Oil and Gas in the New World

- Hydrocarbons known to the natives prior to the arrival of Europeans, called “Anonontons”
- Oil seep near Cuba, NY visited in 1627 by Father de la Roche d’Allion: first record of hydrocarbons in the New World, event documented in the publication *Histoire du Canada* by Sagard (1632).
- In 1669, explorer La Salle reported a natural gas seep near Canandaigua, Ontario County, NY

Roadside Marker, Cuba, NY.
A New Nation’s First Gas Well: The William Hart Natural Gas Well, Fredonia, NY: 1821

In 1821, the first gas well was dug in Fredonia, Chautauqua County, New York.

The Hart Well, originally 27 feet and deepened to 70 feet, was drilled at the site of a gas seep. The well produced until 1858.
first documentation of Hart's well is found in the August 31, 1825, issue of the Fredonia Censor...

almost three months after Lafayette's visit to Fredonia...

Lash and Lash 2014

...northeast bank of Canadaway Creek...
...Hart's well was in decline in the 1850s...

The first gas well in the shadow of the West Main Street bridge. Image courtesy of the O. R. Barker Museum.

Lash and Lash 2014
...William Hart's 1825 well and gasometer... ~1850
Pump Jack, Roho Cabbollos Field, Permian Basin, Texas
Penrod 92

Somewhere . . .
In the Southern Gas Basin

UK Sector

North Sea
Hewlet Gas Field, UK Sector, North Sea
Permian Basin
Carlsbad, NM
Gas Processing Plant, Permian Basin, near Fort Stockton, TX
Beverly Hills Field
Los Angeles Basin
Los Angeles, CA
Signal Hill Field, Los Angeles Basin, Long Beach, CA
Prudhoe Bay Field Well Sites, North Slope, AK

http://www.flickr.com/photos/hogan3774/5182202675/sizes/l/in/photostream/
Petroleum System Elements

- Source Rock
- Reservoir Rock
- Seal Rock
- Structure or Trap
- Maturation of Source Rock
- Migration of oil and gas
Source rock: Kerogen supports the walls of algae. With burial, kerogen breaks down to yield oil and gas.

Seaweed *enteromorpha sp*

http://www.sciencephoto.com/media/16469/enlarge
Source rock: Algae sink to the sea floor after death. Kerogen preservation depends on anoxic conditions along the basin floor.
Black Sea: Model for Anoxic Basins Where Kerogen is Preserved

A = Basins with anoxic deposition

http://cpgeosystems.com/150moll.jpg, Copyright Ron Blakely
Burial of kerogen results in heating, which breaks it down to yield oil, gas, and ultimately carbon.

The depth of each of these events depends on the local geothermal gradient.
Reservoir and Source
Figure 8. Photomicrographs of dolomite facies, #1 Linden. A. thin section photomicrograph from core, 4406.8 m; B. thin section photomicrograph from cuttings, 4409.5 m. Blue voids indicate porosity. Scale bars = 500 μ.
Ledge-forming sandstones
Recessive mudstones
Chestnut Ridge State Park, Orchard Park, New York
Petroleum System Elements

- Source Rock
- Reservoir Rock
- Seal Rock
- Structure or Trap
- Maturation of Source Rock
- Migration of oil and gas
Sella Massif, Dolomites, Italy
Seismic Reflector???
Seal Limit

Thick Chalk Limit

Area of Commercial Chalk Fields
(Limit of Large Salt Diapirs)

MID NORTH SEA HIGH

Chalk Field Other Field

Thick Mature Upper Jurassic Source rocks.

Modified from Sorensen et al 1986
calcite rhombs, and minor amounts of clay. (D2a) The reservoir unit; this facies is similar to and only slightly wispy laminated facies of D2. Matrix clay content and more pure than the overlying M1.

Figure 9. Scanning electron micrographs of key facies. (D1) The D1 facies consisting of unbroken coccoliths floating in a matrix of coccolith fragments, secondary calcite rhombs, and minor amounts of clay. (D2a) The wispy laminated facies of D2a. Matrix clay content and calcite cementation is more pronounced than in the D1 facies. (M1) The M1 reservoir unit; note distinctly purer appearance than the Danian units. (M2) The M2 reservoir unit; this facies is similar to and only slightly less pure than the overlying M1.
(After Harding, 1984 and Albright et al, 1980)
GENERALIZED POST-TRIASSIC STRATIGRAPHY ON HALTENBANKEN

NORTHERN NORTH SEA

CRETAEOUS

PLEISTOCENE

PLIOCENE

MIOCENE

EOCENE

PALEOCENE

CAMPANIAN

SANTONIAN

BARREMIAN

VALENIGIAN

KIMMERIDGIAN CLAY

HEATHER FM.

L JURASSIC

BRENT EQ.

DRAKE EQ.

COOK EQ.

COAL UNIT

HETTANGIAN

AS.

RHAETIAN

MID NORWAY

NESNA FM.

ENGELVAER FM.

TOMMA FM.

LEKA FM.

ALDRA FM.

HITRA FM.
# Jurassic Stratigraphic Nomenclature

<table>
<thead>
<tr>
<th>Period/Epoch</th>
<th>Age</th>
<th>Group</th>
<th>Formation</th>
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<tbody>
<tr>
<td>Jurassic</td>
<td>Lower</td>
<td>Toarcian</td>
<td>Halten GP.</td>
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<td>Aldra FM.</td>
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<td>Pliensbachian</td>
<td>Sinemurian</td>
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<td>Rhaetian</td>
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<td></td>
<td>Middle</td>
<td>Bajocian</td>
<td>Aalenian</td>
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<td>Tomma FM.</td>
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<td>Callovian</td>
<td>Bathonian</td>
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<td>Engelvaer FM.</td>
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<tr>
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<td>Upper</td>
<td>Volgian</td>
<td>Kimmeridgian</td>
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<td></td>
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<td></td>
<td>Nesna FM.</td>
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<td>Oxfordian</td>
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<td>Ryzanian</td>
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GEOSEISMIC SECTION ST 8403-402A
Heidrun Field Platform, Offshore Norway
Fig. 6. Tectonic map of the Prealps and Klippen between Lake Geneva and Lake Lucerne (by R. Plancherel). Structural features of the Molasse and the Helvetic Zone are omitted.

Fig. 6. Carte tectonique des Préalpes entre le lac de Genève et le lac de Lucerne (par R. Plancherel). Les éléments structuraux de la Molasse et de la Zone helvétique ne sont pas représentés.

Fig. 7. Lithological diagram of the Molasse.

Fig. 7. Séquence lithologique schématique de la Molasse.
Figure 4. Core photograph of karst breccia, #1 Linden, 4404.0 m. Note polymictic nature of the breccia clasts, and the presence of dolomitic matrix.

Figure 8. Photomicrographs of dolomite facies, #1 Linden. A. thin section photomicrograph from core, 4406.8 m; B. thin section photomicrograph from cuttings, 4409.5 m. Blue voids indicate porosity. Scale bars = 500 μ.
Petroleum System Elements

- Source Rock
- Reservoir Rock
- Seal Rock
- Structure or Trap
- Maturation of Source Rock
- Migration of oil and gas
Raton and Vermejo Formations NB Coals
Typical Raton Basin Vermejo Coal Production Profile
Coal Bed Methane

- Federal lands in the west
- Well spacing ~ 160 acres
- Conflicts between surface and subsurface rights holders
- Water disposal often a problem
- Floor price around $1.25/mcf
- Ultimate reserves around 150 TCF (?)
Shale Gas: Somewhere over North Texas something is shaking
Dallas Fort Worth International Snail Port
Westside of Airport

NW Runway

Chesapeake Energy Well site near DFW (USAToday image)
Technological Milestones

- Early 1900’s: Shale gas becomes productive. N₂ foam fracs
- 1983: Mitchell drills 1st Barnett Shale well: C.W. Slay No. 1
- 80-90s: Evolution of X-linked gel technology in vertical wells
- 1991: 1st Horizontal Barnett well MEC: T.P. Sims “B” 1H
  Identified fracture azimuth – Max Principal stress
- 1996: Intro of slick water fracs (SWF) & Microseismic
- 1998: SW refracs of original gel fracs
- 2002: Horizontal laterals with multi-stage SWFs
- 2004: 3D seismic tool to avoid karsts and faulting
- 2005: Shift focus to increasing recovery factor
- 2007: Multi-well pads and cluster drilling
2008 M 2 earthquakes in production area

Cornerstone N.G. Engineering, LP
Geologic Setting of the Michigan Basin
Michigan Oil & Gas Plays

- Northern Reef Trend
- Antrim Gas Play
- Devonian Oil (Ordovician Gas)
- Albion-Scipio Trend
- Southern Reef Trend

Michigan’s Lower Peninsula O&G Prod.
Lachine Member

High TOC’s and Significant High Angle Fracturing
Typical Antrim Project

Central Production Facility (compressor, disposal)

Several wells (avg. 13)

~$350K per well (w/ facility)

Peak water in 5 mo. (110 BWPD)

Peak gas in 20 mo. (125 MCFD)

Well Spacing (40-160 Acres)

EUR of ~500 MMCF per 80 acres
CUMULATIVE MICHIGAN ANTRIM PRODUCTION

1989-2007

END 2007: CUM. 2.6 TCFG
A commonly applied model for the Devonian organic-rich shales in NY is that they were deposited in deep permanently anoxic water (>>100 m) at the toe of the slope and that they downlap on underlying shallow water carbonates onto a drowning unconformity – similar models have been proposed for the Utica
2004 - Modern Marcellus Discovery – Renz Unit #1
2004 - Modern Marcellus Discovery – Renz Unit #1
2009  Marcellus Resource Potential

Marcellus Shale Area
28,179,245 Acres
44,030 Sq. Miles

Barnett Shale Area
4,183,088 Acres
6,536 Sq. Miles

Source - AAPG 2008
Fairway Map – Marcellus Shale

Color Contours – Organic rich thickness
Black contours burial depth

Best areas probably where thickest and deepest – A key question is how deep the shale needs to be to produce economically – some shales are only economic at >4000 feet, others appear to be profitable at shallower depths
Total Potential Gas Resources (mean values) 

Forecasts

Data source: Potential Gas Committee (2009)
Shale Gas

- Private lands east of the Pecos
- Conflicts between surface and subsurface rights holders
- Well Spacing 40 to 160 acres
- Water disposal is a problem
- Shallow aquifer protection is critical
- Floor price between $1.25 and $4.00/mcf
- 615 TCF resource at what price?
Fin