Petroleum Systems
(Part Two)

Trap and Reservoir

GEOL 4233 Class
January 2008
Petroleum System Summary

- **Source** (Material and Rocks)
- **Generation** (Maturation)
- Migration
- **Trap**
- Reservoir
Trap Types

(A Question of Seal)

- Structural
- Stratigraphic
- Other
**Traps**

- **Anticlinal** - Rock layers folded into a dome

- **Stratigraphic** - Rock layers changing from a good reservoir to non-reservoir due to change in rock type (pinch-out), reservoir quality (diagenesis), or removal (erosional unconformity)

- **Fault** - Offset of rocks such that oil and gas accumulates in reservoir rock
Typical Hydrocarbon Traps

E Sandstone pinchout

Unconformity

Structural

F Unconformity

Reef core

Flank debris

Stratigraphic

G Reef (a small “patch” reef)
Structural Traps
Simple Anticline

Idealized Oil and Gas Accumulation

Water

Oil

Gas

Water
Surface Anticline
Hunton Limestone (Oklahoma)
The Elephant
East-west seismic depth section, south Ghawar.
Regional east-west cross section.
A Structural ‘Football’
(As Simple as it Gets)

Fig. 214. Missourian sandstone structure map, Mobeetie field. From Dutton, 1982. Permission to publish by AAPG.
Salt-Induced Structural Trap
(Gentle)
Figure 8-10  Integrated fault and structure map for the 6000-ft Horizon. The darkened circles delineate the intersection of each structure contour with the fault contour of the same elevation.
A Major Fault Complication

Figure 8-22 An integrated structure map of a very complexly faulted anticlinal structure. Each fault was integrated with the structural interpretation as shown in Fig. 8-21.
Figure 4-6  A cross section through a complex diapiric salt structure, penetrated by four vertical wells.
Deepwater Seismic Line (Showing Affects of Diapirs)
Structural Traps in a Compressional Terrain

Fig. 219. Structure section, Painter Reservoir, Wyoming. Permission to publish by Chevron.

Structural Traps in a Compressional Terrain
Groningen Field (Largest Gas Field in Europe)

Fig. 217. Cross-section and structure map, Groningen field. From Stauble and Millia, 1970. Permission to publish by AAPG.
Minas Field (Largest Oil Field in Indonesia)

Fig. 31. Minas Field structure map. From Hasan, et al., 1977. Permission to publish by PT Caltex Pacific Indonesia.
Figure 8-41  Typical hydrocarbon trap beneath an angular unconformity.
Figure 8-42  Example of an angular unconformity recognized by electric log correlation. (From Lock and Voorhies 1988. Published by permission of the Gulf Coast Association of Geological Societies.)
East Texas Field
(E.U.R. ~ 5 BBO)

Figure 8-43  Structure map on top of the Woodbine Sand in the East Texas pool. As shown in the cross section insert, the intersection of two unconformity surfaces marks the eastern boundary of this unconformity trap. (From Geology of Petroleum, first ed. By A. I. Levorsen, Copyright 1954 by W. H. Freeman and Company. Reprinted by permission.)
East Texas Oil Field (1930)

Largest “lower-48” field
More than 5 billion barrels recoverable

American Association of Petroleum Geologists, 1990
Prudhoe Bay Oil Field (1968)

- Largest North American field
- More than 8 billion barrels recoverable

American Association of Petroleum Geologists, 1990
Oklahoma City Field (Largest in Oklahoma)
Oklahoma City Field—Anatomy of a Giant

Oklahoma City Field
Oklahoma Co., Okla.
SUB CROP MAP
PRE - PENNSYLVANIAN

Fig. 7.—Pre-Pennsylvanian subcrop map illustrating large areal extent of erosion and truncated shape. Ordovician Simpson and Arbuckle preserved at unconformity surface. A-A' is line of sections in Figures 6 and...
Oklahoma City Field (Wilcox Reservoir)
Simple Fault Trap
(Upthrown Normal Fault)
Extensional
Simple Fault Trap
(Narrow Horst)
Extensional
Fig. 410. Combination stratigraphic/structural trap
SCHEMATIC CROSS SECTION
DOWNTHROWN LOWER GORU PLAY

LARGE NORMAL FAULT
THROW >3000'

UPPER GORU

"CLASSIC" BADIN TRAP

GOOD LATERAL SEAL

TOP MIDDLE SAND

TOP SEMBAR

GENERALLY POOR LATERAL SEAL

DOWNTHROWN 4-WAY DIP CLOSURES

UPPER GORU

TLG

TOP MIDDLE SAND

TLG

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Variably Sealing Fault
Stratigraphic Traps
SCHEMATIC OF POTENTIAL SEMBAR / LOWER GORU STRATIGRAPHIC PLAY

- **ORIGINAL SALINITY**
- **HYPERSALINE**

**TLG**

**RANN OF KUTCH SALTMARSH**

**MOVEMENT OF HYPERSALINE SURFACE WATER**

**SE**

**NW**

**CHILANT**

**ATTACHMENT # 38**

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Truncation Trap on Flank Of Fault Closure
Fig. 409. Stratigraphic trap
Fig. 169. Cross-section of reef production, Indonesia. From Vincelette and Soeparjadi, 1976. Permission to publish by AAPG. See Figure 165.
Horseshoe Atoll Complex
Midland Basin (W. Tx)
Other Traps

Combination

Hydrodynamic

Non (Un) Conventional
Reams Southeast Field
Middle Booch Net Sandstone Isopach
(Showing Combination Trap)
Hydrodynamic Trap

Fig. 244. Hydrodynamically tilted oil-water contact
Example Map View of Hydrodynamic Trap

Fig. 243. Tilted oil-water contact, Frannie Field, Wyoming. From Hubbert, 1953. Permission to publish by AAPG.
Conventional vs. Non-Conventional Gas Accumulations
Petroleum System Summary

- **Source** (Material and Rocks)
- **Generation** (Maturation)
- Migration
- Trap
- **Reservoir**
Reservoir Types

• Clastic
  • Blanket Sandstones (Marine Reworked)
  • Channels / Deltaics / Turbidites / Nearshore Marine
  • Others (Aeolian, Granite Wash)

• Carbonate
  • Limestone
  • Dolomite

• Unconventional
  • Gas-Oil Shale (tight sandstone/limestone)
  • Coalbed Methane
  • Others (hydrates, asphalts)
Isolated (Noneffective) porosity 3%

Connected (Effective) Porosity 29%

Total porosity 32%

Grain

Cement
Reservoir Sandstone

Good Porosity = Lots of Space for Petroleum

Pores (blue)
Reservoir Sandstone

Pore-Filling Cement Reduces Quality

= Less Space for Petroleum
Clastics
Sedimentary Environments
Aeolian Sandstone
Coconino (Arizona)
Very Generalized Isopachs of Sandstones in Variety of Depositional Environments

Figure 21: Typical isopach patterns associated with clastic sedimentation.
Modern Barrier Island
Gulf Coast
Idealized Tidal Delta
Oklahoma (Booch)
Overbank Sandstones
Oklahoma (Savanna)
Modern Mahakam Delta Plain
East Kalimantan, Indonesia
Incised Valley Block Diagram

Log signatures from cross section A-A' (Plate 10)

1. Well #1
   McKe #B-1
   SW Sec 24-10N-17E

2. Well #2
   Addington #A-1
   NE Sec 24-10N-17E

3. Well #3
   McKe #E-1
   NW SW Sec 19-10N-18E

4. Well #6
   Davis #D-1
   NE SE Sec 17-10N-18E
Fluvial (Incised Valley) Sandstone
Oklahoma (Hartshorne)
Fluvial Sandstone
Oklahoma (Red Fork)
Fluvial Sandstone
Oklahoma (Red Fork)
Well Log of Incised Valley-Fill Sandstone
Oklahoma’s Brooken Field (Booch)
Fluvial Sandstone Isopach Map
Oklahoma (Upper Booch)
Turbidite Sandstone
Oklahoma (Atoka)
Carbonates
Sedimentary Environments

Common Sedimentary Environments
Figure 6.38
Carbonate Reservoir
Hunton Limestone (Oklahoma)
Fig. 387. Oriented fractures in rocks.
Fig. 406. Tectonic effect upon reservoir potential
Fig. 4.03: Weathering and limestone porosity
Fig. 386. Vugular porosity in carbonates
Carbonate Reservoir
Red Wall Limestone (Arizona)
Carbonate Reservoir
Wapanuka Limestone (Oklahoma)
Unconventional
Surface Coal Mine in Oklahoma
Gas Transport Mechanisms in Coal

- Fluid Production from Natural Fractures
- Butt Cleat
- To Wellbore

- Gas Desorption from Cleat Surfaces
- Molecular Diffusion through the Coal Matrix
Comparison of recovery trends for conventional gas wells and coalbed methane wells.
Coalbed Methane Well (Oklahoma)
U.S. Coal Basins

Western Interior Coal Region
Woodford Shale (Oklahoma)
Athabasca Tar Sands
Methane Hydrates