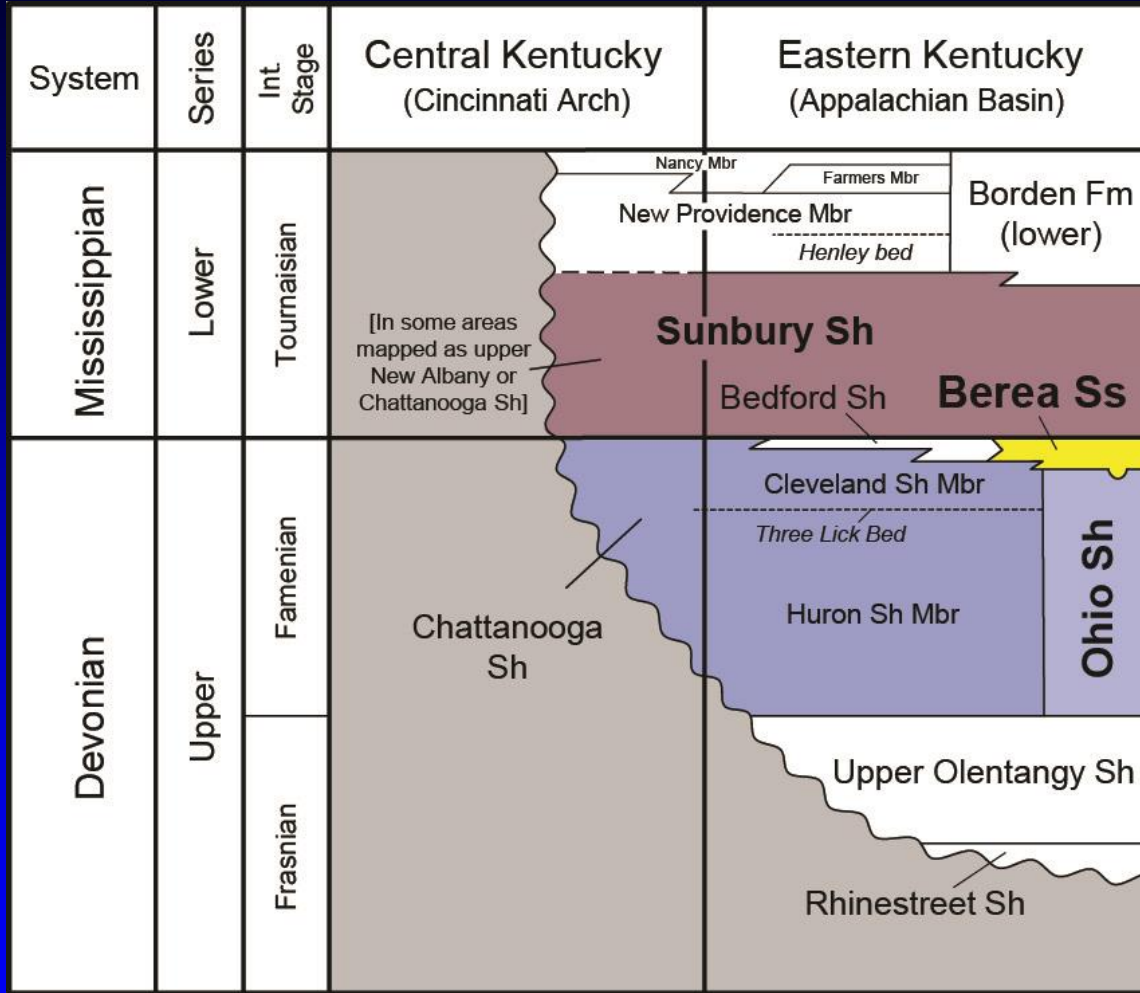
**Kentucky Geological Survey,
University of Kentucky**

Update on the Berea Ss

- **Berea Ss background**
- **Recent KY production trends**
- **Greenup and Lawrence County activity**
- **Research questions raised by recent activity**
- **Berea Sandstone Consortium**



Background



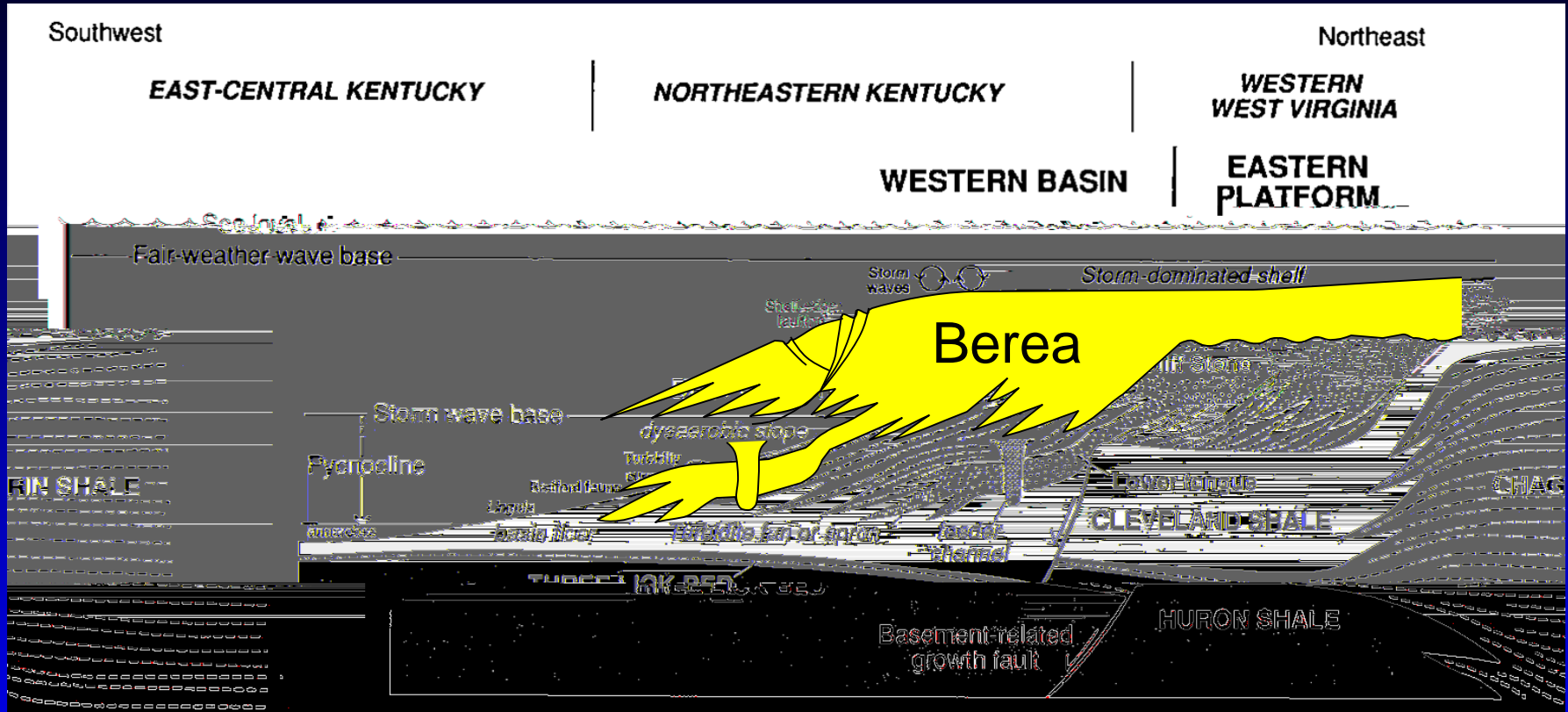
- **The Berea Ss is an upper Devonian**
(siltstone across much of KY)
- **Interfingers with Bedford Sh**
- **Overlain by the Sunbury Sh and underlain by the Ohio Sh (potential source rocks)**

Background

Berea
outcrops in
NE KY



Background

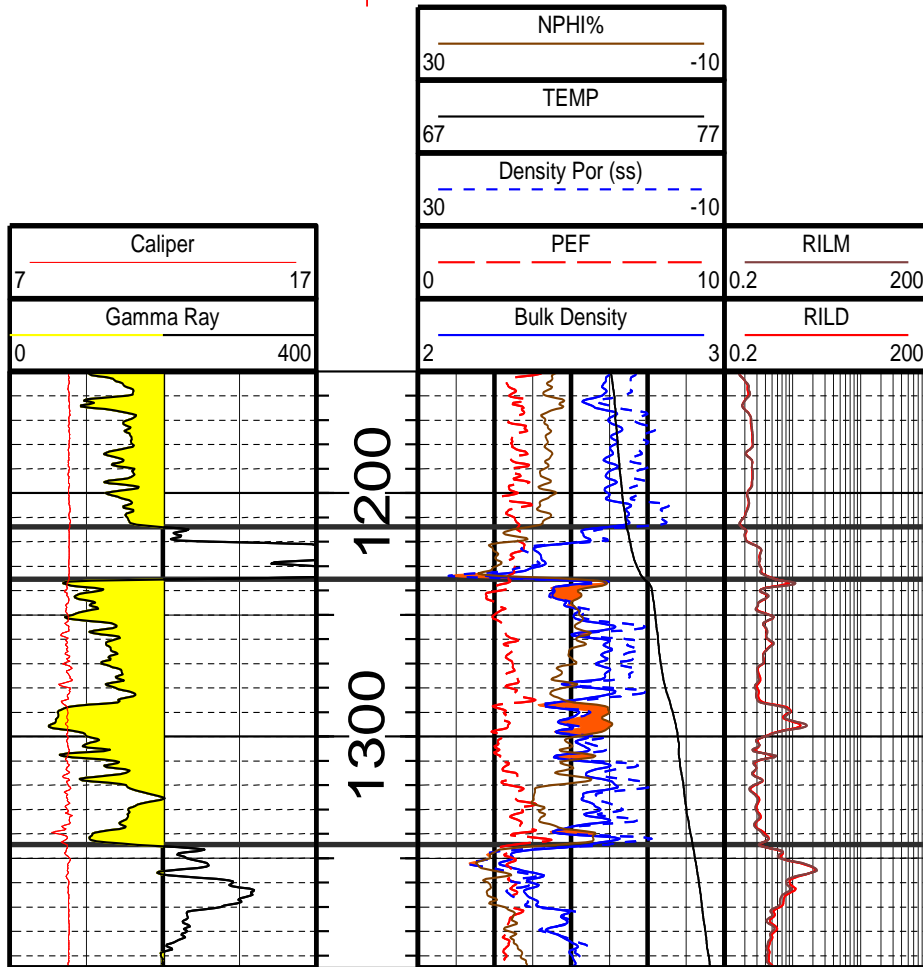


(from Pashin and Ettensohn, 1995)

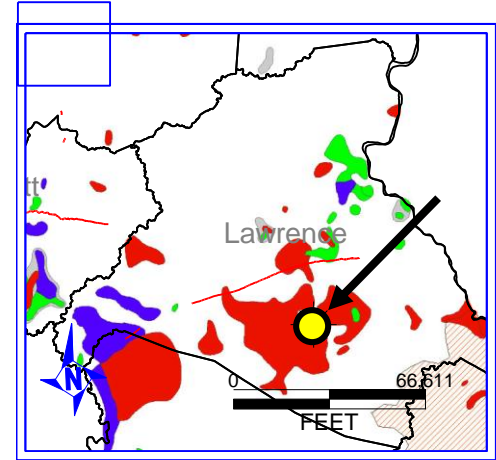
Ky reservoirs are likely developed in storm shelf and slope deposits based on regional models (e.g., Pashin and Ettensohn, 1995)

Background

Eastern KY type Log, Lawrence County



137383
APP ENERGY 1 MOORE, C
Lawrence
KY



Sunbury Sh
Berea Ss/Bedford Sh

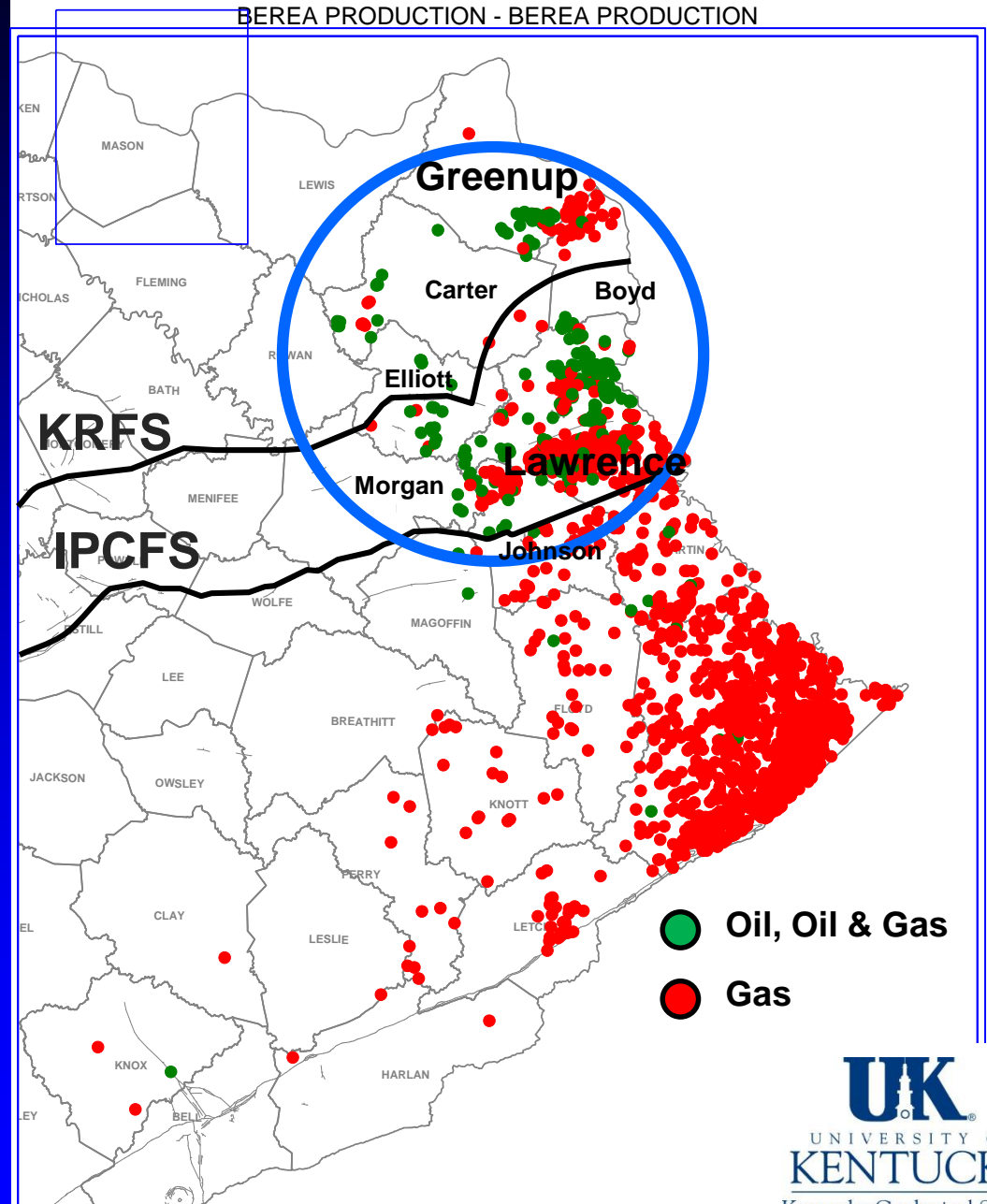
Ohio Sh

**Berea is a classic
low-permeability
reservoir**

Background

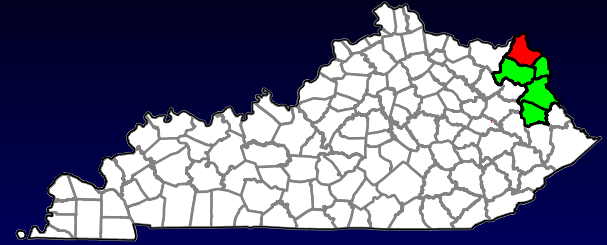
Berea Hydrocarbon Distribution

- Oil production limited to NE KY
 - Shallower part of basin (north of Rome Trough)
 - 1,898 Berea completions (mostly verticals) in KGS database
- ➔ 58 horizontal oil completions since 2011



Recent Production Trends

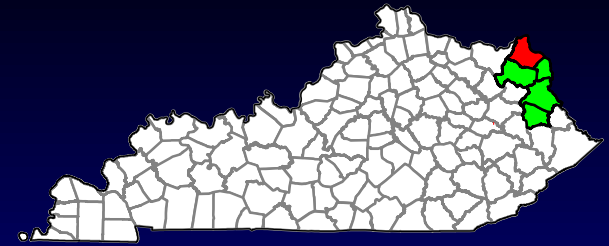
Greenup County



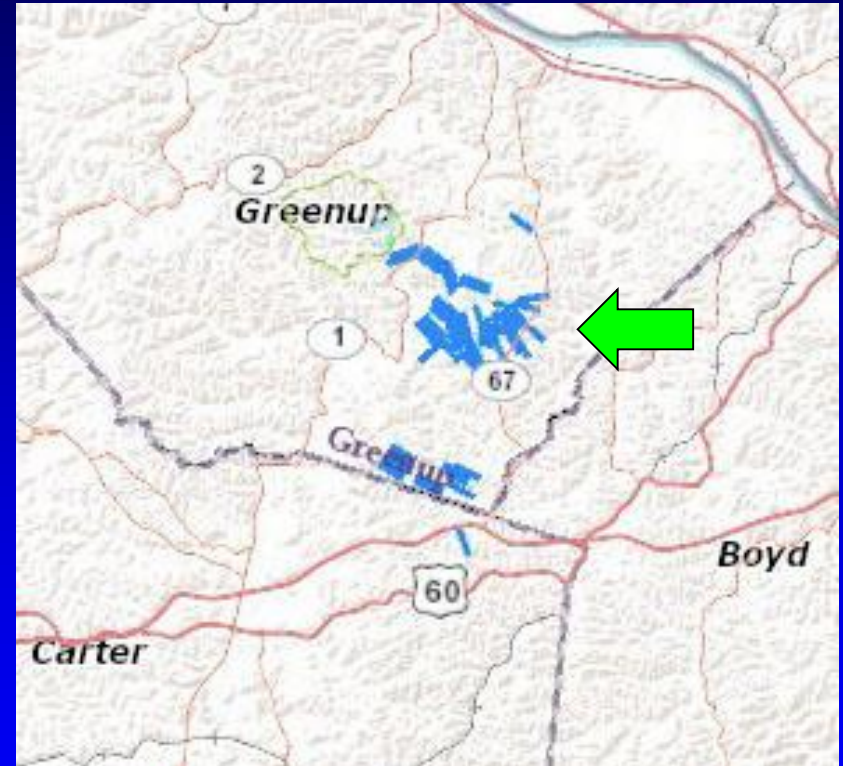
- **Operator: Nytis Exploration**
 - **First completion in March, 2011**
 - **51 horizontal wells permitted**
 - **Completion data submitted for 28 wells**
- **True vertical depths: 979-1362 ft (avg = 1132 ft)**
- **Stratigraphic traps**
- **Average lateral is 2,500 ft, oriented SE-NW (downdip)**
- **Multistage hydraulic fracture stimulation**

Recent Production Trends

Greenup County



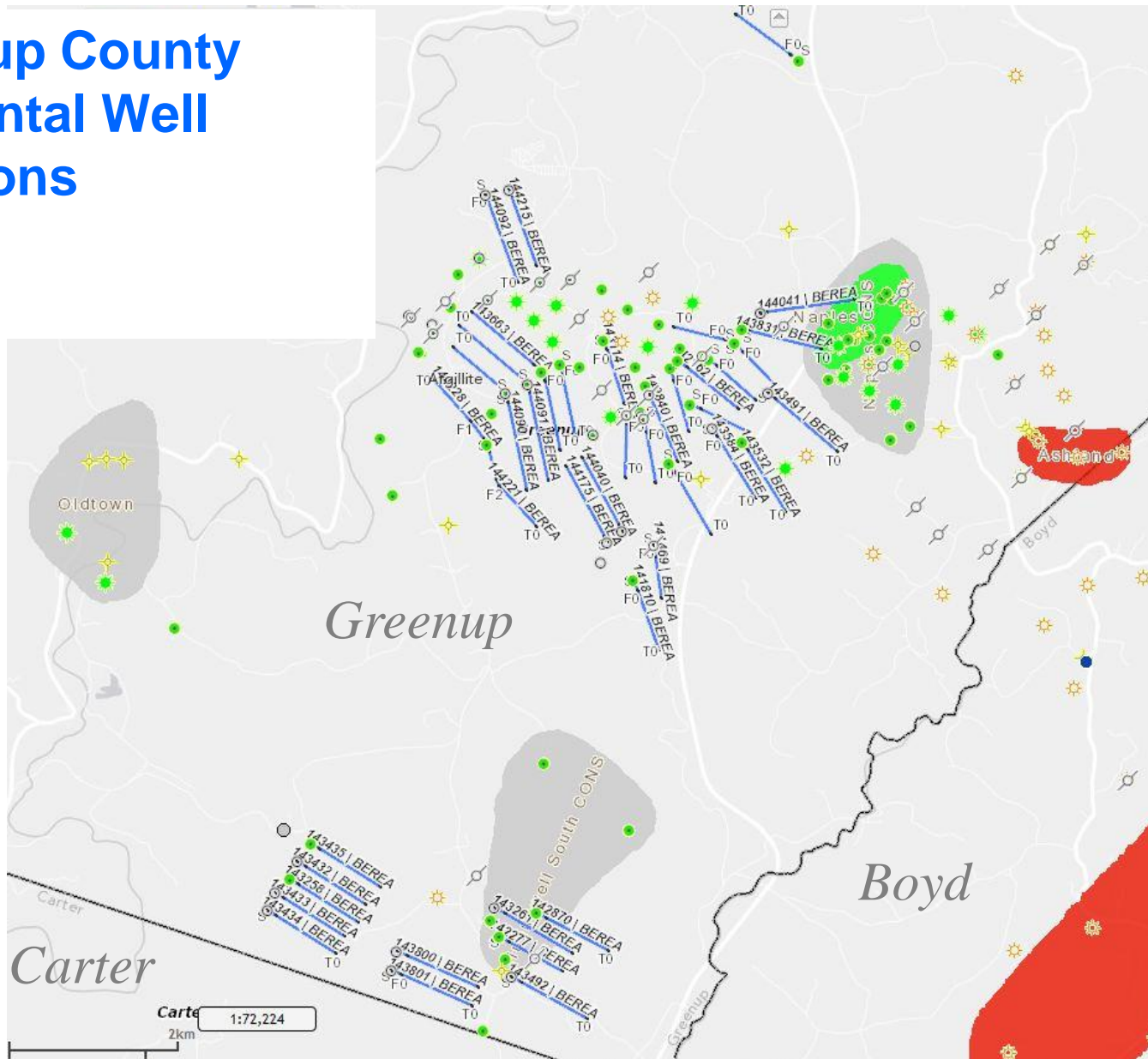
-
- **March, 2014**
- - **12-70 BOPD**
 - **7-37 MCFGD**
- **Water IP:**
 - **15-114 bbl/day**
- **WOR (water/oil):**
 - **1.3-6.0 (avg = 3)**



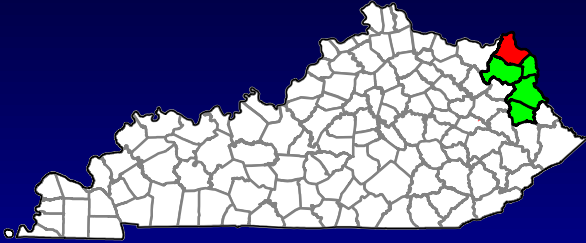
Recent Production Trends

Greenup County Horizontal Well Locations

2014

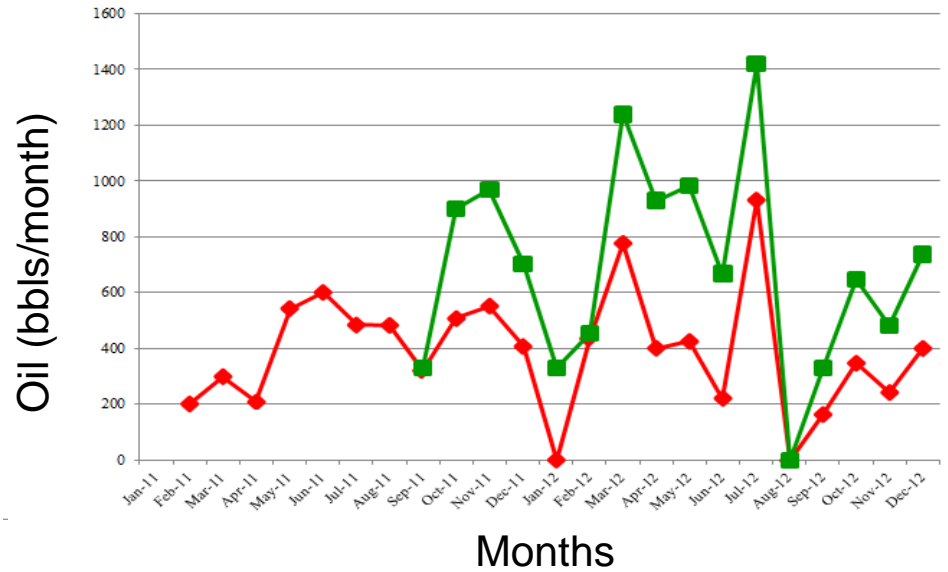


Recent Production Trends Greenup County



Production data
available for two wells:

2011-2012 Production data for two wells



Brice Sheperd 1

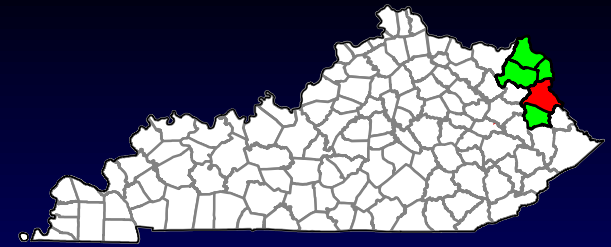
Emory Patton Heirs 2

| | Mean bbls/month | First 6 months bbls/month | Since bbls/month |
|-----------------------------|--------------------|------------------------------|---------------------|
| Brice Sheperd 1 | 389 | 389 | 389 |
| Emory Patton Heirs 2 | 695 | 614 | 744 |

Avg = 542 bbls/month

Recent Production Trends

Lawrence County

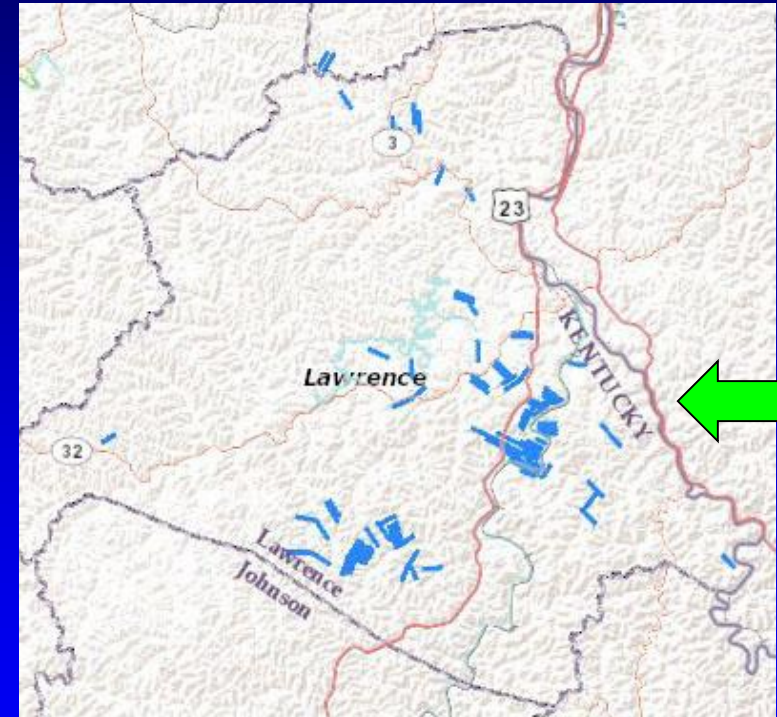
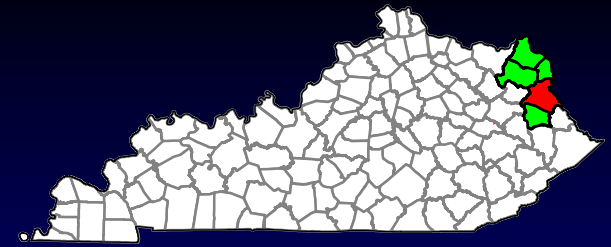


- **Operators: Eagle and others, Nytis Exploration, Hay Exploration, App Energy**
 - **First completion in October, 2012**
 - **98 horizontal wells permitted**
 - **Completion data submitted for 30 wells**
- **True vertical depths: 1115-1862 ft (avg = 1517 ft)**
- **Stratigraphic traps**
- **Average lateral is 2,600 ft., variable orientations**
- **Multistage hydraulic fracture stimulation**

Recent Production Trends

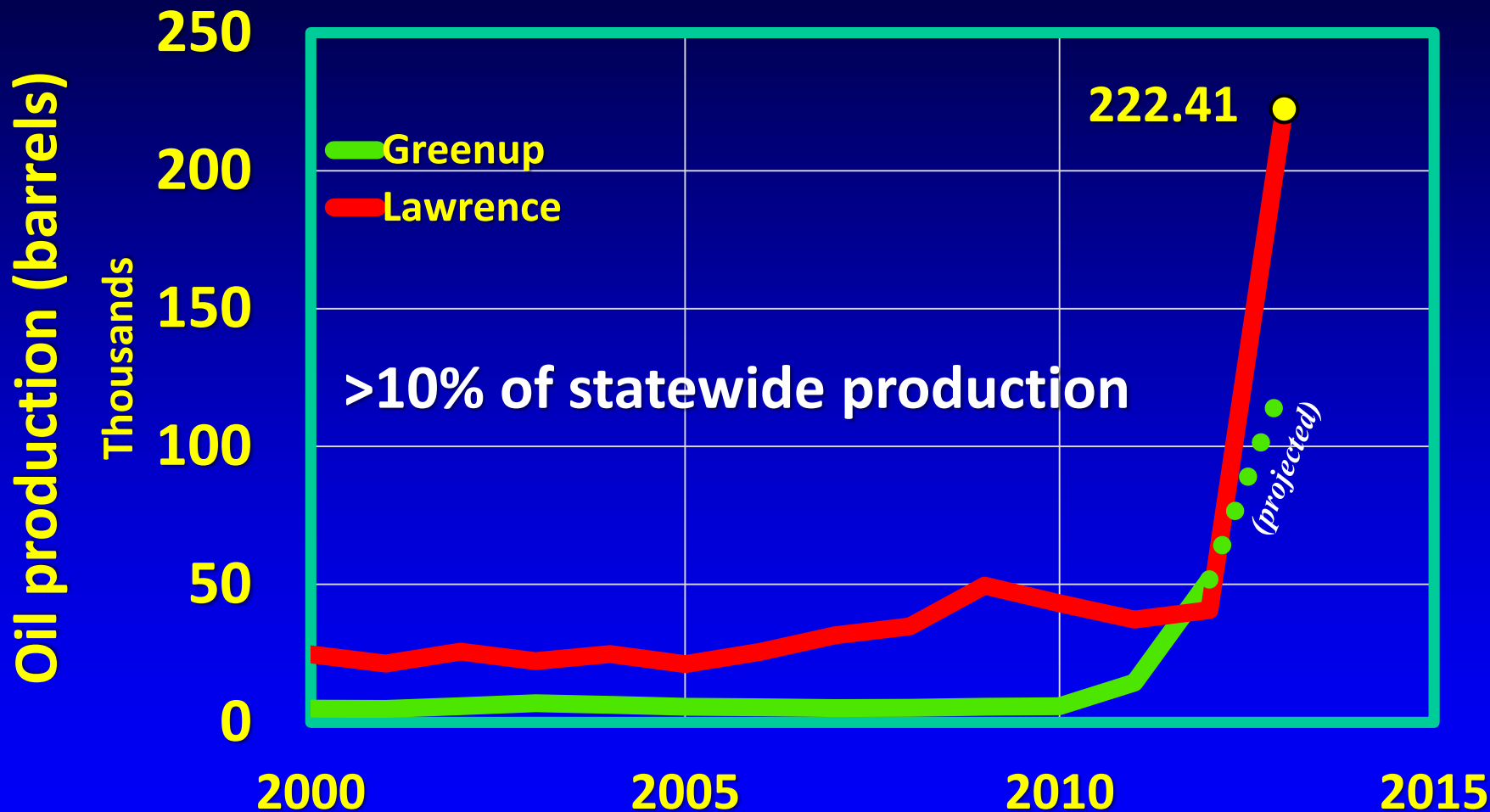
Lawrence County

-
- - 8-44 BOPD, avg. = 25 BOPD
 - 12 MCFGD
- Water IP (for 1 well):
 - 10 bbl/day
- WOR (for 1 well):
 - 0.33
- No public production data available yet



Recent Production Trends

Recent Berea Oil Production, East Kentucky



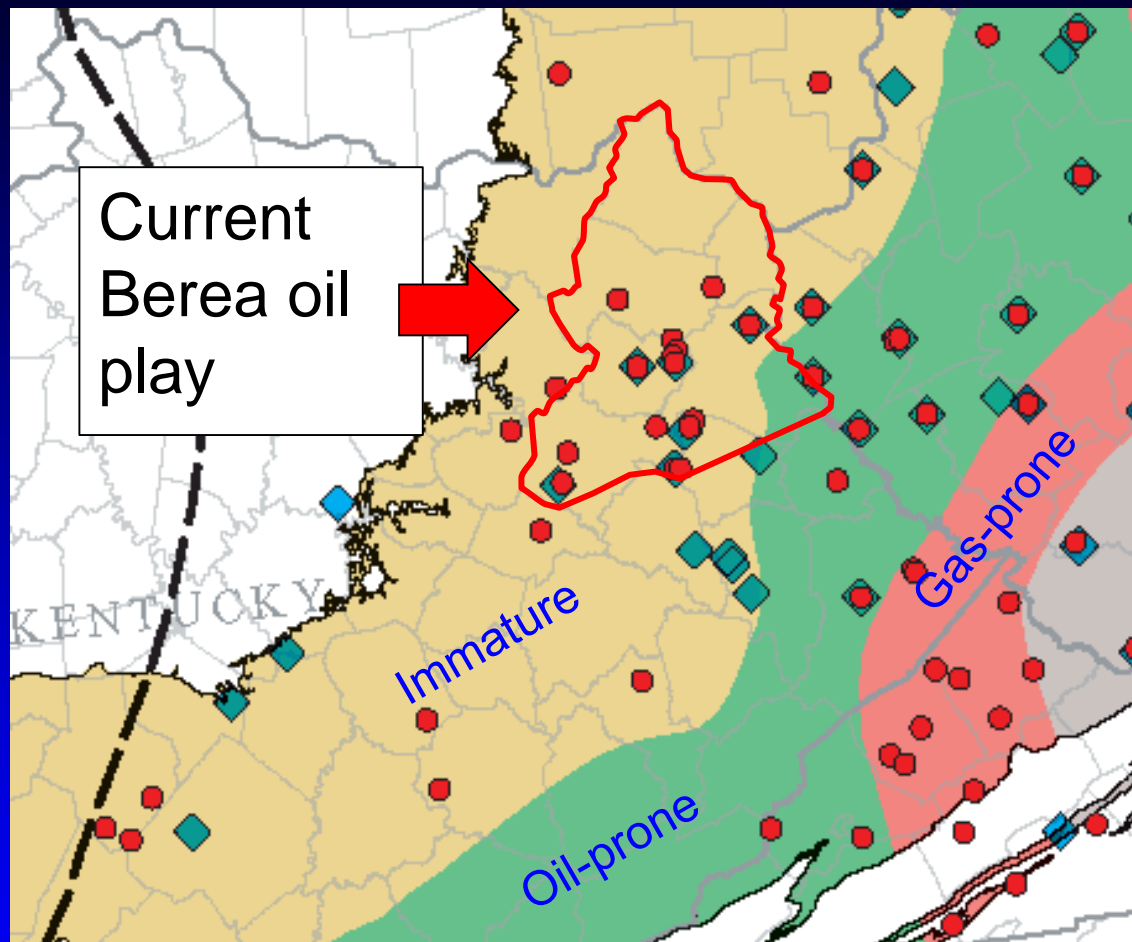
2013 production volume for Greenup County is confidential (3 or fewer respondents)

Recent Production Trends

Summary

- **Initial data shows horizontal drilling has been a technical success in shallow tight Berea reservoirs**
 - **Horizontal drilling has dramatically increased Berea oil production in KY**
 - **Dramatic increases in Greenup and Lawrence County oil production (and for EKY as a whole)**
 - **Berea horizontal play spreading into neighboring Boyd and Johnson counties**
 - **Shallow depths (lower costs) part of the interest**
 - **Determining economic success will require longer term production data**

Research Questions



1) Why does the Berea produce oil and gas in areas where the surrounding source rocks are interpreted as thermally immature ?

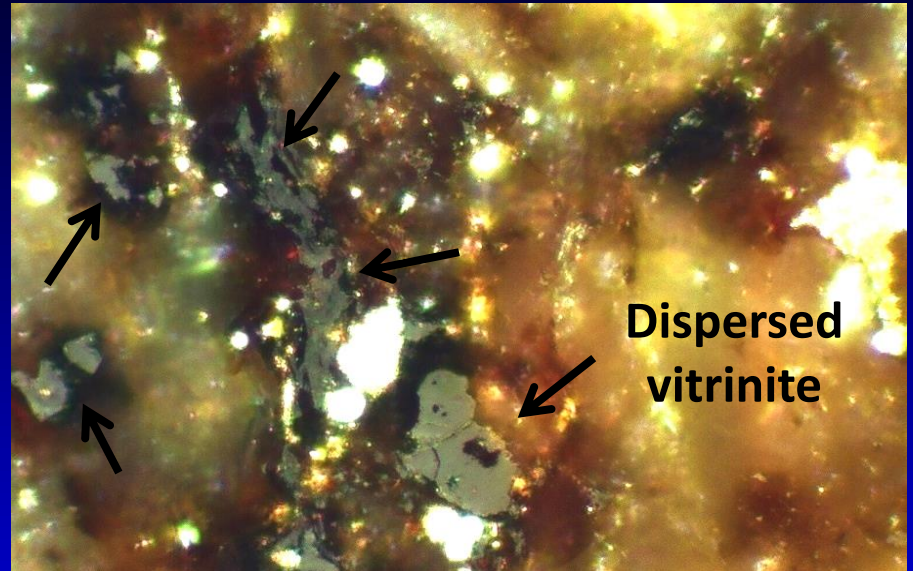
USGS Thermal Maturity Map
(East and others, SIM 3214, 2012)

Research Questions

1a) Is vitrinite suppression responsible for the apparent source rock immaturity?

➤ **Or is some of the vitrinite from Devonian shales actually bitumen with a different R_o and different relationship to maturity?**

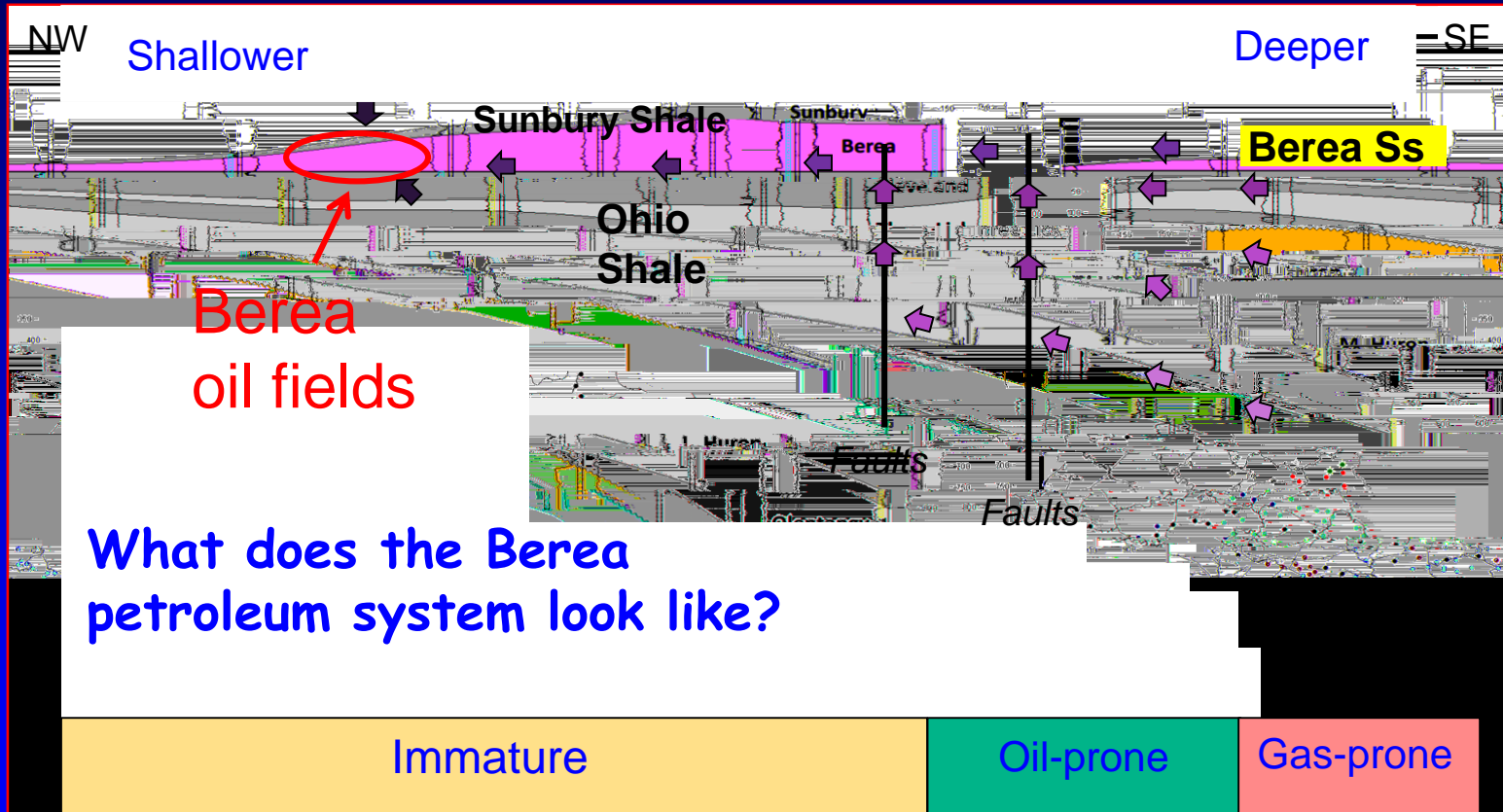
➤ **Can we examine possible Berea sources using different laboratory techniques to better understand R_o and thermal maturity in the basin?**



Petrographic slide of dispersed vitrinite from the Ohio Shale under white light

Research Questions

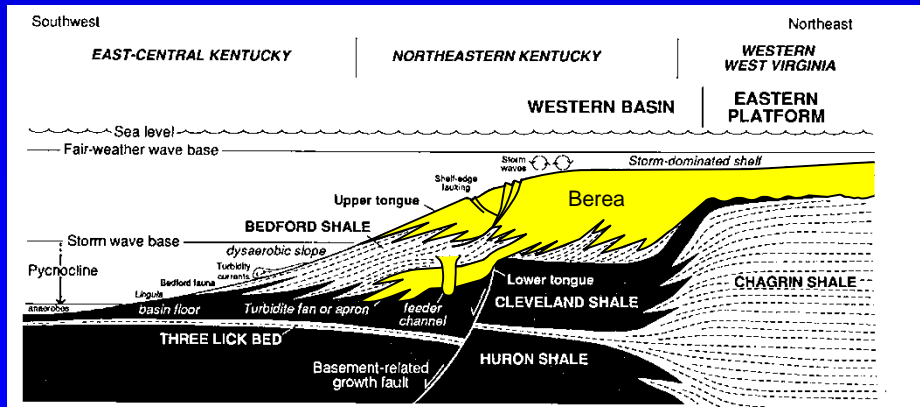
2) Is the Berea hydrocarbon source local, or has it migrated from the deeper (more mature) parts of the basin?



Research Questions

3) What are some of the controls on pay zones, porosity, and permeability in the Berea in Kentucky?

- Regional trends in thickness?
- Sandstone architecture and facies in producing fields (lateral and vertical variability)?
- Any structural influences on facies?
- Any structural influences on oil/gas/water saturations?



Berea Sandstone Consortium Project

- **KGS, USGS, OGS, and 7 industry partners**
- **18-month study of the Berea petroleum system**
- **Collect and analyze samples of source rocks for TOC, Rock-Eval pyrolysis, and reflectance to evaluate thermal maturity**
- **Collect and analyze samples of Berea oil and gas to geochemically tie the produced hydrocarbons to their source**
 - **Advance geochemical analyses including liquid and gas chromatography-mass spectroscopy of bitumen for biomarker analyses and stable carbon isotope composition**

Berea Consortium Project

- **KGS, USGS, OGS, and 7 industry partners**
- **18-month study of the Berea petroleum system**
- **Generate cross sections, and detailed stratigraphic and structure maps of the Berea in KY**
- **Compare geophysical logs, cores, and outcrops to better characterize the Berea petroleum system**
- **Project updates will be posted on the KGS website and a report will be published 1 year after the project is completed**

Thank you

KGS Berea Play Web Page:

[www.uky.edu/KGS/emsweb/berea_ss/
Upper_Devonian_Berea_SS.htm](http://www.uky.edu/KGS/emsweb/berea_ss/Upper_Devonian_Berea_SS.htm)

